STATE OF INDIANA

Michael R. Pence, **Governor**

IDEM

Indiana Office of Energy Development

OUCC
Indiana Office of Utility Consumer Counselor

IURC

January 20, 2016

EPA Docket Center
United States Environmental Protection Agency (U.S. EPA)
Mail Code: 2822T
Attention: Air Docket ID EPA–HQ–
OAR–2015–0199
1200 Pennsylvania Avenue, NW
Washington, DC 20460

Dear Administrator McCarthy:

The State of Indiana via the undersigned agencies appreciates the opportunity to comment on the proposed rule entitled "Federal Plan Requirements for Greenhouse Gas Emissions From Electric Utility Generating Units Constructed on or Before January 8, 2014; Model Trading Rules; Amendments to Framework Regulations" (October 23, 2015, 80 Fed. Reg. 64966).

The State of Indiana has joined with other states in challenging the validity of the Clean Power Plan in court.[1] Indiana firmly believes the court will find the Clean Power Plan invalid. However, in order to fully protect Indiana's interests, the undersigned agencies offer the attached comments. The State of Indiana believes the undersigned agencies provide a particularly broad range of expertise in addressing a diverse list of environmental, energy, markets, and utility regulatory matters at issue.

The State of Indiana believes it to be unprecedented for U.S. EPA to apply a uniform "Federal Plan" template based on the failure of an individual state to file a plan complying with the underlying requirements (Clean Power Plan in this instance) without first providing an opportunity for public comment as to the Federal Plan's applicability to the applicable state. U.S. EPA does not impose compliance plans on an individual state without first providing an opportunity for comment on that particular compliance plan. The State of Indiana therefore believes that U.S. EPA must be soliciting comment solely as to

---

[1] *State of West Virginia, et al. v. United States Environmental Protection Agency, et al.*, Case No. 15-1363 et seq., U.S. Court of Appeals for the District of Columbia Circuit.

the proposed Model Trading Rule(s) and not for purposes of serving as a substitute for an opportunity to comment on a Federal Plan as it would be applied in a particular state. If U.S. EPA seeks to initiate action to impose a Federal Plan on a particular state, the State of Indiana respectfully maintains that U.S. EPA must solicit an additional round of public comments prior to moving forward with such action. In particular, it is imperative for states and the regulated community to be afforded the opportunity to review and comment on the specific allocation methodology proposed within a Federal Plan. U.S. EPA has not adequately provided an opportunity for such input in seeking comments only as to the proposed rule at issue here.

Implementation of the Clean Power Plan poses a number of challenges and uncertainties to the states, with the potential for extraordinary costs and burdens being imposed upon the states' consumers and their respective economies. It is essential that U.S. EPA provide as much flexibility to the states as possible in finalizing Federal Plan requirements and the Model Trading Rules, while minimizing added regulatory burden on the states. The State of Indiana therefore hopes U.S. EPA will seriously consider the attached comments prior to finalizing this proposed rule.

The State of Indiana notes that U.S. EPA has solicited comments on a wide variety of topics concerning the proposed rule. The final version of the Clean Power Plan is also markedly different from that originally proposed by U.S. EPA, with compliance obligations that are significantly more rigorous for states which have traditionally relied in large part on energy from coal. In light of these significant changes and the overall complexity of the final Clean Power Plan, Indiana and other states are still in the process of conducting significant analysis of the implications of the final Clean Power Plan. Given the limited period for comment (especially as it spans across four national holidays) and the complexity of the issues involved, the State of Indiana is unable to provide as meaningful and detailed comments and recommendations at this time as it would like concerning complex matters such as evaluation, measurement, and reporting for energy efficiency programs. As U.S. EPA proceeds in devising its final action(s), the State of Indiana encourages the agency to consult further with experts from Indiana concerning these matters to collect more detailed insight and recommendations on important implementation considerations.

If you have any questions or need additional information, please contact Carol Comer, Commissioner for the Indiana Department of Environmental Management, at (317) 232-8611, or ccomer@idem.in.gov.

Respectfully,

Carol S. Comer

Carol S. Comer, *Commissioner*
Indiana Department of Environmental Management

Carol A. Stephan

Carol A. Stephan, *Commission Chair*
Indiana Utility Regulatory Commission

A. David Stippler

A. David Stippler, *Utility Consumer Counselor*
Indiana Office of Utility Consumer Counselor

Tristan Vance, *Director & Chief Energy Officer*
Indiana Office of Energy Development

Attachments:
Attachment A – Technical Comments
Attachment B – Indiana Evaluation Framework
Attachment C – Indiana Tech. Ref. Manual

Attachment A – Technical Comments

Federal Plan

1. While Indiana has yet to make a decision on whether to submit a state plan, our preliminary analysis, as well as the work that has been done by other reputable entities such as the Midcontinent Independent System Operator (MISO), seems to suggest that a mass-based approach is likely to be both more feasible and more widely adopted than a rate-based approach. Thus, based on currently available analysis, Indiana would preliminarily prefer that a federal plan adopt a mass-based approach rather than a rate-based approach. The mass-based plan pathway appears to allow for the most flexibility while also being the most cost-effective. Furthermore, many stakeholders with whom Indiana has engaged support a mass-based approach. Since trading is a valuable compliance measure, Indiana believes that a mass-based plan provides the best pathway to an effective trading regime. Because the Clean Power Plan (CPP) only allows states to trade with other states under the same plan pathway (for instance, mass-based states may only trade with other mass-based states, regardless of whether states use a state plan or opt into a federal plan), supporting a mass-based federal plan is helpful and will likely increase the market for trading if the majority of states pursue a mass-based path. The mass-based plan pathway also allows for states, or U.S. EPA under a federal plan, to incorporate other cost-effective measures, like renewable energy (RE) projects or energy efficiency (EE) programs, in order to help meet compliance goals. Further, many states and affected electric generating units (EGUs) are already familiar with mass-based limits from similar programs that have been implemented in the past. From an administrative perspective, a mass-based plan is also less resource intensive on states or U.S. EPA to administer because aspects that would need to be in place under a rate-based plan, like an emission rate credit (ERC) desk, wouldn't be necessary. Indiana also urges that U.S. EPA consider allowing states another opportunity to provide comment on a proposed Federal Plan at a later date when states are put on notice that they are subject to the proposed federal plan and U.S. EPA has provided more clarity on many of these issues.

2. Indiana does not oppose U.S. EPA's proposal that states looking to transition out of a federal plan and into an approved state plan must wait until the end of a compliance period to make the transition. If the final federal plan follows a mass-based pathway and allowances have already been distributed to affected EGUs under the federal plan for a compliance period, it would be nearly impossible for a state to transition out of a federal plan, especially if those allowances have already been traded. Further, transitioning in the middle of a compliance period has historically not been allowed under previous trading programs. Compliance periods are relatively short, so states would be able to transition out of a federal plan in a fair amount of time after their state plans had been approved. Affected EGUs also need certainty on compliance requirements in advance and would need to know what would be required of them in enough time to react to differences between a federal and state plan.

Trading and Linkages

1. With regard to the finalization of one or multiple model trading rules, Indiana believes that both the rate-based and mass-based model trading rules should be finalized and

available to the states as soon as possible. Not only will the final model trading rules provide additional guidance to states that choose to submit their own state plans, as well as provide more detail on the types of implementation measures U.S. EPA may expect from an approvable state plan, but the final model trading rules will allow states to take advantage of any presumptively approvable section(s) to be included in their state plans. However, with regard to a final federal plan, U.S. EPA cannot finalize a federal plan for imposition on any particular state until after the state fails to comply with a Clean Air Act mandated submission by the applicable deadline. Further, in order to maximize states' flexibility, it would be beneficial for U.S. EPA to wait to finalize a federal plan for specific states only after other states have submitted their state plans to U.S. EPA. This would allow U.S. EPA to gain a better understanding of which pathway the majority of states that submit state plans will choose, which is beneficial when considering plan options, like trading. Finally, Indiana believes that, when U.S. EPA does finalize a federal plan for a state once the state misses a deadline, there should be an opportunity for states and the public to provide comment on that state-specific federal plan. Other states would thereby have an opportunity to not only take a more in-depth look at what would be included in their state-specific federal plan, but states would also have the opportunity to provide feedback to U.S. EPA on feasible compliance options specific to their state. There could be significant changes between what U.S. EPA has proposed as a federal plan or model rule and what U.S. EPA intends to promulgate as a final federal plan for a state, based on comments received on the proposed federal plan and model rule.

2. Indiana believes that all federal plans, as well as model trading rules, should be ready-for-interstate-trading plans. By having both the federal and model plans as ready-for-trading, the number of trading-ready states would likely increase, which would provide for a larger and more competitive trading market. Indiana would also not oppose the provisions U.S. EPA included in the proposed federal plan and model trading rules that allow for interstate trading to occur between affected EGUs that fall under state plans and affected EGUs that fall under a federal plan. These provisions include an approved state plan that is ready-for-trading and state plans that implement the same trading regime as the federal plan, as well as state plans that use a U.S. EPA-administered tracking system. In order to promote maximum flexibility among states able to trade, the latter provision should be expanded to include the option of linking with state plans that use other tracking systems that are interoperable with a U.S. EPA-administered tracking system, if the state so chooses.

3. Indiana does not oppose the linking of mass-based federal plans to mass-based state plans that choose to use metric tons as their unit of measurement. This would allow for more flexibility in trading and also potentially open up more state plans to be ready-for-trading. If states or affected EGUs would prefer measuring in metric tons, they would be responsible to convert to short tons in order to meet any trading or reporting requirement. Indiana does not believe this will be a common issue, since the final Clean Power Plan uses short tons as its unit for measurement for mass-based pathways and we assume many states will use short tons in their mass-based state plans.

4. As proposed by U.S. EPA, states under a federal plan should be able to link with states under a state plan, even if those state plans include non-affected emission sources in order to broaden the amount of sources able to trade. This would provide affected EGUs in a particular state more flexibility when purchasing ERCs or allowances from the trading market. Further, it would help promote a more competitive market, since more utilities would be able to take advantage of trading, which would help to keep prices for ERCs or allowances fair.

Compliance Periods

1. Indiana strongly prefers U.S. EPA's proposal to provide use of the agency's existing allowance tracking and compliance system (ATCS) to support state plans. Indiana does not have an established system for allowance tracking and there are no state funds allocated for such a purpose. Utilizing an established federal platform will save time and money while leveraging the expertise U.S. EPA has developed through administration of the Cross-State Air Pollution Rule (CSAPR) and Acid Rain Program (ARP) tracking systems. Indiana has relied on the Clean Air Markets Division (CAMD) to manage allowances for both the NO_x SIP Call rules and the Clean Air Interstate Rule (CAIR, the precursor to CSAPR) in the past and is familiar with those types of tracking systems. Offering a common platform will also simplify the administration of allowance trading between states who engage in interstate trading plans.

2. Indiana does not oppose the proposal from U.S. EPA to require monitoring and reporting of CO_2 mass and net generation beginning on January 1, 2021. This action should require monitoring and reporting only, with affected EGUs remaining exempt from complying with a CO_2 emission standard until the interim compliance period begins in 2022. Initiating monitoring and reporting requirements in 2021 would assist in ensuring that affected EGUs have established the appropriate tracking and reporting mechanisms prior to the commencement of compliance standards. The 2021 CO_2 data would also assist states in identifying specific compliance concerns among affected EGUs and potentially allow for a shift in allowance allocation to address these issues.

3. Indiana strongly agrees with the proposal from U.S. EPA to evaluate compliance only after the end of a compliance period with no intervening compliance requirements during such a period. U.S. EPA's stated goal is to strike a reasonable balance between providing flexibility and reducing burden while addressing noncompliance in a timely fashion. The introduction of intervening requirements during a compliance period would increase the regulatory burden on both affected EGUs and states, while impairing the flexibility of EGUs to adjust to the new CO_2 emission standards. With three separate compliance periods established for the Clean Power Plan's interim compliance period, states and U.S. EPA will have multiple opportunities to identify and address noncompliance before reaching the final emissions goal in 2030. More frequent compliance requirements could threaten to reduce needed flexibility and would likely increase costs to consumers. Indiana believes that noncompliance can be effectively addressed without the burden of intervening compliance requirements.

Emission Rate Credits

1. While Indiana recognizes the appeal of U.S. EPA using state goals in the rate-based trading approach, we are concerned about potential challenges associated with using state rate goals in a trading regime. Because one of Indiana's main priorities is flexibility within both the federal plan and model trading rule, Indiana would prefer the use of subcategorized performance rates within U.S. EPA's rate-based federal plan and model rule. By using the subcategorized performance rates, U.S. EPA ensures that ERCs are traded fairly between affected EGUs in different states. Also, the use of subcategorized performance rates in the federal plan and model trading rules will ensure maximum flexibility with respect to trading, since states that partake in trading under a single state plan with a rate-based pathway must also adopt the subcategorized performance rates. Adopting subcategorized performance rates in the proposed federal plan and model trading rule also helps protect against gaming of the ERC market. Having one singular rate that applies to all affected EGUs of a specific type helps to safeguard the validity of an ERC and ensure that one ERC in one state has the same value of another ERC in a different state.

2. U.S. EPA should ensure consistency with the final Emission Guidelines when finalizing categories of sources eligible to receive ERCs. States that have the intention of operating under a state plan may find themselves in a situation where they must operate under the federal plan either temporarily, due to delays in state plan approval, or possibly over the long term. Affected EGUs, whether located in states under a state plan or located in states that fall under a federal plan, will need ERCs from as many eligible sources as possible to show compliance. By not limiting the range of sources eligible to receive ERCs to anything more stringent than the final rule, U.S. EPA would allow for the most flexibility within the federal plan and model trading rules.

3. Indiana agrees with U.S. EPA's proposal that the gas shift ERC (GS-ERC) emission factor should be calculated on a unit-by-unit basis, rather than a calculation using the least stringent region. Indiana also agrees with establishing the NGCC incremental generation threshold on a unit-by-unit basis. Using a unit-by-unit calculation allows U.S. EPA to gain a more accurate sense of any above and beyond reductions a specific unit makes, which allows affected EGUs to better comply with a federal plan. This also provides greater incentive for Indiana's NGCC units to maximize their capacity.

4. Given how the Clean Power Plan is both complex and very different from U.S. EPA's original proposed rule, Indiana has had insufficient time to fully analyze and understand the ERC process. However, Indiana believes that separating ERCs into distinct types would not only cause undue administrative burden when it comes to showing compliance, but also be an excessive burden on affected EGUs. Further, with regard to GS-ERCs, Indiana believes that they should be a part of a non-segregated ERC pool. U.S. EPA's proposal that GS-ERCs must be separated from non-GS-ERCs creates even more unnecessary burdens on not only utilities, but also on states or U.S. EPA. By keeping ERC categories separate, U.S. EPA is proposing the creation of two separate ERC markets and price points, which is an unnecessary complication in an already

complex regulatory scheme. Indiana believes that there should be no distinction between ERC types, as long as they are validated ERCs.

5. The inclusion of the widest possible range of demand-side EE that U.S. EPA proposes as eligible measures for ERC issuance under the federal plan (such as state and utility EE programs, project-based demand-side EE, state building codes and appliance standards, and conservation voltage) would promote flexibility within the federal plan. Indiana also strongly urges U.S. EPA to include both affected and non-affected combined heat and power (CHP) units as an eligible measure for ERC issuance under the federal plan. CHP has proven to be an effective strategy to improve efficiency and reduce emissions at industrial sources in Indiana. The inclusion of CHP will encourage flexibility in the federal plan, which Indiana believes is crucial to achieving effective compliance at the most reasonable cost to consumers.

6. Indiana understands that the timeframe for implementation of the Clean Power Plan is very lengthy and technology will change over time. Therefore, Indiana urges U.S. EPA to implement a process through which new measures could be approved and considered eligible for ERC issuance under the federal plan, but Indiana also cautions that U.S. EPA should not approve new measures too frequently. The issuance of ERCs will already be a burdensome process for both entities applying for ERCs and U.S. EPA. If the rules of ERC eligibility and issuance change too frequently, they may result in confusion as to what counts and what does not. Further, projects that may not have been eligible previously because they did not fit under a certain category could become eligible, making it unfair to previous operators of similar projects.

7. Indiana agrees that consistency with existing programs is important and supports the annual, or less frequent, issuance of ERCs. Considering that all compliance periods established in the Clean Power Plan cover multiple years, there is no clear justification for implementing a more frequent issuance interval. Indiana agrees that staying consistent with existing programs will help minimize deadlines and eliminate confusion and error. However, Indiana is concerned about accounting for EE programs on an annual basis if a 90/10 confidence interval is required. (Please see further discussion of this concern in the Evaluation, Measurement, and Verification section.)

8. Indiana does not have sufficient background to fully understand the role of an accredited independent verifier within the ERC system and requests further guidance from U.S. EPA. Indiana requests that U.S. EPA regional offices provide training on this and other topics, which would be very helpful in understanding the requirements needed for an effective ERC issuance program within Indiana or at the federal level. Indiana also does not believe that an independent verifier is necessary for renewable sources as there are many sources of documentation for RE generation. (Please see the discussion under Renewable Energy and Alternative Types under a Rate-Based Pathway for more information.) With regard to EE program verification, Indiana is concerned with the requirement that no financial relationship exist between a source and a third-party verifier because this would require the state to pay for these verifiers. This would strain agency budgets and might require additional legislative action to accomplish, even if the state

agency charged sources a fee to fund independent verifiers. This could discourage the use of EE for compliance.

9. Indiana believes that the use of banked ERCs allows for much needed flexibility under the federal plan. By allowing an affected EGU to utilize banked ERCs to use during future compliance periods, U.S. EPA is adding a level of security and flexibility for the affected EGU to comply with the subcategorized performance rate goal set forth in the proposed rate-based federal plan.

10. Indiana believes the portion of proposed set-asides for RE projects that benefit low-income communities, in addition to the set-asides by the CEIP, is unnecessary and provides no true benefit to states. Wind and solar projects need to be placed in areas within a state that best utilize their potential output. Further, the location of RE projects within a community is not necessarily a benefit to that community. RE projects benefiting states operating under the federal plan should have the flexibility to locate in areas where they can have the greatest potential to generate without restriction.

Renewable Energy and Alternative Types under a Rate-Based Pathway

1. Indiana's main concern with how renewable energy is treated both in the proposed federal plan and model trading rules is that there should be as few limitations as possible on the eligibility of renewable technologies, the ability to receive ERCs or allowances from renewable energy sources, or the ability to trade ERCs.

   All renewable energy capacity should be eligible to count toward state goals under the federal plan. Renewable energy generation resources should be able to replace and/or offset the negative effects of fossil fuel generation to the maximum extent possible. Doing otherwise would fail to incentivize states, utilities, or other entities to develop these resources as viable offsets and could relegate RE generation to the realm of an undeveloped idea which might have potential rather than fostering a large and growing diverse industry capable of having a significant impact on the environment, the economy, and on society as a whole. These RE resources should include biogas, biomass, CHP, waste to heat power (WHP), and coal-bed methane operations. Such sources have the potential to provide reliable base-load capacity, and they are abundant throughout Indiana. Further, any customer-owned renewable generation provided through either utility feed-in-tariffs (FITs) or net metering programs should also be eligible for ERCs.

2. Any feedstock that has the potential of producing methane and can be effectively and efficiently captured to generate electricity should be authorized. This will promote the widest possible destruction of greenhouse gases (GHGs) and increase the likelihood of technology advances as companies seek more efficient energy generation to achieve greater nameplate capacities from these fuel sources. Bio-digesters and coal-bed methane capture technologies are excellent examples of capturing methane from waste to provide reliable generation and should be encouraged.

3. With regard to who can be eligible to receive ERCs, Indiana would prefer that the widest possible range of potential solutions be available for compliance and that unnecessary

conditions not be imposed as to whom can be a project provider. To the extent such conditions are sought, they should be up to the states. Restricting allowances or ERCs to only owners or operators of affected EGUs could unnecessarily skew the construction of new renewable generation only to large utility providers and may inhibit the construction of new projects by companies who specialize in renewable energy project development. Further, affected units may not have experience with renewable energy projects, especially if they are merchant gas or coal-fired units. In essence, restricting eligibility in this manner would create significant market barriers to entry for merchant facilities, could cause existing merchant facilities to shut down, give large energy companies an unfair advantage, and potentially inhibit innovation for new renewable or clean generation technologies.

4. It is not clear whether U.S. EPA would require entities purchasing power from a resource in a state with a different type of state plan (i.e. a rate based state purchasing wind resources from a mass-based state) to provide a full copy of the Power Purchase Agreement (PPA) to receive ERCs from that source. If this is the case, Indiana does not believe U.S. EPA should retain this information. PPAs contain highly sensitive and confidential information. Unless U.S. EPA is willing to meet the same cyber-security standards that electric utilities must meet, U.S. EPA should not keep this information on its servers where it could be compromised by a cyber-attack. Even so, there is still some risk of keeping hard copies of PPAs at U.S. EPA's offices, so it should not be necessary for an entity to provide this contract to receive credit from the renewable facilities. If U.S. EPA needs to verify that a PPA exists, it can view this information on-site at a utility or the site's headquarters. U.S. EPA should also allow for the fact that a PPA may not exist if a utility has built resources in one state to serve customers in another state. Such utility-owned resources are either placed in the utility's rate base or incorporated into the utility's cost of supplying electricity and should count just as any resource purchased through a PPA would.

5. Most utilities in Indiana receive renewable energy credits (RECs) from the renewable energy provider as a condition of the PPA. RECs may be the best way to track that megawatt hours (MWhs) were actually generated and supplied from a particular source, as they have a tracking number associated with them. Also, these facilities are metered, and the power costs from these facilities are invoiced to the entities purchasing the renewable power. If U.S. EPA needs to verify that an affected source actually purchased renewable energy from a particular source, there should be reasonable methods of doing so without keeping entire PPAs on file.

6. To require potentially hundreds of renewable energy generators to provide a multitude of metrics to U.S. EPA is both unrealistic and a duplication of effort already undertaken. A simpler, more practical and effective approach would be to have the nation's utilities detail in a report to U.S. EPA (provided on a periodic basis) the level of RE in their systems along with specific metrics such as type of RE generator (wind, solar, biomass, etc.) and nameplate capacity for each generator providing energy into the utility's grid, the actual energy (kWh) generated over the specific period used by the utility and provided by each generator as well as the capacity factor for each RE generator providing

energy into the utility's grid. U.S. EPA could then use these metrics (provided by the utilities which track this information anyway) to gauge and account for the use of RE versus other methods of generation by each and every utility in the country. U.S. EPA can then audit or inspect these records from affected sources as it sees fit.

7. It is not necessary to require sources to employ third-party verification sources such as Green-e and CRS because there is clear documentation of such purchases. Requiring a third party verification source would simply add to the cost of using renewable energy as a compliance option and possibly discourage affected sources from choosing renewable resources for compliance.

Evaluation, Measurement, and Verification

1. Indiana has experience with developing comprehensive demand-side management (DSM) program evaluation, measurement, and verification (EM&V). Through a collaborative stakeholder process consisting of electric utilities, consumer advocates, industrial users, environmental organizations, and independent consultants with experience in EE EM&V, Indiana developed a statewide Technical Resources Manual (TRM) and Evaluation Framework. These documents were approved by the Indiana Utility Regulatory Commission (IURC) as part of a state-mandated energy efficiency regime. Mandated DSM programs were in effect through December 31, 2014, and utilities were required to use these standards for mandated programs. The utilities were not mandated to follow these standards for all of their other EE programs, but all utilities did so voluntarily. Indiana invested significant time and resources in developing these standards and they represent an example of how a good program can be implemented. For U.S. EPA's reference and consideration, Indiana has included these documents as Attachments B and C with these comments.

2. The use of one of the three methods of quantifying MWh savings is applicable:

   i. Deemed savings,
   ii. Project-based measurement and verification,
   iii. Comparison group method.

   How the final decision addresses the groupings, i.e. by state, regionally, and/or nationally, should dictate what method is best suited for each resource. The key is how they are measured within each segment and whether or not the methodology is consistently applied.

   The first step is to determine whether eligible savings will be based on gross or net reductions. Of the three methods for EM&V, two produce gross savings and one produces net savings. The proposed rule appears to suggest that gross savings should be eligible even though the baseline definitions can produce both gross and net results. U.S. EPA should adopt a consistent approach to allow for all programs to be measured equally. Otherwise, programs that can only show net savings could be abandoned for programs that show gross savings. A standardized consistent Evaluation Framework can establish by segment the EM&V criteria to be met.

3. The load forecast and energy sales utilized to determine savings must be measured in a manner that recognizes economic conditions actual and expected, customer growth actual and prospective, and consistency with a utility's Integrated Resource Plan (IRP). If there is a lack of consistency between the load forecast/sales estimates and the demand side EE savings, then the potential exists for inaccurate development of carbon credits.

   There should be a TRM developed for adoption by each state, region, or nationally with consistent algorithms across each region, recognizing that the ultimate results will vary depending on how the TRM is to be applied. An Evaluation Framework should also be consistent across the various groupings or individual states. Confidence levels, sample sizes, and survey development should be a few of the parameters where consistency is important. If there is no consistency in approach and implementation, it will be difficult to have assurance that the required levels are reached.

4. Demand side EE savings should be based on an adopted TRM for either the state, the region, or nationally for estimating deemed savings based on the EE measure installed. These deemed savings should then be subject to rigorous evaluation, measurement, and verification in accordance with an Evaluation Framework designed to match the TRM adopted statewide, regionally, or nationally.

5. While existing reporting systems can play a role in meeting EM&V requirements, the level of confidence, deemed savings, and frequency of reporting must be consistent among the states where an EM&V Evaluation Framework is in place. If there is a move to regional or national EM&V reporting, then there must be consistency in reporting requirements and evaluation rigor. If not, then the ability to confidently report on and trade carbon credits would be compromised. Properly designed measurement and verification procedures applied consistently across a region or nationally for each metered resource like RE is an absolute requirement. To do otherwise would increase the potential for unfair and less effective recognition of carbon allowances between states.

6. Double counting occurs when the measured savings from a single EE program, project, or measure is counted more than once. This potential illustrates the need to properly track, account for, and implement quality procedures which are undertaken across states, regions, or nationally. Double counting can occur where savings are being claimed by one or more units, where savings are claimed by an implementer and the utility, or where there are inconsistent baselines across a group of programs. Well-structured and defined tracking and reporting systems will help identify double counting.

7. Indiana requires a 90/10 confidence interval (CI) for its EE programs, but this interval is achieved over three years. This is because it takes approximately three years of verification data to obtain enough samples to achieve the 90/10 CI. While it is possible for programs to meet such a standard on an annual basis, it quickly becomes more expensive as more technicians must be employed in order to reach the sample size necessary to attain a 90/10 CI. Indiana would recommend this standard be applied over three years to prevent the use of EE for compliance from becoming too costly. However, Indiana is not sure how to appropriately award and verify ERCs for EE programs on an annual basis, but also does not want those who implement EE programs to be required to

wait three years before receiving ERCs for these programs. Indiana would recommend that if U.S. EPA were to adopt a 90/10 CI requirement, U.S. EPA develop a formula to hold EE programs accountable for achieving the proper savings while receiving ERCs on a timely basis, such as a refund program.

Allowances and Allocations

1. Indiana urges the inclusion of an allowance set-side or similar mechanism in the context of a mass-based approach for the purpose of making allowances available in emergency circumstances for affected EGUs that are compelled to provide reliability-critical generation and which have demonstrated that a supply of allowances needed to offset their emissions was not available. An allowance set-side or similar mechanism should be in place in the final federal plan for the mass-based approach to provide assurance to all affected parties in the event that an emergency occurs and off-setting allowances are not available. However, more time and input from affected stakeholders is needed to thoroughly evaluate and respond to all elements of this issue.

2. Indiana supports unlimited allowance banking under the proposed mass-based federal plan and model trading rules, including the banking of interim period allowances for use during subsequent interim periods and the final period to provide for more flexibility in federal plan development and compliance with interim period and final period goals.

3. While Indiana supports providing states maximum flexibility in implementation and for demonstrating compliance, further clarification is needed on how the use of borrowing across compliance periods in the proposed mass-based federal plan and model trading rules would work in order to assess how it would benefit the state and affected EGUs and the drawbacks it would create in the long term. Indiana's initial thoughts are that borrowing against future compliance periods adds another level of risk in demonstrating future compliance in an already complex rule that is not warranted. A market-based program and a two-year compliance period reduce the need for borrowing. Indiana believes this also applies to the concept of ERC borrowing as well. By allowing borrowing, U.S. EPA could unintentionally damage the future of the ERC market by allowing the use of ERCs that are not yet guaranteed. Again, Indiana supports maximizing flexibility; however, U.S. EPA needs to implement measures to ensure states are not penalized in the later compliance periods.

4. Indiana has no objections to the allowance transfer deadline for the mass-based trading program. Five months seems to be an adequate amount of time for allowance true-up and is consistent with other similar trading programs. However, Indiana would prefer to engage stakeholders for their perspectives on this issue prior endorsing the proposed allowance transfer deadline.

5. Indiana would prefer to further consult with stakeholders regarding the proposed historic data-based allocation approach and alternative approaches to allocating allowances in the proposed mass-based federal plan and model trading rules prior to taking a position on the various elements of this issue. Indiana believes that allowances should be allocated to affected EGUs in a manner that is fair and rational, as well as timed and structured such

that a well-supplied market is created as early as possible to ensure that allowances are available at a reasonable price to any affected EGU that needs them, including those that may need to operate at unexpected times for reliability purposes. Indiana understands that under the proposed model rule, states will have the flexibility to allocate allowances as they specify in their respective state plans.

6. Indiana prefers the direct allocation method, which would allow U.S. EPA to distribute allowances for free to existing emitters, distribution utilities, and other entities that U.S. EPA chooses to receive the economic value of allowances in lieu of auctioning allocations under the model trading rules and mass-based trading federal plans.

7. Indiana has no objections to the proposed approach of recording allowances seven months prior to the start of each compliance period or the alternative of 13 months proposed for comment in the proposed mass-based federal plan and model trading rules. Both options offer advantages and disadvantages to be considered from the perspective of the state and affected EGUs. Therefore, Indiana would prefer to garner further stakeholder input on this issue prior to specifying a preference.

8. The output-based set-asides proposed to incentivize increased generation by NGCC units and the renewable energy set-aside under the proposed mass-based federal plan offer flexibility in addressing leakage for state plan development without using the new source complement, which Indiana appreciates. However, it is difficult to thoroughly evaluate and offer substantive comments on all aspects of these set-asides given the limited amount of time available to develop and submit comments. This is an option that Indiana will analyze further to see if it is viable as a part of a state plan that does not use the new source complement to address leakage, considering that anything in the proposed federal plan or model trading rules is presumptively approvable. Further, Indiana urges that states should be allowed to choose to submit a state allowance-distribution methodology to provide a demonstration that leakage will not occur due to specific characteristics of the state, provided that it meets the requirements in the final EGs and is supported by credible analysis. Indiana believes that this alternative demonstration would provide more pathways for addressing leakage.

9. Indiana believes that states should be allowed to decide how to redistribute any allocations left over in the set-asides to all affected EGUs after they have been distributed and allowances from units that retire or are modified or reconstructed and are no longer affected EGUs. States should have the option to distribute allowances to the remaining affected EGUs on the same distribution basis as the initial allocations were made instead of being required to allocate those allowances solely to the state's RE set-aside. This would allow states more flexibility for compliance with interim and final period goals. Indiana requests further clarification on whether redistribution to the RE set-aside from retired units is required to address leakage.

10. Indiana prefers the proposed approach to allow states to determine allocations via state allowance-distribution methodologies and replace the federal plan allowance-distribution provisions. This may be an option for states that know they would not be able to get a

state plan approved in time but still would like the flexibility to utilize allocations at the state end. However, more time is needed to thoroughly evaluate and comment on the proposed schedule for submitting state allowance distribution methodologies to the agency, for submitting the resulting unit-level allowance tables to the agency, and for the agency to record allowances. Indiana also prefers the alternative approach that would allow a state to notify U.S. EPA of its intent to submit a state allowance-distribution methodology in advance, in which case the agency would hold off on recording U.S. EPA-determined allocations to allow more time for state-determined allowances to be recorded. Indiana believes that states should be provided with as much flexibility as possible given the complexity of the Clean Power Plan requirements.

Clean Energy Incentive Program

1. Indiana requests more guidance and clarity about all aspects of CEIP implementation. The concept of a CEIP is likely to encourage early action among interested entities, but there are major uncertainties and questions that have yet to be answered. Until U.S. EPA provides more guidance on this proposed program, Indiana cannot offer comment on specific aspects of the proposed CEIP. Aspects of the proposed program, like borrowing ERCs from a future compliance period in order to award early action ERCs, need to be further clarified in order for states to fully understand how the CEIP program would work and how to best utilize the program within a state. Indiana believes greater direction and guidance is needed from U.S. EPA about how exactly a program like the CEIP would be carried out under both a rate- or a mass-based plan pathway, regardless of whether that pathway falls under a state plan, federal plan, or a state plan that implements one of the model trading rules.

2. Indiana strongly believes that one of the most important factors when considering the proposed federal plan and model trading rules is the reliability of the electric grid. In commenting on the proposed Clean Power Plan in 2014, Indiana supported the idea of a reliability safety valve that, in emergency situations, would allow sources with higher carbon intensity to operate, in order to provide reliable electricity to our nation’s power grid. By allowing for the creation of a bank of ERCs as a part of the Clean Energy Incentive Program (CEIP), states that opt in to the federal plan or adopt one of the model trading rules, as well as U.S. EPA, ensure that a safeguard is in place for the reliability of the nation’s electric grid. Indiana also supports the possibility of a set aside for reliability purposes in the event of an emergency situation because the market for allocations may not be as robust as needed at the time of an emergency.

3. Indiana does not support U.S. EPA’s proposal to adjust the stringency of state targets during compliance periods in order to account for the issuance of early action ERCs during 2020 and/or 2021 under a rate-based federal plan. Indiana believes that the subcategorized performance rates already have the potential to significantly burden Indiana’s utilities and by decreasing them further, the incentive to take part in the CEIP is lessened. Rather than awarding utilities or project providers for taking early action with zero-emitting carbon energy, increasing the stringency of the performance goals or state goals after the interim compliance period begins could do more harm than good. ERCs should be retired throughout the interim compliance period in an amount equivalent to

the number of early action ERCs awarded during CEIP implementation. By retiring ERCs in the interim compliance period, affected EGUs will not be hit with more stringent targets and will know exactly how many ERCs will be unavailable to them in future years.

4. With regard to the size of reserve of matching ERCs for low-income EE programs and RE projects under the proposed CEIP, Indiana believes the reserve for matching ERCs should be split in a way that does not limit the use of the reserve because the split is not able to be readjusted. Because the amount of RE or EE available in a state differs, the reserve of matching ERCs for that particular state should be dependent on the amount of either RE or EE available to projects or programs within that state. If, after the size of matching ERCs for a particular state is decided by U.S. EPA and it later realizes that the size of one particular reserve is too large or the other is too small, U.S. EPA should be able to adjust accordingly, in order to ensure that each state can fully maximize the amount of zero-emitting carbon being generated or MWhs being avoided under the CEIP. Indiana believes flexibility needs to be built in to the size of the reserve of matching ERCs in order to allow states or U.S. EPA to adjust as needed to meet the demand between RE projects or EE programs.

Miscellaneous

1. Indiana disagrees with the inclusion of three EGUs on U.S. EPA's list of affected units, found in U.S. EPA's Technical Support Document (TSD) *Federal Plan Affected EGUs*. The three units listed are Warrick ALCOA units 1-3, Whiting Clean Energy units CT1, CT2, and ST1, and Portside Energy units GT and ST. In the proposed Clean Power Plan, Warrick ALCOA units 1-3 were never included as affected EGUs. These units do not sell any electricity to the grid, nor are they large enough to meet U.S. EPA's definition of an affected unit in the final Clean Power Plan. Both Whiting Clean Energy and Portside Energy also do not meet the definition of an affected source. While the definition of 'affected unit' is different between CSAPR and the Clean Power Plan, Portside Energy (units GT and ST) is working on an applicability determination with CAMD and it appears that they will not be considered an EGU under CSAPR and were also not considered an EGU under the state's CAIR rules. Whiting Clean Energy has also looked at the definition of an affected EGU under the Clean Power Plan and, based on their analysis, has determined that their units are also not applicable. Whiting Clean Energy is looking at utilizing a CHP exemption for the units CT1, CT2, and ST1. Therefore, Indiana believes these units should not be included as affected units under either the Clean Power Plan or proposed federal plan.

2. In the proposed Clean Power Plan, U.S. EPA interpreted that a source could fall under both 111(b) and 111(d) regulations because existing sources that underwent a modification would no longer be allowed to exit the 111(d) program. However, that interpretation has changed under U.S. EPA's proposed federal plan and model trading rules. Now, U.S. EPA interprets the regulations in a way that forces sources that undergo a modification to exit the 111(d) regulation and become subject to 111(b) standards. While Indiana recognizes that under the proposed federal plan or model rule, this may not be an issue due to U.S. EPA's decision not to include a new source complement, yet

include a set-aside in order to address leakage concerns. This new interpretation proves to be problematic for states that choose to submit a mass-based plan with a new source complement. Given the fact that states that opt to submit a state plan may only have legal authority under section 111(d) to enforce a state plan, Indiana is unclear as to how to regulate sources under both 111(b) and 111(d) if a state chooses to adopt a mass-based plan that includes a new source complement. Some states opting to submit a state plan may only have the authority to adopt enforceable mechanisms (i.e. rules) that apply to existing sources. Anything more could be considered going above and beyond what is federally required, which may not be allowed under a state agency's authority. Indiana would like to see U.S. EPA reconcile how states will deal with this new interpretation of sources falling under either 111(b) or a 111(d) mass-based state plan with the new source complement.

Indiana Evaluation Framework

Date: September 25 2012

With up-dated measure life tables of February 2013

Prepared for:

The Indiana Demand Side Management Coordination Committee

Submitted by

The Indiana Statewide Core Program Evaluation Team:
TecMarket Works, The Cadmus Group, Opinion Dynamics Corporation, Integral Analytics, Building Metrics, and Energy Efficient Homes Midwest
with support from Vickie Benson and Maria Larson

TABLE OF CONTENTS

Introduction

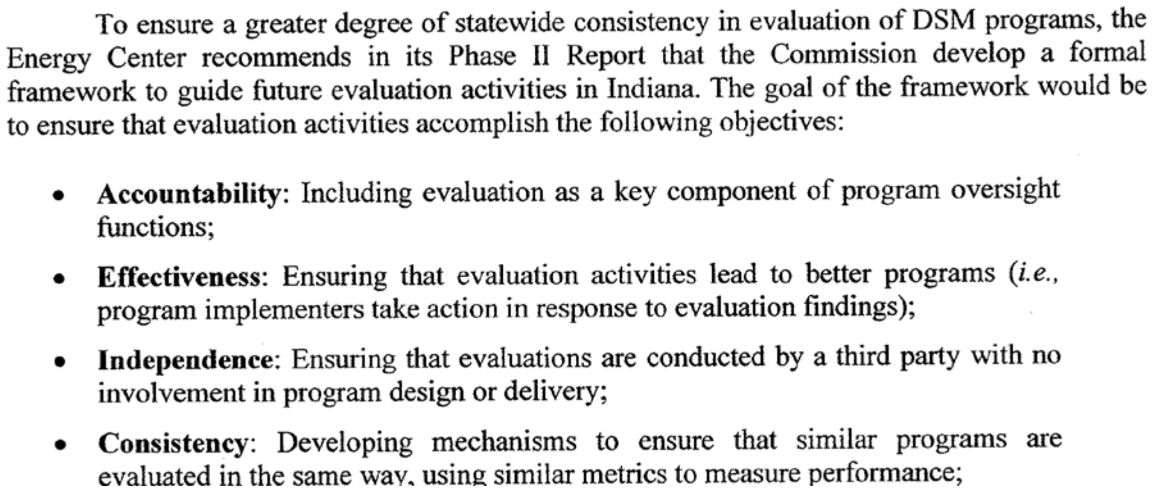
This document establishes the Indiana statewide Core programs Evaluation, Measurement, and Verification (EM&V) Framework (Framework).

The purpose of this EM&V Framework is to:
- Develop an overall approach to the evaluation of statewide energy efficiency programs in Indiana;
- Standardize evaluation approaches for the assessment of energy efficiency programs in Indiana;
- Provide specific guidance on the evaluation of energy efficiency programs.

The primary purpose of the Framework is to provide a consistent platform from which evaluations can designed and implemented so that evaluation results are both reliable and comparable across programs, administrators, and energy providers. In order to accomplish this purpose this Framework is segregated into two chapters. The first chapter is the Evaluation Policy chapter. The Evaluation Policy chapter provides information pertaining to evaluation-related policies that impact when, how and for what reasons evaluations are conducted. The second chapter is an Evaluation Protocol chapter. The Evaluation Protocol chapter provides information specific to how evaluations are to be conducted.

Evaluation Administrators conducting evaluations of the statewide Core programs are required to design and implement evaluations that reflect the policy needs presented in the Evaluation Policy chapter and implement evaluations that follow the requirements presented in the Evaluation Protocol chapter. The Demand-Side Management Coordination Committee (DSMCC) Evaluation Measurement and Verification Subcommittee (Subcommittee) is the party responsible for ensuring all evaluation plans and their subsequent implementation are developed and conducted in alignment with this Framework.

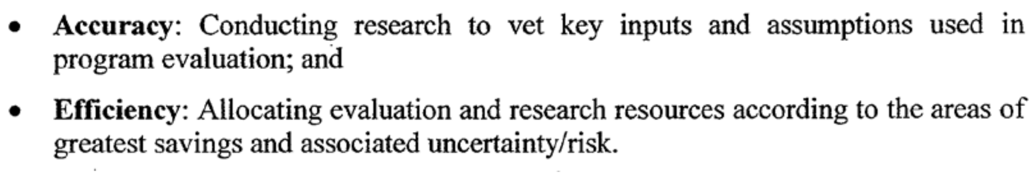
The purpose of this EM&V Framework as specified in the Indiana Utility Regulatory Commission (IURC) Order 42693[1] is:



> To ensure a greater degree of statewide consistency in evaluation of DSM programs, the Energy Center recommends in its Phase II Report that the Commission develop a formal framework to guide future evaluation activities in Indiana. The goal of the framework would be to ensure that evaluation activities accomplish the following objectives:
>
> - **Accountability**: Including evaluation as a key component of program oversight functions;
> - **Effectiveness**: Ensuring that evaluation activities lead to better programs (*i.e.*, program implementers take action in response to evaluation findings);
> - **Independence**: Ensuring that evaluations are conducted by a third party with no involvement in program design or delivery;
> - **Consistency**: Developing mechanisms to ensure that similar programs are evaluated in the same way, using similar metrics to measure performance;

---

[1] IURC Order 42693, page 44.



- **Accuracy**: Conducting research to vet key inputs and assumptions used in program evaluation; and
- **Efficiency**: Allocating evaluation and research resources according to the areas of greatest savings and associated uncertainty/risk.

Evaluation Objectives

The goal of evaluation in Indiana is to provide the DSMCC and other interested parties with information on the effects of the programs implemented and to provide evidence that can be used to help guide future programs and service offerings. This will require flexibility in the evaluation approach so that resources are effectively spent to acquire study results that are reliable, comparable across programs, actionable and which can be used to improve the cost effectiveness of the statewide energy efficiency service portfolio.

Evaluation and Analysis Approach

Evaluations covered under this Framework include program-specific evaluation efforts, including:

Impact evaluation – quantifying the verified gross and net energy savings delivered by programs.

Process evaluation –assessing the way in which the programs are designed and implemented, the way they interact within the market, the levels of and drivers for participant satisfaction with the operations and offerings, and other investigative areas.

Market effects evaluation –assessing the ways in which energy efficiency programs impact the operations of energy service markets such that additional savings above and beyond those achieved through direct program services to participants are documented.

While written specifically to guide the design and implementation of program-specific energy impact or process evaluation as well as market effects evaluations, this Framework can also provide valuable guidance to the way crosscutting studies are designed and implemented. These types of studies can include the following efforts:

- Statewide potential studies that assess market baselines and future savings that may be expected for different technologies and customer markets over a specified time horizon.
- Analysis of technology or service gaps that can be met by energy efficiency programs
- Analysis of barriers to energy efficiency implementation and development of approaches to overcome those barriers through redesigned programs
- Meta-analysis studies that look at the energy efficiency efforts as a whole and assess accomplishments and identify opportunities at the state level.
- Action Plans that specify energy saving objectives and methods of achieving those objectives.

All evaluation or evaluation related studies, including crosscutting studies and their associated costs must be approved by the Subcommittee.

Key EM&V Resource Documents

There are four key EM&V resource documents that will provide the technical basis for planning and conducting evaluation efforts in Indiana, these include:

1. **Indiana EM&V Framework** – This document provides the overall structure and guidelines for EM&V of Core programs in Indiana. The guidance in the EM&V Framework will have precedence over guidelines or direction provided in supporting documents including those listed below.
2. **Indiana Technical Reference Manual (TRM)** –This document provides the deemed savings estimation approaches and calculation algorithms that should be used in the planning process for program measures in Indiana.
3. **Program-Specific EM&V Plans** – The EM&V Plans developed for the evaluation of the Core programs or for market effects analysis must be consistent with the guidelines outlined in this Framework and must present the evaluation approach to be used to assess the program's efforts, and the approved budget for those efforts.
4. **Industry Standard Protocols** – When not specified in this Framework the Evaluation Administrators and their subcontractors (if any) should follow industry standard protocols for best evaluation practice allowed within the resources available as approved by the Subcommittee. Protocols such as the California Evaluation Protocols[2], the Impact Evaluation Framework for Technology Deployment Programs[3], and other similar publications provide additional perspectives and recommendations for conducting program evaluations. In addition, organizations such as the International Energy Program Evaluation Conference (www.IEPEC.org) publish proceedings containing papers, panels, and presentations on evaluation policy, methods, results and applications that are useful for evaluation professionals. However, while these other documents may be useful for evaluation professionals, this document (the Indiana Evaluation Framework) supersedes all other evaluation protocols, guidelines, policies and publications and is the official evaluation guidance document for evaluations of Indiana's statewide core programs.

---

[2] California Energy Efficiency Evaluation Protocols: Technical, Methodological and Reporting Requirements for Evaluation Professionals, TecMarket Works, April 2006.

[3] Impact Evaluation Framework for Technology Deployment Programs, USDOE, EERE, July 2007.

Evaluation-Related Policy

This section of the Framework provides key provisions of several evaluation-related policies that are overseen by the Indiana DSMCC EM&V Subcommittee. The evaluation policies presented in this Framework are not intended to be comprehensive of all evaluation policy decisions affiliated with the evaluation efforts for Indiana's statewide Core Programs. The contents of the Framework are to convey the key evaluation policy aspects for which the Subcommittee has indicated are to be included in the Framework and communicated to stakeholders associated with the evaluation efforts. It is assumed that as the evaluation efforts are implemented in Indiana these Framework decisions will need to be adjusted by the Subcommittee via the Framework updating process.

All evaluation administrators and contractors conducting evaluations of Indiana's statewide Core Program should be familiar with the evaluation-related policy decisions presented in this document.

Updating the Framework

The Framework is a living document that will be updated periodically, on as needed basis by the Evaluation, Measurement and Verification (EM&V) Administrator or others as directed by the Subcommittee.

When the DSMCC or the DSMCC EM&V Subcommittee identifies a need to update the Framework the Subcommittee will undertake that effort or make arrangements for the Evaluation Administrator or other appropriate parties to undertake that effort. Issues regarding the need for an update to the Framework can be brought to the attention of the Subcommittee by any member of the DSMCC or the Subcommittee or by the Evaluation Administrator, the Third Party Administrator (TPA) or other program implementation contractors. Issues pertaining to the need for an update may also be brought to the Subcommittee by other interested parties. However, an update effort can only be undertaken at the direction of a majority vote of the Subcommittee. A formal change proposal must be developed by or at the direction of the Subcommittee or one of the Subcommittee members.

Updates will be conducted in a manner that ensures coordination with the TPA, the DSMCC, the EM&V Subcommittee and the Evaluation Administrator conducting evaluations for the Subcommittee. A coordinated approach will ensure that updates address all issues identified over the course of the year and that appropriate advice and consultation is received prior to a vote to adopt any change to the Framework. The updating process can be initiated at any time, but must be conducted to allow adequate discussion by impacted members of the DSMCC, the DSMCC EM&V Subcommittee and evaluation contactors conducting evaluations of the Core programs.

Updates to the Framework apply following a majority vote of the Subcommittee to accept a recommended change. If a change needs to start at a specific date or following a specific event, the Subcommittee may also vote to specify a start date for a change or identify an event trigger for a change to take effect. The proposal to update the Framework must include a proposal for how and when the change will take effect. The program cycle is defined by the Commission as the period of time over-which a set of program activities are approved and funded for implementation.

When an update to the Framework has taken place, a draft of the updated version will be submitted to the Subcommittee. The Subcommittee will be given ample time to review the draft. Following no less than a 2 week review process the Subcommittee will then vote to accept or reject the proposal. If the proposal passes by a majority vote of the Subcommittee members the revised Framework is accepted. Once accepted the Subcommittee will make arrangements for the updated Framework to be distributed to all DSMCC members and to impacted members of the DSMCC, the DSMCC EM&V Subcommittee and selected evaluation contactors conducting evaluations of the Core programs, and file any updates with the IURC if required.

All updates and changes to the Framework must be consistent with existing processes and procedures associated with the operations of the DSMCC. See Appendix D for change tracking documentation to be included in each update.

Documenting Framework Changes

Each version of the Framework, following acceptance of the first version, will include a "*Changes and Updates to the Framework*" Appendix. The appendix will list all changes made to the Framework, the date of the change acceptance by a majority vote of the Subcommittee, the change that was made and the reason for that change.

Updating the Indiana Technical Reference Manual

The Indiana Technical Reference Manual (TRM) serves as the primary source for establishing measure specific deemed energy savings values and the associated calculation approaches. The TRM is a program planning tool. It provides the approach for calculating estimated energy savings for future program initiatives.

Updating Process

Updates to the Indiana TRM will be initiated when Indiana impact evaluations have established sufficient evidence to suggest that a change to a specific TRM calculation is needed or when there is enough evidence within the energy efficiency program evaluation field to suggest that a change to the Indiana TRM is needed. As such, it is not recommended that a change be initiated unless the Evaluation Administrator and the Subcommittee have collectively decided that a change is necessary and the evidence is real (i.e., initiate an update only when a savings pattern or technology use condition is consistent).

Following the instructions of the Subcommittee, at the end of each program cycle (when reliability of the evaluation results are highest) the contactors should launch a comparative assessment of the estimated TRM estimated gross ex ante[4] impacts associated with the installed measures and the ex post evaluated energy impact results for those measures (when applicable) and assess if the savings levels are statistically different. If the savings are found to be statistically different, and the cause of that difference can be reasonably identified as being associated with typical installation and use conditions or a change in typical baseline conditions, the evaluation contactor should develop a new estimation approach and provide a change recommendation to the Subcommittee. A majority vote by the Subcommittee is required to accept the recommendation. Once accepted, that recommendation is forwarded to the DSMCC for adoption. The DSMCC can elect to accept or reject that recommendation. If the recommendation is accepted, the TRM is to be updated for each change approved by the DSMCC.

All updates and changes to the TRM must be consistent with existing processes and procedures associated with the operations of the DSMCC. See Appendix D for change tracking documentation to be included in each update.

Adding New Measures to the TRM

The energy impact Evaluation Administrator can recommend to the Subcommittee the addition of new measures to the TRM. Likewise the Subcommittee can instruct the Evaluation Administrator to include a new measure to the TRM if in the opinion of a majority vote of the Subcommittee a measure should be added. New measures can be added to the TRM at any time, subject to the Indiana TRM process set forth within the Indiana TRM.

---

[4] Gross ex ante: the projected expected gross savings for a program as estimated during the program planning and approval phase.

Guidance on Evaluation Budgeting and Budget Management

Targeting the Evaluation Budget at approximately 5% of the Portfolio Budget

The evaluation cost in Indiana should be set at a level not to exceed approximately 5% of the portfolio budget without approval by the Subcommittee for any given cycle. However, for any given program year within a cycle, evaluation budgets are more flexible (i.e., within reason these budgets may deviate from 5% of program projected costs as approved by the Subcommittee).

Regardless of the types of evaluation, the study budgets must be focused on achieving the most reliable results for the most important energy efficiency and demand response efforts. Careful allocation of evaluation resources must be achieved to provide the greatest value for the evaluation dollar. To help assure cost effective evaluation, the Subcommittee must approve all evaluation budgets proposed by the evaluation administrator.

Managing the Evaluation Budget to Increase Reliability and Reduce Error Risk

The evaluation budget must be managed to provide the most reliable evaluation results with the lowest probability of error. The Evaluation Administrator and members of the evaluation team and the Subcommittee will consider the following when developing and approving program-level EM&V approaches and budgets:

- The importance of the program’s energy saving contribution to the portfolio. Programs that are expected to provide significant savings should be evaluated using more rigorous approaches than initiatives with lower savings expectations.
- Programs that spend larger portions of the portfolio budget should have a level of evaluation rigor that matches the importance of the program’s total financial investment. Thus, larger or more complex programs may have evaluation budgets greater than 5%. However; this increased funding should be off-set by those programs that have evaluation budgets which are lower than 5%.
- Measures with higher level of uncertainty are likely to require higher allocation of budgets. Concentrating effort on measures of high uncertainty will reduce the overall portfolio risk.
- Sampling approaches, sample-size targets, and confidence limits should provide the highest level of accuracy achievable for the available budget. Large programs and programs that are important for reaching energy saving targets should have sampling approaches that reflect that importance. Low impact or smaller programs may have lower precision and confidence levels. However, the precision of the evaluation effort at the program level should be set at 90% confidence and 10% precision levels for a program-cycle[5] unless approved for different levels by the Subcommittee. The Evaluation Administrator is responsible for assessing the portfolio and recommending sampling methods and sizes that maximize accuracy and reliability and stay within the evaluation budget limits.

---

[5] Program cycle: the period of time over which a set of programs are approved for implementation and are subject to a 90/10 level independent evaluation assessment. This period is determined by the DSMCC and is based on a regulatory decision specifying that timeframe.

Monitoring the Evaluation Expenditures to Assure Reliable Results

During any given program cycle the expenditures must be monitored to make sure that evaluation resources are spent in a way that best reflects the need for reliable timely evaluation results. The Evaluation Administrator must monitor the individual program’s progress and the expected level of gross savings and adjust the evaluation approaches as needed to best provide both reliable program-level and portfolio-level evaluation results. Program evaluation needs can change as program participation changes. The Evaluation Administrator and the evaluation team will work with the Subcommittee to adjust and refocus the evaluation efforts as needed. When changes to the evaluation approaches or the funding levels are identified, the Evaluation Administrator will provide recommendations for changes to the Subcommittee for review and approval.

Evaluation Management, Coordination, Communication & Progress Tracking

Progress reporting

It is important that the Subcommittee maintain an excellent understanding of the progress and focus of the evaluation activities as they progress. To accomplish this objective the Evaluation Administrator will provide monthly progress report detailing the status and progress of each program evaluation and crosscutting evaluation effort. The report will be e-mailed to the Chairperson of the Subcommittee and copied to all Subcommittee members. The Evaluation Administrator will also present the contents to the Subcommittee during one of its monthly meetings to be specified by the Subcommittee Chairperson. The presentation of the progress report will typically be delivered via electronic means to help control travel costs.

During the presentation of the progress report the Evaluation Administrator will address any issues or questions raised by the Subcommittee member or provide follow-up communications with the Subcommittee as required to address issues or questions raised by Subcommittee members.

Following the progress report presentation the Subcommittee Chairperson will provide the Evaluation Administrator with any comments regarding the progress report. Within two days of receipt of those comments, the Evaluation Administrator will provide a final progress report to the Subcommittee for transmission to the IURC.

Coordination with the DSMCC EM&V Subcommittee

The Evaluation Administrator reports to the DSMCC EM&V Subcommittee and is expected to maintain communications on an on-going basis. In addition, there will be situations in which Subcommittee members will need to contact the Evaluation Administrator in the conducting of the evaluation efforts. The evaluation contactor will maintain communications with the Subcommittee to assure that evaluation issues are handled in an efficient and cost effective manner. It is expected that these communications will be as needed and cover a wide range of evaluation issues.

In addition to the presentation of the monthly progress report, the Evaluation Administrator is expected to periodically attend Subcommittee meetings and provide presentations or issue-focused discussions as required by the Subcommittee.

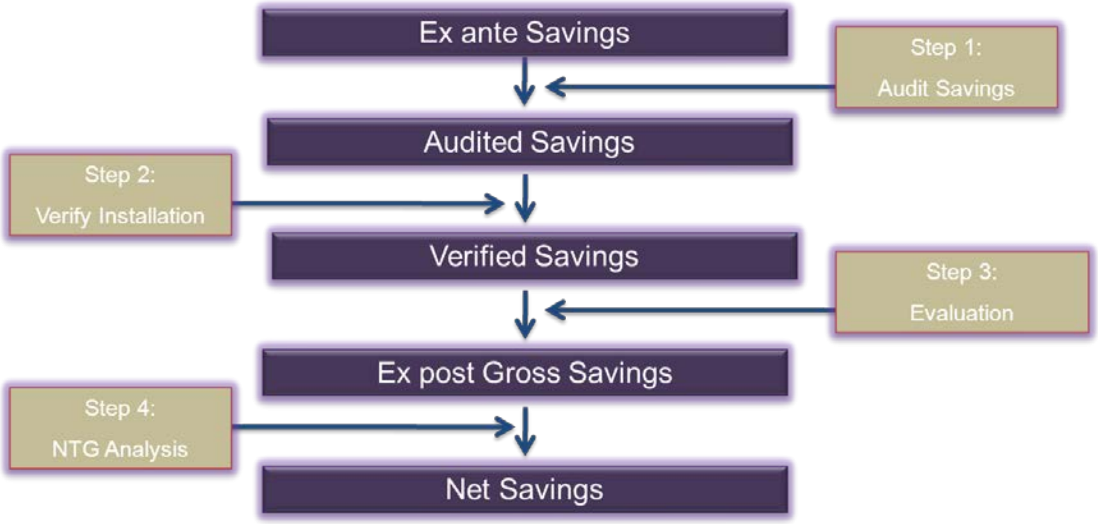
Progress tracking

The Evaluation Administrator is responsible for tracking the progress of the evaluation efforts and for maintaining oversight of the evaluation activities of the staff and subcontractors working under the direction of the Evaluation Administrator. The Evaluation Administrator is responsible for the quality and reliability of the evaluation efforts and is the primary director of the evaluation efforts and is responsible for assuring that studies are implemented in a way that is consistent with the evaluation plans and the available resources.

Policy on Gross and Net Savings and Application of Results

This section describes the typical steps taken in conducting impact evaluations of DSM programs. It also provides definition of different types of energy savings and proposes their appropriate use.

Figure 1 DSM Impact Evaluation Steps



Step 1: Auditing Savings

Validation of the Third Party Administrator will be performed by the evaluation team. The methodology involves the following steps:

1. Reviewing the program tracking databases.
2. Checking saving estimates and calculations against the best available information, (i.e. the Ohio[6] TRM and/or the adopted Indiana TRM.
3. Reviewing hardcopy program applications from a sample to verify consistency with data recorded in program tracking databases.
4. Adjust program tracking data as necessary to correct any errors, omissions identified in above.
5. Recalculate program savings based on the adjusted program tracking data.

Where custom measures are installed and not part of the TRM, engineering assumptions may be reviewed for a statistically representative sample of projects.
This step results in **Audited Deemed** savings.

---

[6] Ohio Draft Technical Reference Manual of August 6, 2010

Step 2: Verifying Installations

Step 2 confirms measures have been installed and are operating. This step uses a random sample of installations selected for detailed analysis. Typical methods for collecting necessary data include the following:

1) Telephone Surveys
2) Site Visits

This step may be adjusted to address issues such as:

- Measures rebated but never installed;
- Measures not meeting program qualifications;
- Measures installed but later removed; or
- Measures improperly installed.

Findings from this step produce **Verified Savings.**
Note: adjustments shown here impact the number of measures reported but do not adjust the TRM saving value.

Step 3: Performing Evaluation

At this stage, engineering analysis, building simulation modeling, billing analysis, metering analysis or other accepted statistical methods are used to determine ex post gross savings. Adjustments may include: changes to the baseline assumption; adjustments for weather; adjustments to occupancy levels; adjustments to decreased or increased production levels; and so on. This step does not need to occur annually for every program.

In all cases, the evaluator may use secondary or primary data to perform this step. Secondary data refer to using results from another, similar program, then making minor adjustments for local conditions and installation rates. An example might be using compact fluorescent lamps (CFL) installation rates from a similar utility to adjust the number of bulbs actually installed and saving energy. A significant body of knowledge, derived from evaluation of DSM programs over the last three decades, is readily accessible. Secondary data should always be explored as a cost-effective method for adjusting gross savings. Primary data involve collecting information the evaluation requires through surveying program participants, conducting site visits, or metering existing and installed equipment.

Note: findings reflected from this effort impact the ex post savings reported and serve as inputs for potential TRM adjustments over time from repetitive ex post studies, but do not adjust the TRM saving value directly (see updating the TRM section of this document).

Step 4: Applying NTG

"Net savings" refers to savings directly attributable to a program and represent the savings that are directly attributable to the program's efforts. Net savings are determined by adjusting the evaluated gross savings estimates to account for a variety of circumstances, including savings weighted[7] freerider[8] effects, spillover[9] effects and market[10] effects. Because market effects

---

[7] Freerider, spillover and market effects adjustments to the NTG ratio are to be weighted to reflect the level of savings associated with those effects compared to the level of savings that are achieved directly from the installed measures. Savings are weighted so that the adjustments to the net savings are based on the level of savings associated with the actions taken, thus small savings actions result in small adjustments where large savings actions result in larger adjustments, depending on the level of occurrence.

baseline evaluations are conducted once during a program cycle (instead of annually) or as determined by the Subcommittee, there are two types of net savings definitions in Indiana. The first definition applies to the savings reported in the *annual* evaluation reports due on April 1 of each year. This metric is call *Participant Net Savings* because it only includes the net savings associated with participants (includes freerider and participant spillover adjustments). The other net savings is called the *Total Net Savings* because it incorporates adjustments for freeridership, participant spillover and market effects[11].

The following equations are used to calculate the program's NTG ratio for the two types of net savings estimates:

Participant Net Savings

Annual Net-to-Gross Ratio = (1- freerider adjustment + participant spillover adjustment)

Total Net Savings

Net-to-Gross Ratio = (1- freerider adjustment + participant spillover adjustment + market effects adjustment)

For this Framework, three purposes of net savings are identified.

1. To understand the level of net savings achieved by the program and the portfolio to help determine which program to offer in the future.
2. For use in utility-specific calculations of lost revenues associated with the energy efficiency programs.
3. As a critical evaluation metric to be used for improving program design and implementation. Combined with process evaluations which assess program administration and operations and uncover processes that are ineffective or not well-conceived, the net savings metric assists program implementation toward performance improvements.

---

[8] Freeriders are those who would have taken exactly the same action (or made the same behavior change), installing a measure (or changing a behavior) at exactly the same energy efficiency result, at the same time as they took the program-incented action. Partial freeriders are those who would have taken exactly the same action, but the program expedited that change, or they would have taken a similar actions, but not at the same level of efficiency as the program-incented action, or they would have taken the same behavior change but at a later time than the program-encouraged behavior change.

[9] Savings produced as a result of the program's influence on the way participants use energy through technology purchase and use changes or through behavior changes induced or significantly influenced by the program or the portfolio.

[10] Savings produced as a result of the program's or portfolio's influence on the operations of the energy technology markets or changes to energy-related behaviors by customers.

[11] The process and timing of incorporating market effects savings into goal setting and accomplishment tracking will be determined in the future, but is not an established process at this time.

Determining the final market effects influenced total net-to-gross (NTG) ratio is not required every year (market effects are difficult to measure annually because of how rapidly markets change), but, at a minimum, it should be evaluated every three or four years or once a cycle.[12]

Uses of Various Saving Estimates

As the process above shows, different saving estimates will be produced at the various points in the EM&V process. These estimates serve different purposes as displayed in the table below:

Savings Estimate	Purpose
Ex ante (savings as projected by the TPA)	Goal setting
Audited Savings (checks for accuracy in tracking system)	Intermediate step only
Verified Savings (adjusts for confirmed installations)	Assessment of goal attainment
Net Savings (ex post evaluated program-induced savings)	Program design improvements Planning future programs Cost effectiveness analysis Calculations of lost revenues

Table 1 Uses of Various Saving Estimates

---

[12] The process for reconciliation of the added savings achieved via market effects (changes to the way the energy technology markets work) caused by the program are not finalized at this time. Once this process has been established by the DSMCC, this document will be updated to include that effort.

Benefit Cost Tests and Input Metrics To Tests

Overview of Benefit-Cost Assessment for DSM Programs

A variety of frameworks have historically been used to assess cost-effectiveness of energy efficiency initiatives.[13] In the late 1970s, the California Public Utility Commission (CPUC) implemented a least-cost planning strategy in which demand-side reductions in energy use were compared to supply additions. One result of this strategy was the Standard Practice Manual (SPM) that is now used in many other states for informing the benefit cost approach and for use as a starting platform from which non-California state-specific changes to the SPM approach are established.

The SPM established several tests that can be used to evaluate the cost-effectiveness of publicly funded energy efficiency initiatives. Most regulated energy efficiency programs use one or more versions of these tests, sometimes with variations unique to the requirements of a particular regulatory commission. The benefit cost assessment ~~covered~~ employed by this Framework uses the costs to implement the programs by the Third Party Administrator and the benefits resulting from those costs. [14]

The Total Resource Cost (TRC) Test

This section addresses the total resource cost (TRC) test exclusively because this is the test currently established in Indiana for use with the statewide Core program evaluation. Further, the TRC test to be used for the Core programs is understood to be the “simple” TRC test. Some variations on the simple test are noted in the following subsections, but with the proviso that these variations are included for informational purposes and should not be construed as applying to benefit-cost (B/C) tests for the Indiana statewide Core programs. This test reflects the ratepayer’s (both participants and nonparticipants) perspective.

The TRC test measures the costs of a program as a resource option based on the total costs of the program, including both the participants’ incremental costs and the ~~utility’s~~ TPA’s program implementation costs (including the TPA’s, administrative, marketing and operational costs[15]). The TRC B/C ratio is computed based on the present value of the program benefits (primarily avoided cost of generation) as well as the TPA’s total program implementation and operation cost~~s (measure total cost to the utility and utility program administration and operational costs)~~. Because the Indiana Core Programs are implemented by a third party administrator, the benefit cost assessment is based on the costs for that administrator to implement the program.

---

[13] This discussion draws upon the National Action Plan for Energy Efficiency, (2007). *Model Energy Efficiency Program Impact Evaluation Guide.* Prepared by Steven R. Schiller, Schiller Consulting, Inc. (www.epa.gov/eeactionplan). Staff of TecMarket Works and Cadmus (Nick Hall, M. Sami Khawaja, and David Sumi) served on the Technical Group for preparation of this Guide, and are currently assisting with an update to the publication.

[14] The administrative or other costs for the utility’s oversight, management and tracking functions are not included in the benefit cost tests to be reported in the EM&V reports.

[15] Excludes participant incentives

The ratio is usually calculated on a life-cycle basis considering savings and costs that accrue over the lifetime of installed energy efficiency equipment, systems. When the ratio is 1.00 or greater, the program is considered cost-effective, with appropriate consideration of uncertainties in the TRC ratio calculation. This is the most commonly applied test.

For current application of the TRC in Indiana, the portfolio must be cost effective. However, individual measures within a program and a program do not need to be cost effective on their own, as long as the portfolio of approved programs is cost effective.

$$TRC\ Test = \frac{Avoided\ Costs^{*}}{\cancel{Utility}Program\ Costs + Participant's\ incremental\ Costs[16]\ Net\ of\ Incentives}$$

Other Benefit-Cost Tests

There are other benefit cost tests that provide benefit cost ratios from different perspectives. Brief summaries of these tests are provided below.

- **Utility cost (UC) test.** The UC test measures the net costs of a program as a resource option based on the costs incurred by the administrator of the program. The benefits are the same as in the TRC test (energy and demand savings value), but the costs are defined more narrowly and do not include consumer costs.

  $$Utility\ Test = \frac{Avoided\ Costs^{*}}{\cancel{Utility}TPA\ program\ Costs}$$

- **Participant test.** The participant test assesses cost effectiveness from the participating consumer's perspective by calculating the quantifiable benefits and costs to the consumer of participating in a program. Since many consumers do not base their decision to participate entirely on quantifiable variables, this test is not necessarily a complete measure of all the benefits and costs a participant perceives.

  $$Participant\ Test = \frac{Lost\ Revenue + Incentives}{Participant\ Costs}$$

- **Societal test.** The societal test, a modified version of the TRC, adopts a societal rather than a utility service area perspective. The primary difference between the societal and TRC tests is that, to calculate life cycle costs and benefits, the societal test accounts for externalities (e.g., environmental and other non-energy benefits), excludes tax credit benefits, and uses a societal discount rate.

---

[16] *Note: Participant incremental cost net of incentives is the cost associated with what the participants spent on the energy efficiency project that they would not have spent without the program less the incentives provided by the program. The TRC is to include the participant's cost that are program-induced and not include costs that the participant would have incurred without the program.

$$Societal\ Test = \frac{Avoided\ Costs^{*} + Environmental + Other}{\cancel{Utility}TPA\ Program\ Costs + Participant\ Costs\ Net\ of\ Incentives}$$

- **Ratepayer impact measure (RIM) test.** The RIM test only applies to ~~utility~~ programs implemented by or on behalf of utilities. It measures what happens to consumer bills or rates due to changes in utility revenues and operating costs caused by the program. This test indicates the direction and magnitude of the expected impact on rates.

$$RIM\ Test = \frac{Avoided\ Costs^{*}}{\cancel{Utility}TPA\ Program\ Costs + Lost\ Revenue}$$

TRC Test Inputs

The inputs required for the benefit-cost analysis of the Indiana TRC, and the suggested possible sources, are summarized in the following table.

Inputs – Basic TRC	**Possible Sources**	**Notes**
Net energy savings (direct and market effects)	Evaluation findings	
Measure life	Evaluation findings, Evaluation Framework, and/or utility-specific	Secondary sources
Discount rate	Utility-specific	
Avoided energy costs	Utility-specific	
Program operations costs	Third Party Administrator (TPA)	Work with TPA to assure appropriate accounting categories
Customer incremental costs, net of what they would have spent without the program (typically this is cost above and beyond that of the non-program induced change)	Third Party Administrator	Must be consistent across a program cycle
Load shapes	Application of shapes from Evaluation and secondary sources, by measure/sector	
Inputs – Expanded TRC	**Possible Sources**	**Notes**
Value of avoided carbon emissions (Not included in Indiana benefit cost tests)	Typically a policy-based cost or based on a traded value	Not to be included in the current Indiana TRC test
Avoided emissions and prices (NO_x, SO_x) (Not included in	Evaluation modeling of generation emissions	

Indiana benefit cost tests)		

Table 2 Benefit-Cost Analysis Inputs and Sources

The Indiana Core program portfolio is required to be cost effective based on the TRC test. That is, the implementer's cost to acquire energy efficiency resources ~~by the implementer~~ needs to be equal to or less than the cost to acquire resources from new power supplies. However, individual programs are not required to be cost effective as long as the fit within a portfolio that is cost effective. This policy allows the development and testing of pilot programs or the launching of new programs or programs that have higher start-up or operational costs, but which are expected to be cost effective once lower cost operations are achieved. It also allows the offering of programs that may not be cost effective but help provide a balanced set of energy efficiency services across all customer segments.

Contents of Evaluation Reports

Reporting Requirements for Impact, Process, and Market Effects Evaluations

All evaluated gross and net direct energy savings will be reported annually and for the program cycle as a whole, by program, by year, by utility. Savings will be reported in three ways, including 1.) ex ante gross, 2.) ex post gross, and 3.) ex post net savings. The reported results will include:

- Electric energy savings kilowatt hours (kWh).
- Electric demand savings (kW).
- Coincident Peak kilowatts (kW).
- Natural gas savings (therms) associated with Core program measures installed by the statewide TPA.
- And where specifically contracted, therm savings associated with gas measures installed via the Core programs (if any).

Associated with the direct energy savings is the reporting of the following metrics:

- Number of participants and location by participating utility as obtained from the Third Party Administrator database tracking system
- Estimated freerider and free driver percentages (used to calculate net savings)
- Hourly customer usage patterns (obtained for selected programs for which customer on-site metering is conducted)

Reporting of process evaluation results. Although the process evaluation efforts will be somewhat different for each program, to a certain extent these studies will follow a similar theme and approach associated with reporting the results of the approved evaluation’s scope of effort. That is, the reporting of process evaluation results will depend on the researchable issues on which each evaluation will focus. For this reason we are not identifying the topics on which the evaluation effort will report, however each evaluation report will report the methodological approached used in the process evaluation, the researchable issues on which the evaluation focused, and the findings and recommendations associated with each issue. Findings and recommendations will be numbered so that they can be tracked and referenced and structured to guide program improvement effort. That is, evaluation recommendations should be detailed enough to be well understood and actionable by the TPA.

Reporting of results will focus on assessment of the following:

- Establishment of the Key Performance Indicators.
- Verification of robust program tracking databases.
- Assessment of participation processes.
- Assessment of market actor interactions/processes.
- Analysis of program design.
- Verification of program processes.

Reporting of market effects results. An initial market study will lead to the development of two reports: one on the residential market, and a second for the commercial market. The reports will be cross-cutting by describing the market baseline for multiple end-uses as well as overall market characteristics such as attitudes and barriers towards energy efficiency. Future market effects studies will report changes in the operations of the market and changes to key market change parameters that are caused by the program, and the energy savings associated with those market changes that are program-induced. Energy savings will be reported for the program cycle across the portfolio in the same formats that are required for ex post savings reports. These include:

- Electric energy savings kilowatt hours (kWh).
- Electric demand savings (kW).
- Coincident Peak kilowatts (kW).
- Natural gas savings (therms) associated with Core program electric measures installed by the statewide TPA.
- And where specifically contracted, therm savings associated with gas measures installed via the Core programs (if any).

Annual Reporting for Impact and Process Evaluation

The evaluation team must provide annual reports on process and impact evaluation with an end of cycle report that includes the last year and the accumulation of savings across the program cycle. The process activities to assess and inform program administration and delivery will be provided directly after the process evaluations are completed, rather than waiting for the April 1st required energy impact reporting date. This will allow faster process reporting feedback and help expedite program improvements. The focus of this process reporting will be identifying what is working well and also opportunities for improvements.

Impact reports should provide incremental and cumulative information for the annual status of EM&V activities, including the Core program's contributions to the annual savings goals and feedback for future Core program design. The reporting should provide impact evaluation results for each participating utility, by program and program year. Cost effectiveness calculations should also be reported as soon as the impact evaluations are finalized.

In addition to the reports provided to the Subcommittee, the evaluation team must also prepare for submission to the Subcommittee an annual Summary Report[17] intended for the general public. This report will provide summary information for the Core programs in a format suitable for non-technical readers.

Consistency Across Reporting Years

In order for reporting to be useful for the intended audiences across program years and cycles, and to support energy efficiency planning at the state level to guide policy and planning, it is essential that the evaluation research be reported in a comparable manner. This means that reports must be consistently structured so that reviewing and commenting on evaluation reports does not require substantial investments of time for stakeholders. Further, key messages should

---

[17] Per the Phase II Order 42693.

be communicated succinctly and executive summaries should be concise. The body of evaluation reports must be consistently organized across reports and years, and technical details supporting the work are preferably contained in appendices only.

Reporting Topics Specific to the First Program Cycle

Indiana Technical Reference Manual (TRM) Early reporting (2012) will document efforts to develop an Indiana-specific Technical Resources Manual (TRM), based on algorithms and data sources used in the Ohio TRM and other sources. The Indiana TRM will form the basis of the ex ante savings estimates used in the Core program evaluations after it is formally accepted by the Subcommittee and has been adopted by the DSMCC for use prospectively.

Market Effects Baseline As described above, findings from the market effects evaluation will focus on efforts to document market baselines for program measures for the purpose of estimating energy savings from program induced changes in energy equipment market operations.

Early Evaluation Results and Feedback

The Need for Early Reporting

There is a need for early feedback approaches for both impact and process evaluation so that the Third Party Administrator can, in consultation with the DSMCC, make prompt in-cycle changes to maximize energy impacts and customer satisfaction. This will also facilitate energy impacts goal attainment. Reporting will therefore include early results and/or feedback wherever possible. All early feedback reports, memorandums or other forms of feedback will be communicated to the Subcommittee and the TPA at the same time so that the Subcommittee can work with the TPA to resolve or take action on the finding as appropriate.

The overall objectives for Energizing Indiana include *demonstrating the feasibility* of initiating effective programs, and *meeting established energy savings goals* for Core programs[18]. Thus, the evaluation objectives require a team to develop credible data sources and measurement criteria for evaluating both quantitative energy savings and qualitative market change indicators for current and for future program design and evaluation needs.

The reporting function is critical to achieving this evaluation objective. In order for the Core program concepts to be effectively tested in the marketplace, it is imperative that the evaluation provide timely reporting of both quantitative and qualitative information. Two likely methods for early reporting are: (1) Interim reports ("as needed," to be determined by the EM&V contractor in consensus with the Subcommittee), and (2) roundtable discussions and/or oral presentations, providing periodic sharing of insights and suggested improvements to individual programs and the overall process of the statewide Energizing Indiana program.

Stakeholder Information Needs

The following table provides a list of suggested information needs for the key Energizing Indiana stakeholders, and also shows which evaluation activities will serve each of those needs. The needs are arranged across the top of the table, with evaluation activities down the left side. Where there is an "X" in the table, that activity provides content to the information need. The stakeholders who are associated with each information need are coded at the top of each column, as follows:[19]

CC = DSMCC (Demand Side Management Coordinating Committee
A = Third Party Administrator (TPA)
I = Implementer (TPA's as implementer or their subcontractors)
C = Commission (Indiana Utility Regulatory Commission)
OUCC = Office of Utility Consumer Counselor
P = Public
U = Utilities (Participating Utilities)

---

[18] Per the Phase II Order 42693.

[19] Stakeholder information needs indicated in the following table are provided for illustrative purposes and are not intended to be comprehensive. Actual information needs may be different than those indicated in the table.

Table 3. Matrix of Primary Information Needs and Evaluation Activities Serving those Needs

	Jobs	ROI	Constituent Impact (Incentives) Distribution	Public Perception	Energy Savings	Bill Impact	Rate Impact	Cost Effectiveness	Public Acceptance	Cost Allocation	Contract Goal Achievement	Market State (Iterative)	Customer Satisfaction	Customer Awareness	Program Impact	Utility Collaboration	Portfolio Impact	Territory Specific Savings	Program Collaboration	Value Perception
	C, CC, OUCC	*C, CC, OUCC*	*CC, OUCC, U*	*OUCC, U*	*C, CC, U*	*C, OUCC, U*	*C, OUCC*	*C, CC, OUCC*	*OUCC*	*CC, OUCC, U*	*A, I*	*A, I*	*A, I, OUCC, U*	*A, I, U*	*A, I*	*A, I OUCC U*	*A, CC, OUCC*	*U*	*U*	*P*
Tracking/database management			X		X													X		
Measurement of baseline estimation, calculation of baseline efficiencies			X		X						X							X		
Calculation of kWh savings, peak kW savings, therm savings, demand resource savings			X		X						X							X		
Annual evaluation reports		X	X		X						X				X		X	X		
Annual impact evaluation	X	X	X		X	X	X				X				X		X	X		
Load shape analysis							X													
Benefit-cost analysis		X						X		X										
Documentation of direct program effects	X	X	X			X	X								X		X	X		
Determination of economic impacts	X	X	X			X	X	X							X		X	X		
Determination of deemed savings/TRM					X															
Interviews and surveys with program staff at various levels, participants, non-participants, market			X	X		X			X				X	X		X		X	X	X

	Jobs	ROI	Constituent Impact (Incentives) Distribution	Public Perception	Energy Savings	Bill Impact	Rate Impact	Cost Effectiveness	Public Acceptance	Cost Allocation	Contract Goal Achievement	Market State (Iterative)	Customer Satisfaction	Customer Awareness	Program Impact	Utility Collaboration	Portfolio Impact	Territory Specific Savings	Program Collaboration	Value Perception
	C, CC, OUCC	***C, CC, OUCC***	***CC, OUCC, U***	***OUCC, U***	***C, CC, U***	***C, OUCC, U***	***C, OUCC***	***C, CC, OUCC***	***OUCC***	***CC, OUCC, U***	***A, I***	***A, I***	***A, I, OUCC, U***	***A, I, U***	***A, I***	***A, I OUCC U***	***A, CC, OUCC***	***U***	***U***	***P***
actors																				
Market Effects Baseline Research				X					X			X		x						
Review and analysis of deemed savings and cost values								X												
Review of program design										X	X					X			X	
Review of program operations documents for consistency with design and practicality											X									
Review of program participation levels relative to program costs		X						X												
Review of records on processing time and costs		X						X												
Development of a submission process to propose new protocols and modifications																X			X	
Analysis of policy implications	X																			

The Evaluation Planning and Reporting Cycle

Hiring the independent Evaluation Administrator

Consistent with the Phase II Order, (Order 42693) of December 9, 2009, the Subcommittee will hire an independent administrator to conduct evaluations and report results for the Core programs. Because program evaluations must be conducted on the evaluations that are specifically planned, designed and implemented under this order, the Evaluation Administrator must be hired in time to plan the evaluation efforts so that evaluation efforts are ready to be launched early in the program cycle. In addition, because there are measurements that need to occur before or very early in the program implementation cycle it is necessary to hire the Evaluation Administrator at the same time, or shortly after the hiring of the TPA. Both program design and evaluation planning efforts need to occur before the initial program cycle implementation date for each program cycle.

The evaluation planning cycle

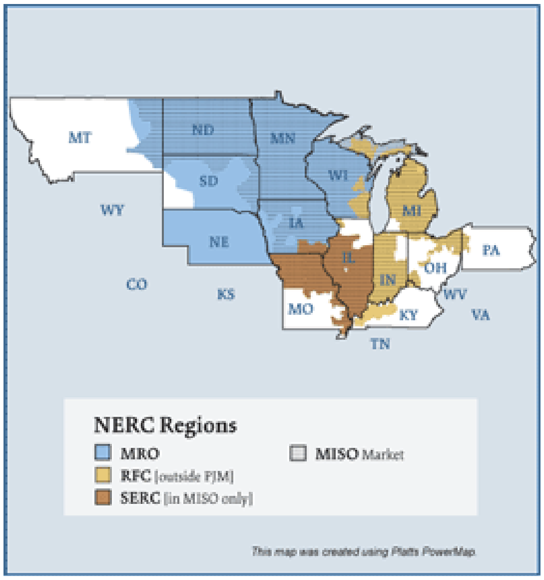
To have an effective evaluation approach evaluations must be carefully planned to cover a specific set of programmatic activities in order to provide the information needed for energy savings achievement reporting, efficiency policy decisions and to determine least cost energy supply strategies for Indiana. Evaluations need to be planned to match an approved program implementation cycle so that the evaluation findings match the decision periods for the offered programs. A two-year program cycle needs a two-year evaluation plan. A program cycle of four years needs a four-year evaluation plan. Evaluation planning needs to occur once each program cycle, with adjustments to the evaluation plans to match the changes made to the programs offered. Evaluation plans should be developed as soon as the programs plans are approved for implementation. Evaluation planning prior to program design approvals can result in inefficient use of evaluation resources as evaluation designs are developed for programs that may substantially change though the program design approval process. Evaluations that are planned after the programs are launched can miss the collection of critical pre-program baseline information and be launched too late to provide effective feedback needed to change program operations as evaluations identify need for programmatic change.

Evaluation plans should be developed and provided to the Subcommittee for review, ideally prior to the program launch and in time for the collection of pre-program baseline data.

The plans need to cover individual programs as well as any overarching or market focused evaluation initiatives. All program-specific plans should also have task-level timelines that indicate when the evaluation efforts will be conducted. All plans should have high-level budgets that reflect the program-specific evaluation costs and the costs associated with any crosscutting or market focused evaluation efforts. If needed, separate task level budgets can be requested by the Subcommittee to support the review of the evaluation plan, however detailed task level budgets will not be presented in the evaluation plans.

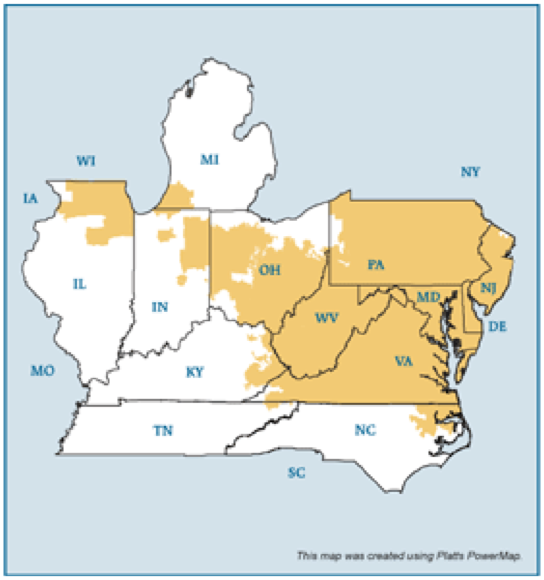
MISO & PJM Compliant Evaluations

Indiana electric power supply territories are located within the MISO and the PJM electric power markets as defined by the Federal Energy Regulatory Commission (FERC).



This map was created using Platts PowerMap.

MISO Electric Region



This map was created using Platts PowerMap.

PJM Electric Power Region

In selected cases program evaluation results may be provided to the regional power markets to support payment to the utilities for achieving reduced demand and energy within a market region. These power supply market operators (MISO/PJM) can provide incentives to energy efficiency providers that reduce the power supply needs associated their grid networks. In some cases the system operators have developed their own program or project evaluation requirements that must be followed in order for a utility to qualify for load reduction incentives. These studies are typically more rigorous than typical program-level evaluation in that they require a higher level of field verification, equipment monitoring and metering. If any of the Indiana Core program are considered to be system operator incentive qualified programs, and if utilities are contemplating submitting their energy savings to a system operator for incentives, those program evaluations conducted as part of the Core program evaluations will most likely need to be modified. In order to qualify for system reduction savings each utility must submit their system load reduction results separately to their system operator. The incremental added cost (if any) to comply with a system operator’s evaluation requirements will be paid directly to the Evaluation Administrator by that utility to avoid any negative impact on the evaluations of the Core programs across the other utilities.

In most cases system supply operators need programs that provide significant load reduction during peak hours, however they also need programs that provide energy savings when there are supply constraints during off peak periods. Because the Core programs are designed to be primarily energy savings programs it is anticipated that none of the Core programs will be submitted for system operator incentive payments and, therefore, system operator required adjustments to the evaluation plans will not be needed.

Annual Updates to the Evaluation Plans

While the primary evaluation plan will be completed once per program cycle, annual modifications are expected. Programs that do not undergo any delivery changes are unlikely to need evaluation plan modification. The Subcommittee will coordinate with the Evaluation Administrator to identify changes to the portfolio that might trigger an adjustment to the evaluation efforts. All changes to the evaluation plan must be approved by the Subcommittee.

Approving the Evaluation Plans

The Subcommittee will review proposed plans and if necessary request a presentation from the Evaluation Administrator. The Subcommittee can request any supporting or additional information to adequately review the evaluation plans. During that review process the Subcommittee may have the Evaluation Administrator change evaluation approaches, timelines or budgets to meet the evaluation needs for the Core programs.

Following the Subcommittee's review of the evaluation plan, a vote to accept the plans and approve them for implementation will be taken. If the plans are not approved, the Evaluation Administrator will alter them to meet the desired needs of the Subcommittee. However, it is critical to ensure independence of the Evaluation Administrator. The Subcommittee will not specify the evaluation approaches to be used in the study. The Evaluation Administrator shall design the evaluation efforts as independent evaluation contactors.

Timeline for Providing Evaluation Reports

Program evaluation reports shall be provided to the Subcommittee each year, following completion of the program year being evaluated. Crosscutting and market focused evaluation reports will be provided on a date to be specified by the Subcommittee, working in conjunction with the Evaluation Administrator to set that date. Typically, final program evaluation reports will be provided no later than 3 months following the end of the program year being evaluated (no later than April 1 for a typical program year and for the end of cycle periods as well). This means that draft evaluation reports must be delivered to the Subcommittee on or about March 1 of each year. This allows time for the program to close out its annual tracking systems and provide that information to the evaluation contactor, and also allows enough time for the evaluation contactor to conduct any remaining M&V and impact analysis on sites that are sampled late in the program year. It also allows a two-week period for the Subcommittee to review draft reports and provide comments to the Evaluation Administrator in time for preparation of the final report.

Benefit cost assessments require the inclusion of final energy impact results. Therefore the benefit cost assessments will be reported 30 days after the final energy impact reports are due. The benefit cost assessment will be provided in a benefit cost chapter added to the final energy impact and process report. The draft benefit cost report will be delivered May 1 of each year.

Final reports will be provided to the Subcommittee no later than 30 days following receipt of the Subcommittee's review comments on the draft reports.

Data Required to Support the Evaluation Effort

Information needed by the Evaluation Contactors

This section of the Framework discusses the types of information that the Evaluation Administrators will need to provide in support of the evaluation efforts. A detailed list of the type of information needed to conduct evaluations for different types of programs is provided in Appendix B. Each evaluation will need a somewhat different set of information from the TPA. There may be cases where the Evaluation Administrator may need to request additional information not listed in Appendix B. TPAs should establish their program tracking system to be able to rapidly provide the information requested by the evaluation contactor.

When requested information is to be provided to the Evaluation Contactor

One of the most common reasons that evaluations are not delivered on time is that the information needed to conduct the evaluation is not provided in a timely manner. For the purposes of conducting Indiana evaluations, The TPA is to provide the requested data within two weeks of receipt of the data request from the evaluation contactors. However this time period can be extended under special circumstances for up to two additional weeks. If the TPA cannot provide the requested data within two weeks, the TPA is to notify the DSMCC of the reason for the delay. If the TPA cannot provide the data, they are to inform the DSMCC of the reasons such data are not available. The type of data needed is outlined in the Appendix B to allow the administrators ample time to collect and maintain that data. The TPA will need to modify its operational procedures to collect the needed data and store them in a way that can be rapidly accessed and transferred to the Evaluation Administrator. It is the TPA’s responsibility to establish and maintain program-tracking systems that are capable of supporting the evaluation efforts and of meeting the data needs requirements of the evaluation efforts.

Request for program information

All requests for data must be submitted in writing to the TPA and the Subcommittee at the same time so that all members of the Subcommittee are aware of the data request. Evaluation contactors are to only request data that are required to conduct the evaluations. The Evaluation Administrator will limit all data requests to information critical to the success of the evaluation. Evaluation data requests will need to plan for sample erosion due to a wide variety of conditions.

The TPA is not to limit, filter or influence the content of the information provided to the evaluation contactor. All measure-specific information provided must be reported by the TPA using the standard measure descriptions used during the program planning and approval process, or as modified and approved by the DSMCC.

Safe keeping and security of information received

All requested data that are obtained from the TPA will be securely maintained by the Evaluation Administrator and will be destroyed not sooner than one year and no later than 24 months following delivery of the evaluation reports. When longer term data storage and maintenance is required, the evaluation contactor will request approval of the Subcommittee.

Data Security

Definition of Data Security

This section of the Framework deals with data security and provides guidance on how utility, TPA and evaluation data will be transferred, stored and safeguarded. The guidance provided below represents the minimum level of data security requirements. However, each utility and TPA may have its own set of data security requirements that may be more restrictive and will take precedence over the guidance provided in the Framework. It is up to the Evaluation Administrator to understand each of the data security requirements of the participating utility companies and the TPA and comply with these requirements or arrange for alternative compliance agreements.

The evaluation database, including all incorporated EM&V data as well as customer data obtained from the program implementer and utilities must be in a secure electronic repository. It will contain all primary and secondary data collected and assembled along with all of the processing code used to data edit and transformation, including the database of evaluation results that will be used to supply all necessary inputs to evaluation reporting. To ensure data security, methods should be specified for auditing and analyzing the data in addition to the methods employed for identifying, measuring, recording, and transmitting required data in a secure manner.

Encryption Key Sharing

At the beginning of the project, it is considered best practice for all participating vendors to exchange public keys with each other. It is best if this exchange is done in-person, during a kick-off meeting, so that all parties can physically identify each other, however, public keys can be sent to participants via email if necessary. These keys will be included by each participant responsible for sending encrypted files so that only authorized people can decrypt the files.

Data Transfer Setup

A secure File Transport Protocol (SFTP) server is recommended as the most secure and efficient protocol for transferring data between utilities and the evaluation team. The hosting facility must be highly secure both physically and at the networking level. The SFTP site can be set up and managed by the evaluation team on one of these servers running a recommended application such as Serv-U FTP server.

It is suggested that security groups be created for each utility along with a home folder, which can only be modified by its corresponding utility and designated administrators. A designated user from each utility, with contact information provided, can then be added to a corresponding security group, thus inheriting the proper permissions to upload/download specific files.

Data Handling

Once data are transferred from a utility or TPA to the EM&V contractor's facility, it is the responsibility of the EM&V contractor to ensure that those data are handled in a secure manner. Here are some guidelines that should be followed:

1. Separate files containing personally identifiable information (PII) from files that do not contain this information. This will help in setting up a clear process for handling each type of data.

2. Files containing PII should be stored on device that is:
    a. secured physically (locked away from unauthorized personnel)
    b. secured at the network level (only authorized members of the evaluation team)
3. Files containing PII should be stored encrypted, when not in use.
4. Access to encrypted files should be documented and go through an approval process, where the evaluation project manager must approve all requests for access.
5. An example procedure of handling customer data would be as follows:
    a. Encrypted customer data are uploaded to the SFTP site.
    b. Files are deemed to contain PII, and downloaded to a secure location at the contractor's facility by a data administrator.
    c. A user from the project team needing access to these files requests access from the project manager.
    d. Project manager grants access and notifies a data administrator to decrypt the files and leave copies available for the requesting user for a limited period of time.
    e. Once the user is finished with the unencrypted files, they are expunged from the server.

Evaluation Protocols

This section of the Framework provides guidance from the DSMCC EM&V Subcommittee to the Evaluation Administrator and other evaluation professionals responsible for conducting evaluations of Indiana's Core programs so that evaluation-related definitions, approaches, and savings estimates can be comparable and reliable regardless of the evaluation contractors conducting those studies or the utility sponsoring the joint statewide programs. Evaluation contactors are required to understand and follow the evaluation provisions presented in this framework and design and conduct evaluations consistent with the provisions of this chapter of the Framework.

Evaluation Standards, Ethics and Expertise

Evaluation Standards and Ethics

There are a number of evaluation standards and ethics that apply to the Indiana evaluation efforts. These standards and ethical considerations guide all evaluation activities covered under this Framework:

Independence

The evaluation efforts for Indiana's core programs are to be independent of the core program design, approval and service delivery responsibilities. Evaluation contactors can provide support to the core program design process by providing evaluation research information, market condition or operations information, program related data, or information needed to support the program design effort, but are not to be responsible for developing program core program plans or involved with the submission of those plans for review and approval by the DSMCC. Evaluation contactors are to maintain an arms-length relationship with the core program design, approval and delivery process within the State of Indiana.

Evaluation efforts are to avoid not only conflicts of interest but also the appearance of conflicts of interests. The evaluators should be independent professionals who do not benefit, or appear to benefit, from the study's findings. The evaluations are also to be independent of the TPA, such that the Evaluation Administrator independently develops their study approaches, independently implements those approaches, and independently reports the results from the associated analysis. While evaluation plans, budgets, timelines and activities are to be approved by the Subcommittee prior to their implementation, the evaluation efforts will be planned and conducted by independent evaluation professionals. The core program evaluation team must not have or appear to have any conflicting relationships with the core program development, approval or implementation process.

Transparency

Each evaluation should have a detailed study plan that identifies how the evaluation is to be conducted, specifying the individual tasks within the study to be completed. The study plan should also specify how data will be collected, describe processes to assure objectivity and accuracy, and identify the analysis approach to be applied for each of the four types of evaluation metrics (jobs created, carbon saved, energy demand reduction and energy saved).

The evaluation effort is to be transparent. The methodological description of the study should be sufficiently detailed to allow the research design to be assessed for appropriateness by outside reviewers as required by the Subcommittee. The study design should be specific enough to allow other evaluation professionals to understand the approaches used at a sufficient level of detail. The study approach should be transparent to the extent that others can replicate the study approach and obtain similar results. The study plan should also specify how data will be collected, describe processes to assure objectivity and accuracy, and identify the analysis approach to be applied for each of the evaluation objectives. Proprietary or "black-box" analysis approaches that are not fully specified and disclosed to the Subcommittee and the Evaluation Administrator are not to be used.

Threats to Validity

The Evaluation Administrator should assess the various threats to validity for the study design and analytical approach and develop a study plan that minimizes those threats and reduces the associated level of uncertainty. Both the evaluation plan and the study report should identify these threats and describe how the evaluation approach minimizes any impacts on the study findings.

Alternative Hypotheses

To the extent possible, the study design should be developed in a way that addresses alternative hypotheses regarding how observed effects may have occurred.

Best Practice Analysis

The study approach should, to the extent possible, use current best practice evaluation approaches that maximize the use of technical advancements and the most current analytical approaches consistent with the available evaluation budget and the study timeline requirements. Because the field of evaluation is constantly changing, it is not possible to define best practice approaches in a way that the definition can remain current. Likewise, the selection of best practice approaches is always limited by the available evaluation budget. It is up to the contractors conducting evaluations in Indiana to stay current within the field of energy program evaluation and recommend approaches that produce reliable results and which can be conducted within the available resources. Several guidance documents are available to help Evaluation Administrators select and apply best practice approaches. A sample of these guidance documents include:

- National Energy Action Plan Model Energy Efficiency Program Impact Evaluation Guide, Steven Schiller, USEPA November 2007
- International Performance Measurement and Verification Protocol, IPMVP Committee, March 2002
- National Energy Efficiency Evaluation measurement Verification Standard, Schiller, Goldman, Galawish, Lawrence Berkeley National Laboratory, April 2011
- Impact Evaluation Framework for Technology Deployment Programs, Reed, Jordan, E. Vine, USDOE, July 2007
- EERE Guide for Managing General Program Evaluation Studies, Barnes, Jordan, USDOE, 2006
- California Evaluation Framework, TecMarket Works Evaluation Team, TecMarket Works, June 2004
- California Evaluation Protocols, TecMarket Works Evaluation Team, TecMarket Works 2006

Likewise international energy program evaluation conferences (IEPEC.org) and energy efficiency industry conferences (AESP.org) present publish and discuss peer-reviewed research approaches that help evolve the field toward more reliable approaches.

Essentially, the use of best practice evaluation approaches means that the most reliable approaches that can be employed within the available evaluation budgets shall be used to estimate the energy impacts of the energy efficiency programs covered by this Framework.

Unbiased Assessment

The evaluation design, data collection efforts, analytical approach, and reporting of results should be objective and unbiased. Unsubstantiated claims or unsupported conclusions or personal points of view should be excluded from any evaluation reports or presentations. The study results should be based on objective data/information analysis. Study findings and recommendations should be supported with data and analysis approaches that objectively and impartially assess the available information.

Attribution of Effects

The study should focus on identifying the outcomes of the projects and programs in question and identify where possible the gross and net effects that can be attributed to the program's efforts.

Conflict of Interest

Evaluation Administrators must disclose any real or perceived conflicts of interest that they might have. These conflicts of interest or perceived conflicts of interest should be identified as a component in the contractor selection process and contractors bidding on the evaluation efforts should present any real or perceived conflicts of interest in their proposals. Likewise, as evaluations evolve and as conditions change within the market, unreported conflicts of interest or potential conflicts of interests should also be brought to the attention of the Subcommittee during the course of the evaluation effort as appropriate as they are identified.

A conflict of interest would be reflected in but not necessarily limited to one or more of the following conditions:

1. Any member of the evaluation team or members of their immediate family are a part owner or stockholder or employed by any of the utilities sponsoring programs that are being evaluated by those contactors.
2. Any member of the evaluation team or members of their immediate family is an employee of any of the utilities sponsoring programs being evaluated.
3. Any member of the evaluation team or members of their immediate family is employed by an organization who offers energy efficiency program implementation services within the United States.
4. Any member of the evaluation team or members of their immediate family is employed by a company or organization owned by or controlled by another organization or company who offers energy efficiency program implementation services.
5. Any member of the evaluation team or members of their immediate family would be in a position to financially benefit from the results of the evaluation findings.

Sampling

All studies that rely on sampling approaches for collecting data to drive the impact analysis objectives should, to the extent possible, use procedures that minimize bias and maximize the sample's representativeness of the targeted population. Pending the availability of sufficient evaluation budgets, sampling approaches should be structured to be no less rigorous than a 90% level of confidence per utility, per program cycle, with a precision limit of ±10% for the key attributes on which the sample is being selected.

IPMVP Field Metering and Verification (M&V)[20] Efforts

Field measurements, when required for assessing equipment baselines and post-retrofit or post installation operations should be conducted using one of the four primary data collection protocols specified in the IPMVP (International Performance Measurement and Verification Protocol). This protocol describes options A, B, C, & D for both single project end use and whole building actions. The IPMVP requires that key performance indicators that drive the estimates of program impacts should be collected via on-site metering, monitoring and verification efforts. The protocol requires measurements to be collected that represent key savings calculation indicators. M&V plans should be developed for each study requiring on-site M&V activities. M&V sampling should be established to be representative of the types of projects and equipment use conditions that represent the largest portion of energy savings. Not all evaluations will require M&V field efforts.

Survey and Interviews

When surveys and interviews are used to collect data from which impacts are calculated, the questions should be objective, unbiased and non-leading. Closed-ended, scaled, or quantitative response questions should be structured to allow a full range of applicable responses. Open-ended questions should be single subject response questions that allow for a complete response. Complex questions that require a preamble to set a stage for a response consideration should be avoided to help assure that the response is objective and not guided toward a specific outcome.

On-site Staff Identification

When on-site (in customer’s homes or business) or when in-field efforts (such as public-place data collection) are conducted in which members of the evaluation team come into contact with utility customers, members of the evaluation team will wear apparel approved by the Subcommittee that will identify them as Energize Indiana team members. Likewise each staff evaluation team member will display Subcommittee approved identification badges attached to their shirts. Vehicles used to conduct on-site visits will display the Energize Indiana logo prominently on the vehicle so that the vehicle can be identified as a program-related vehicle.

American Evaluation Association: Guiding Principles for Evaluators

The American Evaluation Association (AEA), the professional association for evaluators, works to ensure ethical work in the evaluations of programs, products, personnel, and policy. To proactively guide the work of professionals in everyday practice and to inform evaluation clients and the general public of expectations for ethical behavior, the Association developed a set of guiding principles that are incorporated into the Indiana Evaluation Framework. These principles include the following provisions:

A. Systematic Inquiry: *Evaluators conduct systematic, data-based inquiries about whatever is being evaluated.*
B. Competence: *Evaluators provide competent performance to stakeholders.*

---

[20] M&V refers to Metering and Verification associated with on-site field data collection efforts. The term (M&V) is used differently than the term EM&V in which the E stands for “Evaluation” or the analysis efforts that constitutes the analytical activities within the field of evaluation. Evaluation is the step in which evaluation-related data are analyzed to produce evaluation findings. IMPVP is an M&V effort associated with data collection and operational verification and in itself does not produce evaluation findings but provides the data on which evaluation findings are based.

C. Integrity/Honesty: *Evaluators ensure the honesty and integrity of the entire evaluation process.*
D. Respect for People: *Evaluators respect the security, dignity, and self-worth of the respondents, program participants, clients, and other stakeholders with whom they interact.*
E. Responsibilities for General and Public Welfare: *Evaluators articulate and take into account the diversity of interests and values that may be related to the general and public welfare.*

Appendix A: American Evaluation Association Guiding Principles provides a more detailed presentation of these principles.

Evaluation Expertise

The evaluation planning and implementation efforts should be directed, managed and implemented by members of the Evaluation Administrator's team who are trained, skilled and experienced in the specific areas of evaluation to which they are being used. Lead evaluation directors and managers should be experts with substantial experience in designing, managing, directing, and implementing evaluations, and reporting the results from those studies. Individuals assigned to the evaluation efforts should have the tools, skills and experience appropriate for the types of study and analysis approaches being used and the researchable issues being investigated. Inexperienced staff should be well supervised and their work reviewed for objectivity and accuracy before it is delivered to the Subcommittee.

Risk Mitigation and Reliability

Bias and precision

Bias arises when either the sampling design or the measurement approach leads to estimates that do not equal the true target value (e.g., average savings of population of CFL distributed). In other words, bias is a negative property to be avoided. A confidence interval is a range of values that is believed—with some stated level of confidence—to contain the true population quantity. The confidence level is the probability that the interval actually contains the target quantity. **Precision** provides convenient shorthand for expressing the interval believed to contain the estimator (e.g., if the estimate is 1,000 kWh, and the relative precision level is 10%, then the interval is 1,000 ±100 kWh. Stated another way, we are 90% confident that the true unobserved population value is between 900 and 1,100 kWh).

To illustrate four possible conditions relative to bias and precision, an image is often used of a target with different result patterns.

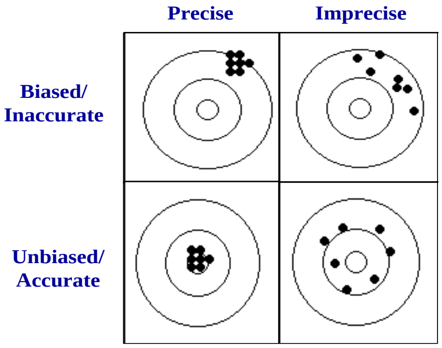


Figure 2 Bias and precision relationship

- *Unbiased and precise measurement*: results are tightly centered over the target bull's eye.
- *Unbiased and imprecise measurement*: results are very loosely arranged in a random pattern around the bull's eye, where the *average deviation*--high, low, left and right--is zero.
- *Biased and precise measurement*: results tightly clustered but systematically away from the bull's eye.
- *Biased and imprecise measurement*: results very loosely arranged in a pattern that is not centered on the bull's eye.

In real research, of course, the bull's eye is an unknown entity, for instance, the true value of energy savings for a measure. The bias of a measurement is typically assessed *on face value* and through past experience by how well it comes into contact with the thing being measured. Metering assures direct measurement of consumption and demand, so it normally has low bias, whereas an engineering review may be based on research conducted for a distant utility under conditions that diverge from the program in question, hence higher bias. Metering of one or even five installed measures, however, might not be a *precise* basis for assigning savings, insofar as the amount of savings varies greatly from one installation to another. Paradoxically, then, a more biased measurement that is very precise might be more rigorous than a very imprecise but less biased measure. Rigor is the process of attempting to achieve unbiased and precise measurement.

Guidelines for assigning value to information

Where resources are limited—*i.e., in nearly every case*—overall validity and precision are optimized by a strategic allocation of effort. Importantly, not all programs need the same level of evaluation rigor. Evaluation budgets should be focused to achieve the most valid and reliable results where they matter most. Evaluation rigor should be matched to the importance of the information being gathered through the evaluation efforts. To achieve this balance the following evaluation rigor considerations are incorporated into the Evaluation Framework:

1. *Contribution to portfolio energy savings*
2. *Share of portfolio budget*
3. *Measure parameter uncertainty*
4. *Expanding programs*
5. *Specific program issues (slow launch, low enrollment, etc.)*

Mechanisms for achieving rigor

The primary mechanisms by which high levels of rigor are achieved in evaluations include higher sample sizes, frequency of measurement, and estimation methods. Reducing errors usually increases evaluation costs. Thus, research expenditures intended to improve statistical precision should be justified in terms of the value of improved information. Methods of measurement are quite varied but include the metering of equipment on site; on-site inspections without metering; telephone surveys of participants, non-participants, or trade allies; engineering analysis of program data; and review and analysis of secondary data sources. The precision of these methods must be weighed against their relative cost, to achieve an optimal allocation of resources. Likewise, the *number of measurements*, i.e., sample size, and hence the cost, must be balanced against the gains. General principles include:

1. Evaluation planning should focus the type and use of field measurement and verification efforts on those components of the portfolio that have the greatest risk of lowering the precision of the impact estimates.
2. Method selection should consider previous evaluations and the degree of change that has occurred so that as programs change over time, the evaluation focuses additional rigor on programs that have changed.
3. Sampling approaches, sample size targets and confidence limits should be considered so that the effort is focused on improved estimation accuracy or on improving the operations of the programs. For programs that are important components of the efforts should have sampling approaches that reflect that importance.

In addition to the above rigor considerations, at a minimum all statistical precision should match standards outlined in the Indiana TRM. Rigor achieved should also correspond to evaluation reporting criteria.

Common sampling approaches

The development of the sample requires understanding the necessary accuracy, determining the sample frame, and developing the suitable sampling methodology. Appropriate statistical techniques typically used in energy program evaluation include, but are not limited to:

- ***Simple random sampling:*** drawing randomly from an entire population. This is often, but not always, the most efficient form of sampling.
- ***Stratified sampling:*** drawing randomly from sub-groups within a population. This is used when the variance in a measure is unequally distributed across a population, such as when the size of savings varies by the size of sites and there is a broad distribution of sizes. Random sampling is done within size groupings.
- ***Ratio sampling:*** sampling to estimate the ratio between two values. This is done, for instance, to estimate a realization rate, where the sample captures both a claimed savings value and a verified savings value. This is not a sampling method, per se, but rather a special use of a sample that affects the sample size. Sampling to estimate a ratio can be more efficient than sampling to estimate a single parameter value.
- ***Nested sampling:*** drawing a sample from within another sample, such as when a site metering sample is drawn from a sample of site verifications.
- ***Systematic sampling:*** often used when a sampling frame is unavailable, such as in store intercept studies. Data is collected at a fixed interval with a random starting point.

90/10 Evaluation confidence and level of precision

Energy program evaluation is typically based on estimating energy impacts using a representative sample of program participants to determine how measures are installed and used. The results of these efforts are then used to estimate savings for the program. The Indiana Core program evaluations have a target confidence level of 90% with a relative precision of 10%. How this is applied will depend on several factors, including the need for participant surveys, contractor or trade ally interviews, participant phone verification, on-site verification, on-site metering or monitoring or other data collection approaches for which sampling is constructed. For Indiana evaluations, the evaluation effort should target sampling efforts at key energy estimation metrics to achieve a 90/10 objective. However, a 90/10 objective is not required for all evaluation efforts. The 90/10 standard can be lowered when is not considered beneficial for assessing the researchable issue on which an evaluation objective is based. This provision allows for lower levels of confidence and precision when a 90/10 level is not needed. As a result, a 90/10 objective may be appropriate for assessing the energy impacts of a program, but may not be needed to investigate an objective within the process evaluation. Likewise, a program may be small enough or have a low level of expected savings that the resources used to obtain a 90/10 objective may be better spent increasing the reliability of the findings of a larger program or focusing on a technology with one or more programs that provides larger savings. However before a 90/10 objective can be reduced the Subcommittee must approved that reduction.

This Framework does not specify how the 90/10 objective will be obtained, that is left to the professional discretion of the independent evaluation contactor to determine how best to deploy evaluation resources to achieve the highest level of reliability at the lowest level of estimation error risk at the portfolio level. However the Evaluation Administrator should structure their sample at the 90/10 level per program, per utility, to the extent that this objective can be achieved within the available evaluation budget. At the time of the writing of this Framework there are six utilities[21] implementing five[22] statewide programs through a single TPA. Because the DSMCC has set the 90/10 objective at the program level and at the utility level, this means that a Core program evaluation is not a single evaluation effort as typically structured in other states, but is essentially six independent impact evaluations per program. At this time there are five statewide programs. This means that from a sampling perspective, 30 independent evaluations need to be conducted for the 5 Core programs (one per utility per program).

The evaluation efforts for Indiana's Core programs are expected to achieve utility-specific, program-specific estimates with a relative precision of approximately 10%, with a confidence level of 90% over the course of a multi-year program cycle. Thus, the energy impact estimates for a single year can be a lower level of precision, however, the final end-of-cycle evaluation reports which include all of the years of the program cycle, should be 90% confidence with a 10% level of precision per program per utility to the extent that the evaluation budget permits.

---

[21] Duke Energy, Vectren Energy, IP&L, I&M, NIPSCO and IMPA.

[22] Residential lighting, home energy audit, low-income weatherization, energy efficient schools, commercial and industrial program.

M&V Field Protocols[23]

This section of the Framework deals with measurement and verification (M&V) protocols, and principles relevant to applying M&V activities for evaluation of the Core programs. Engineering calculations, observation site visits, and metering are techniques that fit together as M&V activities and are used to varying degrees depending on the measure and program and site context. Topics include:

- Overview of M&V
- Selection of an M&V methodology
- Developing the site visit sample
- Quality assurance (QA/QC)
- Training

Overview of M&V

The following schematic provides an illustrative example of comprehensive M&V.

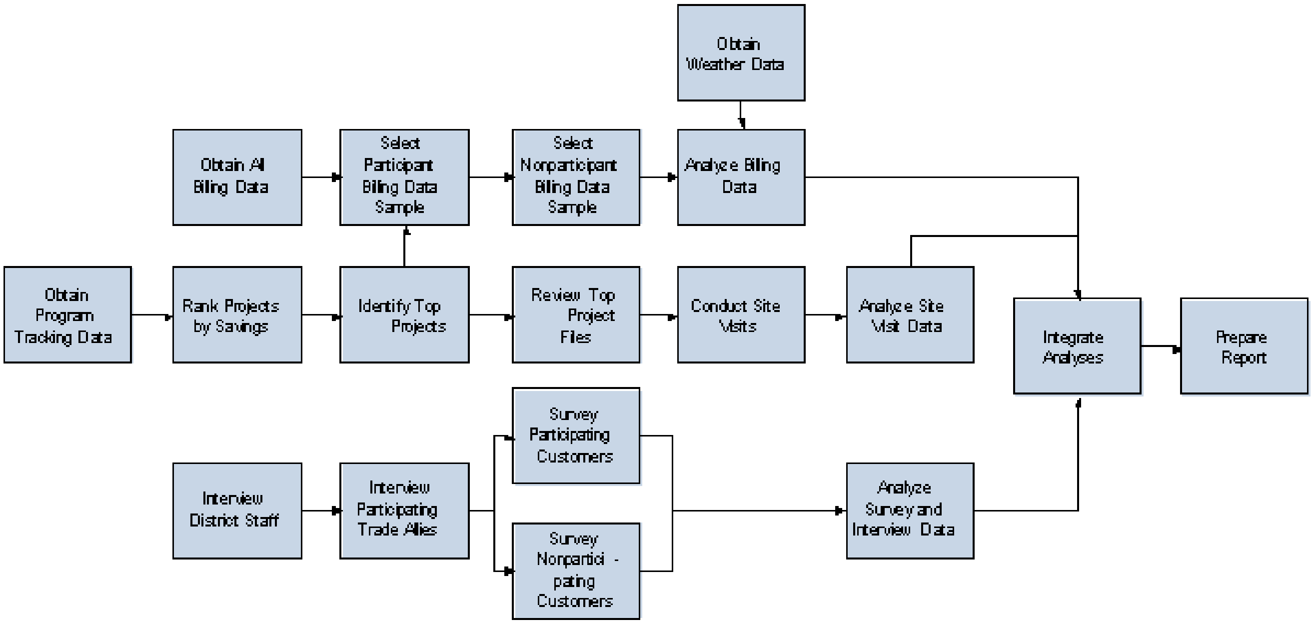


Figure 3 Comprehensive Monitoring and Verification

Evaluators generally conduct post-retrofit site visits and associated M&V to determine the savings realization rates associated with a sample of completed DSM projects.

---

[23] EM&V=Evaluation, Measurement and Verification. EM&V includes the analysis of the collected data (the E component of EM&V). M&V is a limited sub-set of EM&V and is strictly a measurement and equipment operations verification effort.

Selection of an M&V Methodology

The selection of an M&V methodology or analysis rigor for each sampled site will typically be based on several factors (measure complexity, magnitude of savings, etc.), and this will affect planning for site M&V unit costs accordingly. The following types of on-site verification activities are available to meet the evaluation goals, and will need to be adjusted based on actual site details:

- ***Verification:*** These sites include physical inspection and verification of the operating conditions of the systems under consideration.
- ***Verification with spot measurement:*** These sites involve physical inspection of the installation with spot measurement/reading of the current operating conditions.
- ***Verification with basic rigor:*** These sites will involve meeting–at a minimum–the standards of IPMVP Option A (Partially Measured Retrofit Isolation),[24] including the use of direct measurement.
- ***Verification with enhanced rigor:*** These sites will largely involve using IPMVP Option B (Retrofit Isolation)[25] level analysis.
- ***Phone Survey****:* Call to determine measure presence and operating characteristics.

Developing the Site Visit Sample

The primary sampling criteria will usually involve stratification of the program population into homogenous groups based on type (e.g., single family vs. multifamily, office vs. retail, etc.), the expected contribution to portfolio savings, and the uncertainty of input variables. Selecting a statistically valid sample is important to an evaluation such as the Indiana Core programs and requires a complex tradeoff between cost and accuracy.

Evaluators will normally develop the final sampling plan in the first phase of the project and will ensure that the statistical concepts and underlying sampling procedures are clearly explained.

Quality Assurance and Quality Control

Quality Assurance and quality control (QA/QC) procedures should be set at the inception of the evaluation process: meters should be tested in a metering lab before their use in the field; and nearly all measurements logged should be confirmed using an independent spot- measuring tool—both at installation and at removal—to check logging meter readings. Field staff members should remain on site until all readings are stable and in explainable or expected ranges. Best practice indicates that all metering points are photographed three times: before the meters are installed, with metering equipment, and after the meters are removed. This allows the evaluation team to confirm equipment nameplates and meter placements after they leave the field.

---

[24] Savings are determined by field measurement of the key performance parameter(s), which define the energy use of the affected system(s) and/or the success of the project. Measurement frequency ranges from short-term to continuous, depending on the expected variations in the measured parameter and the length of the reporting period.

[25] Savings are determined by field measurement of the energy use of the affected system. Measurement frequency ranges from short-term to continuous, depending on the expected variations in the savings and the length of the reporting period.

Training

To ensure consistency of data collection processes and analyses among all members of the evaluation site-visit team, the evaluation team’s senior engineers will generally conduct a training session covering general technology, data collection topics, and project-specific forms and databases. All staff members must be trained in safety topics appropriate for their work and are to be provided with industry-standard safety gear.

Standards and Approaches for Survey Research

Survey research is a critical piece of the evaluator's toolkit. Nearly all evaluations require the collection or analysis of survey data. This section provides guidance on the design and fielding of structured surveys.

Principles of Question Wording and Order

A survey is a structured conversation. Like any conversation, word choice can impact understanding. People interpret the same word differently. Survey questions need to be specific, simple and direct; they should address one subject at a time, and need to be exhaustive and mutually exclusive. Questions that will be used in an algorithm to estimate an overall value need to be developed with the algorithm in mind. The algorithm needs to be developed before the survey is designed. The following parts of this section of the Framework provide guidance on survey construction to minimize data bias and improve evaluation reliability.

Closed-Ended Versus Open-Ended Questions

Surveys typically contain a combination of open- and closed-ended questions. Open-ended questions allow respondents to answer the question in their own words while close-ended questions require respondents to select their response from a provided list.

Close-ended questions are more common because they are easier to administer and analyze and less subject to interviewer effects. Open-ended questions can provide more rich and detailed responses than close-ended questions. However, open-ended questions take longer for respondents answer, require more skilled interviewers, and must be coded for analysis.

A common short-cut is to ask an open-ended question and have the interviewer "field-code" the response by fitting it into pre-defined categories that are not read to the respondent. This approach can reduce analysis time and survey costs, but it is not recommended in most cases. The interviewer becomes the coder and considerable training is typically required for each question to ensure that all interviewers are coding the open-ended responses correctly and consistently. If field-coded open-ended questions are used, long lists of response categories should be avoided as they are difficult for interviewers to manage and can introduce measurement error. Such questions should have no more than five response categories with responses that fall outside these categories typed out in full and recorded as an "other."

Questions that measure a numeric quantity, such as number of CFLs purchased or number of rooms in the house, can and should be asked as an open-ended question. Asking the respondent to fit numeric responses into close-ended category ranges is more likely to produce errors. If ranges are used, the categories should not overlap so that they are mutually exclusive.

Question Scales

Numeric rating scales are one of the most common question forms. An important decision is the number of scale points. For a scale to provide a reliable and valid measure of a concept, respondents must uniformly understand the meaning of the response categories. Scales with a small number of points are easier for respondents to understand so that respondents tend to interpret the categories in the same manner. The drawback of these scales is that they do not allow finer distinctions in attitudes and behaviors that most respondents are able to make. But scales with too many categories can only provide this higher level of distinction if each point has a clear and distinct meaning. Long scales without clear meaning can create measurement error.

The optimal number of scale points to maximize reliability and validity of survey responses has been the subject of numerous studies. The general consensus is that scales with a moderate number of points – five or seven – tend to have greater reliability and validity than scales with fewer or more points.

Survey Development and Testing Techniques

Before survey fielding begins, evaluators should employ some form of testing of survey instrument to make sure respondents interpret the questions as intended and are not struggling with the answers.

During the survey development phase, designers could conduct focus groups or cognitive interviews in which the evaluator has the opportunity to talk with respondents to better understand how they interpret the questions. Focus groups and cognitive interviews are time intensive and costly techniques that most are not able to employ. A simple but often overlooked test is to read the survey aloud to someone who was not involved in its development. This exercise will often reveal awkward and confusing wording that can be easily improved.

Once a survey is final and ready for fielding, more formal testing should be conducted. Surveys should be pre-tested with a small number of actual respondents while the evaluator listens to the actual interviews as they are being conducted. Monitoring is one of the only ways a survey designer can hear the full interview from the respondent’s perspective. The designer will hear if respondents struggle to understand questions, have difficulty providing an answer that fits the response options, if the interview is too long or repetitive and respondents become impatient compromising data quality.

Evaluators should closely examine the pre-test data to make sure the survey is programmed correctly and respondents are asked all appropriate questions.

All surveys must be reviewed and approved by Subcommittee before fielding begins.

Survey Fielding

Surveys should be fielded using best practices that are appropriate for the collection mode to ensure minimum bias. For telephone surveys, evaluators should employ call centers that train all new interviewers on proper telephone survey procedures and evaluate the quality of their work on a regular basis. Interviewers should also be trained on the specific survey before they begin calling respondents. The evaluator should explain the purpose of the survey and any unusual or complicated questions.

The survey field period should be long enough so that all sample telephone numbers are dialed numerous times at different times of day to maximize the chance of reaching all respondents. The call center should have procedures for recording the outcome of each call. Ideally, the call dispositions will be recorded in manner that allows the calculation of a response rate using standards set forth by the American Association for Public Opinion Research (AAPOR).

Because mail and Internet surveys are self-administered, evaluators need to pay careful attention to the visual appearance and design of these instruments to minimize respondent error. Evaluators should consider consulting an expert in the field of mail or internet survey design before crafting their field instruments. The field period of mail and Internet surveys should be long enough so that at least one reminder can be sent. The outcome of each email invitation or mailing should also be tracked in a manner to allow the calculation of an AAPOR response rate that is appropriate for internet and mail surveys.

Survey Methods Reporting

Evaluators should document the survey procedures and methods used so the results can be replicated or compared to other studies. All survey projects should retain:

1. Final survey instruments.
2. A sampling plan that includes a description of the population under study, the sampling frame, the source of the sampling frame, the method used for drawing a sample of respondents from the sampling frame. Any quotas used in fielding the survey should also be detailed.
3. Survey dispositions and response rates. Both should be tracked and calculated using AAPOR Standard Definitions.
4. A description of any survey weights and weight methods.
5. A topline that contains frequency results of all questions asked in the survey.
6. Final data files and computer code used for analysis.

Ethical Considerations

Evaluators have ethical responsibilities when conducting surveys with utility customers. For each survey, evaluators should inform customers of the sponsor of the survey and that their participation is voluntary. Customers who choose not to answer a question should be respected and not pushed to provide an answer. Any information, alone or in combination, that could identity a customer should be kept confidential unless the customer explicitly waives confidentiality. The Council of American Survey Research Organizations (CASRO) and AAPOR provide codes of standards and ethics. Evaluators must abide by one of these standards. The full CASRO standards can be found at: http://www.casro.org/codeofstandards.cfm. The AAPOR standards can be found at: http://www.aapor.org/AAPOR_Code_of_Ethics/4249.htm.

Energy Impact Baseline Approaches

Prescriptive Measure Baselines

The baseline for prescriptive measures will be one of the following:

For early replacement scenario (i.e., replacing existing functioning equipment), the appropriate baseline is the efficiency level of the pre-existing operating equipment. This scenario has another baseline that starts after the end of the remaining useful life (RUL), or when the existing equipment would have ceased to operate. The baseline at that moment is what the customer would have replaced the equipment with, i.e., current market practice or code if the code is enforced. (See Appendix C for detailed discussion of useful lives.)

For non-early replacement scenario (i.e., the equipment is replaced via a new construction program, or for measures where there is no standard RUL identified in this Framework , the baseline is minimum applicable minimum efficiency that is standardly available in the market for that type of equipment or the standard mean market practice or standard mean current practice representing the typical installation. For applications in which there is no building code or appliance standard the baseline is the minimum efficiency level for equipment that is typically installed in similar projects by non-participants. In these conditions the evaluation professional will need to make a judgment call about what is considered minimum efficiency for the range of equipment available in the market. The minimum efficiency equipment (typically called the inefficient choice) represents the lower levels of equipment efficiency available in the market. **Minimum Efficiency Typically Installed**:

When baseline is set to minimum efficiency, or minimum efficiency level under a code or standards, free rider adjustments are needed to convert gross to net savings. However, it is also possible to set the baseline at a level that includes the influence of freeriders, thus eliminating the need for a freerider adjustment to the gross savings. In this baseline (Standard Market Practice, or SMP) approach, savings are estimated as the difference between the market standard practice baseline and the program induced high efficiency unit. When this approach is used it is assumed that the practice of establishing the market mean practice provides average per measure energy savings that will directly reflect the program’s impact net of freeriders. This approach is used when there is a reasonable expectation that participants make decisions similar to those made by non-participants in the absence of the program.

Custom Measure Baselines

For custom program evaluations the baseline approach can be different for each installation. That is, the technologies as well as the technology configuration and use conditions can be different in each case. As a result, it is not advisable to establish a set of standard baseline approaches. Instead the Framework specifies how project-level baselines can be set, depending on the type of change induced by the program. The evaluation contactor must select the baseline approach appropriate for a set of sampled projects that best reflect the needs of the project and program-level evaluation.

Because there are several different ways that program managers and evaluation experts can define a custom baseline condition, significant differences in savings estimate can result. By defining baselines for various installation conditions, these approaches aim to reduce such differences.

Types of Custom Projects

There are typically four types of custom projects.

1. Measures that are not included in the Indiana Technical Reference Manual (TRM) and are unique to a specific non-typical process or application. They are typically not part of prescriptive programs because they do not conform to standard installation and use conditions.
2. Measures not included in the Indiana TRM but are promoted by one or more programs and can be considered a typical installation and therefore should be considered for inclusion in future updates to the Indiana TRM. Because they are not included in the Indiana TRM, custom baseline approaches are needed.
3. Measures that are in the Indiana TRM, but that are installed in a different environment or have a different use conditions than those assumed in the Indiana TRM.
4. Measures that are in the Indiana TRM, but that require simulation modeling or other advanced approaches in order to estimate interactive effects within a facility (if different than category 3 above).

Any one of these four types of custom measures can be mapped into three types (A-C below) of custom projects which require different considerations for estimating pre-program baseline conditions.

A. ***Building*** performance related projects (insulation, space heating, space cooling, domestic water heating, lighting etc.) and,
B. ***Process*** projects that are typically based on the activities that take place within a participant's facilities (paint drying, curing, baking, forming, cutting, stamping, molding, chilling, extruding, compressing, welding, etc.). Space heating and cooling projects are included in the building envelope definitional standard because the performance of these systems is dependent upon both the efficiency and operational conditions of the equipment and conditions of the facility's envelope.

While these two groups work well for many projects, there are also projects that substantially impact post program energy use across both of these groups.

C. ***Building and process*** projects where a change in one significantly impacts the energy use conditions of the other. For example when a facility installs a new high efficiency kiln for drying and forming that is more efficient and better insulated than the previous kiln such that the decreased energy used for baking pottery changes the load on the building's heating and cooling systems. The impacts on the building are the HVAC interactions resulting from the process change.

Within these three types of projects are other considerations for establishing baselines.

A. Building Projects

There are two types of building projects: 1) those that are not associated with a building code that is in force at the time of the program-induced change, and 2) those that are covered by a building code which limits the choices that can be considered for the project.

B. Process Projects

There are also two types of process projects: 1) those in which the levels of production (i.e., number of units produced annually) increase after installation and 2) those in which they do not increase. Both are further divided into: 1) those not covered by an applicable Federal or state standard, and 2) those covered by an applicable Federal or state standard.

C. Building and Process Projects

Some custom projects impact the energy use associated with the operations of the facility and the energy use of certain processes operating within that facility. For these types of projects, baselines must be established for both the facility and the process within the facility. Note that there are cases in which the installation of the installed measure interacts with the energy use of another existing measure (e.g., the installation of a custom lighting measure interacts with the energy use of the existing Heating, Ventilation and Air Conditioning (HVAC) system. In such cases, only the baseline for the installed measure (e.g., lighting) needs to be determined.

Custom Project Baseline Definitions

This section defines the baselines for two types of custom *building* projects and four types of custom *process* projects.

1. **Building or facility equipment not covered by a code:** Involves measures associated with the building or facility (envelope, non-deemed and non-process equipment) and measures not covered by a building code. If the program-induced change is an early (before end of life) replacement, the baseline is the pre-program in situ energy consumption. If the program-induced change is a normal replacement (replaced at the end of the effective useful life), the baseline is the energy consumption associated with current practice.
2. **Building or facility equipment that is covered by a code**: Involves measures associated with the building or facility (envelope and non-TRM and non-process equipment) and which are measures covered by a building code that limits the equipment choice. If the program-induced change is an early replacement, the baseline is the pre-program in situ energy consumption. If the program-induced change is a normal replacement, the baseline is the energy consumption associated with current building code.
3. **Process equipment *not covered* by an applicable Federal or state standard**: Involves measures associated with the process or operational activities occurring within the facility that are not covered by an applicable Federal or state standard. If the program-induced change is an early replacement, the baseline is the annual energy consumption of the pre-existing equipment at the post-program level of production. If the program-induced change is a normal replacement, the baseline is the annual energy consumption of equipment representing current practice at the post-installation level of production.
4. **Process equipment *covered* by an applicable Federal or state standard**: Involves measures associated with the process or operations occurring within the facility that are covered by an appliance of equipment standard which limits equipment and change

options. If the program-induced change is an early replacement, baseline is the annual energy consumption of the pre-existing equipment at the post-program level of production. If the program-induced change is a normal replacement, the baseline is the annual energy consumption of equipment that meets the applicable standard at the post-installation level of production.

Note that for numbers three and four above, the issue of whether production increases is irrelevant since the basic assumption is that a given program is not the primary cause of a customer's decision to increase production. There are two reasons supporting this assumption. First, a decision to increase the level of production usually requires a firm to consider a very complex set of organizational and economic factors, only one of which may be the price of electricity and/or gas. Second, to assess whether the program was the primary cause of this decision would require a very complex and prohibitively expensive analysis designed to tease out the effect of the program from the multiple drivers of production changes such as the supply and demand for the firm's product within a national or global market.

In both numbers three and four, the baseline and the post-installation energy use assume the post-installation level of production. This results in greater savings than in the case in which the program is assumed to have caused the increase in the level of production. Both rules recognize that even though the level of production has increased in the post period thereby *increasing* consumption, the *efficiency of production* (kWh/unit) has improved, which has a positive impact on the economic efficiency of the firm and the gross state product.
Figure 4 below presents the various pathways to defining baselines in each of the types and sub-types discussed above. These definitions also apply to peak kW demand.

Defining "Current Practice" for Custom Program Baselines

In determining what constitutes a "*current practice*" in the absence of a building standard or an applicable Federal or state standard, the assessment needs to focus on what equipment choices and installation configurations would have normally been adopted in the absence of the program. (Note: The use of the term current practice should not be confused with the term standard market practice in which a net freerider baseline is defined.) This can be challenging for assessing projects with non-prescriptive measures or for which there is no common per-participant or industry practice which the participant would have followed or that are typical for non-participants. Establishing a *current practice* for a custom project will require some assessment of what each participant would have done in the absence of the program. It is essentially what would have been done without the program assessment. Thus when current per-participant or industry practice is set as the baseline, it is already set at what would have occurred, not as market current practice, but as the custom program participant's current practice. As a result, the impact results are already net of freeriders and no additional freerider adjustment is needed.

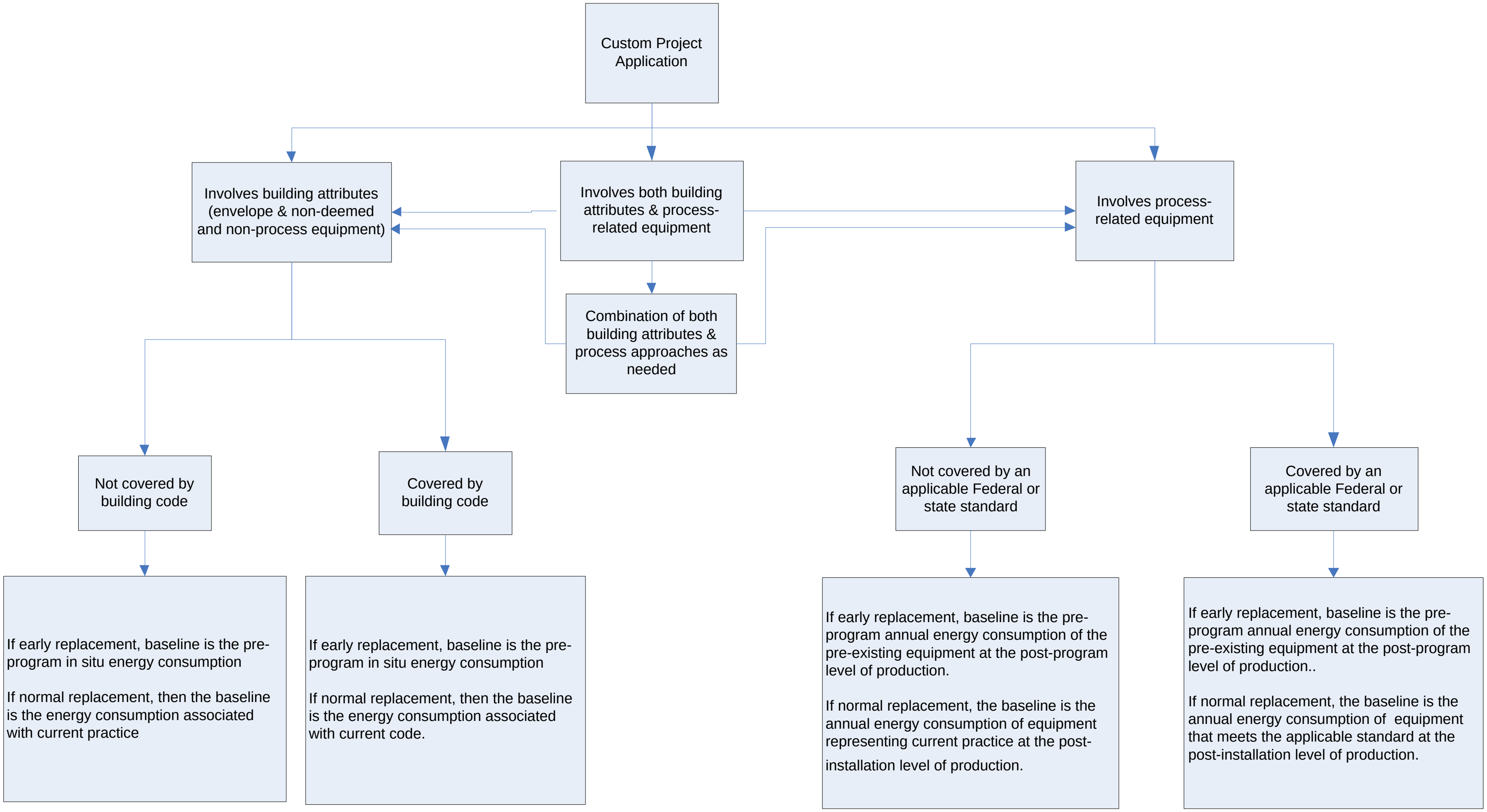
The assessments need to explore a variety of factors affecting what project would have been done in the absence of the program. Factors could include, among other:

- Procurement decision criteria for similar non-program covered equipment;

- The participant’s traditional capital investment practices and how they impact equipment choice decisions;
- Past purchase trends for similar equipment;
- Customer self-reports of what they would have installed (if anything) had the program information and incentive not influenced the choice decision;
- Surveys of designers and/or vendors familiar with the process affected by the measure (e.g., interviews with wastewater treatment plant engineers to determine whether variable frequency drivers (VFDs) are common practice on wastewater aerators).

Because energy efficiency programs are designed to influence equipment decisions, one cannot assume that all participants follow what is typically purchased for a specific purpose or use. For many types of custom projects, there may be no typical industry practice. Likewise energy programs are designed to move both early adopters as much as late adopters.

Figure 4. Determining Baselines for Custom Projects under Various Installation Conditions



If early replacement, baseline is the pre-program in situ energy consumption

If normal replacement, then the baseline is the energy consumption associated with current practice

If early replacement, baseline is the pre-program in situ energy consumption

If normal replacement, then the baseline is the energy consumption associated with current code.

If early replacement, baseline is the pre-program annual energy consumption of the pre-existing equipment at the post-program level of production.

If normal replacement, the baseline is the annual energy consumption of equipment representing current practice at the post-installation level of production.

If early replacement, baseline is the pre-program annual energy consumption of the pre-existing equipment at the post-program level of production..

If normal replacement, the baseline is the annual energy consumption of equipment that meets the applicable standard at the post-installation level of production.

Effective Useful Life and Remaining Useful Life for Custom Measures

Since agreed upon effective useful lives (EULs) for general categories of custom projects are not available, case-by-case documentation for the proposed EUL for each custom project should be used in the impact evaluation. Documentation could include dates of installation of the existing equipment that would allow the calculation of its age or, absent such documentation, customer estimates of the age of the existing equipment for each custom project. In some cases, manufacturers' specifications for equipment comprising the custom application could also be used to estimate the EUL. Or, information on time-to-failure of similar equipment supporting similar applications (e.g., plastic extrusion) could be identified within a given industry.

With respect to remaining useful life (RUL), the situation is even more challenging. Information gathered from knowledgeable people at the site must be gathered to support an estimate of the RUL. For example, such questions as the following could be asked:

- At the time the equipment was replaced, about how many years were left in its useful life (without major repairs which may have led to replacement)?
- Which of the following best describes the condition of the existing equipment when it was replaced: fully functional, fully functioning but with significant problems, or non-functional?
- How long would the old equipment have met the technical and performance needs of the facility?

Custom Measure Early Replacement: When a technology is replaced earlier than what would have occurred without the program, the baseline condition is the energy use condition prior to the program-induced change for the remaining useful life of the replaced measure. Once the remaining useful life has expired, the baseline should be established using one of the three methods outlined above and applied to the remaining useful life. In some cases functional application impact calculation adjustments will need to be made by the evaluation contactor when they find that program-caused changes also impact the functions of equipment or processes that are different than the pre-condition.

Use of Control or Comparison Groups as Baselines

When the evaluation approach uses experimental or quasi-experimental evaluation approaches[26] the estimation of a pre-program baseline is not required. This is because the participant (test) group's energy use is statistically compared to the consumption of a matched non-participant group (control or comparison group). When random assignment is used to allocate sample points into both the participant and non-participant groups, the difference in consumption between the test and control group provide a net impact result that does not need to be adjusted or modified to provide results that are net of freeriders and participant spillover for that examination period. The same condition applies if quasi-experimental designs are used to establish the test and comparison groups. In both cases the baseline becomes the energy use of the test or comparison group. Experimental designs use random assignments into the two types of groups. Quasi-

---

[26] Experimental approaches randomly assign people to the participant and control group so that there is theoretically no difference between the two groups. Quasi-experimental approaches build a comparison group (instead of a control group) and statistically control for variable influences that impact the study's findings.

experimental designs use assignments other than random. Quasi-experimental designs are more challenging than experimental design, because differences between the groups that influence energy use need to be controlled statistically.

Net Energy Impact Attribution Approaches

Standard Market Practice approach

The standard market practice (SMP) approach is a way to set energy impact analysis baselines so that the baseline already incorporates the influence of freeriders. In this approach a freerider assessment is not needed because the use of a standard market practice baseline is already what the market is doing without the program's direct influence. The SMP baseline is typically set at the mean of the level of energy efficiency being installed across the market being targeted by the program.

Self-report participant approach

When the SMP approach is not considered to be optimal or appropriate and when experimental or quasi-experimental designs cannot be used, the evaluation should employ a self-reporting approach. This approach will be highly consistent across programs with in the Indiana Core Program portfolio, with a similar battery of self-report questions. The surveys and interview instruments ask a series of questions designed to specifically assess the influence of the program on the participant's decisions. The questions focus on information sources used for making purchase decisions, how the program information influenced the decision, and assessing how the incentive influenced the decision. Participants are also asked about additional actions taken due to the influence of the program, but for which an incentive was not requested or paid. The assessments include consideration for not just the incentives provided, but the information and educational aspects of the program. Net savings can be produced from the incentive, the information provided by a program or the education effects the program has on the purchase and use decision. Each, independently or together, can cause net impacts to be achieved by a program.

The battery of questions used for net analysis are be kept to a minimum and include only those questions that can reliably be used to estimate net effects. Burdening customers with unnecessary questions that have not been shown to improve the accuracy of an estimation calculation are be avoided. The development of a standard set of short, focused net-to-gross (NTG) questions will allow the evaluation team to assess freeriders and participant spillover, but will not allow for the addition of market effects.

Analysis of self-report data

The general analysis approach is to develop an algorithm, based on the direct attribution questions, that establishes an initial attribution factor. Responses to the direct attribution questions will be compared to the context and decision-making questions to identify inconsistencies. The analytical procedures for establishing attribution and for identifying and addressing inconsistencies should be established prior to analysis.

The Evaluation Administrator must develop a transparent, straightforward matrix approach to assign a score to participants, based on their objective responses to survey questions. Question response patterns are then assigned attribution scores, and the confidence and precision estimates are calculated on the distribution of these scores. The reporting of results should include a matrix (or flow diagram) showing the combinations of responses given to the attribution questions and the percentage of customers (and percentage of the overall savings) that fall into each category. This allows stakeholders to fully understand how each question (and within each question, the response categories) affects the final result.

The Evaluation Administrator’s method will also rely on the concept of partial freeridership (partial attribution). Experience has taught evaluation professionals that program participants do not fall neatly into freerider and non-freerider categories. For example, partial freeridership scores were assigned to participants with plans to install the measure; though, the program exerted some influence over their decision, other market characteristics beyond the program also proved influential. In addition, with partial freeridership, we could utilize “Don’t Know” and “Refused” responses by classifying them as partial credit, rather than removing the entire respondent from the analysis. Evaluators then typically weight the respondent freeridership scores by the estimated savings of equipment installed, given the wide variation in nonresidential program participant energy savings.

Self-report spillover methodology

The concept of spillover refers to additional savings generated by program participants due to their program participation, but not captured by program records. Spillover occurs when participants choose to purchase energy-efficient measures or adopt energy-efficient practices because of a program, but they choose not to participate or are otherwise unable to participate in the program. As these customers are not “participants” for these additional actions, they do not typically appear in program records of the savings generated by spillover impacts. Thus, the energy efficiency programs’ spillover effect serves as an additional impact, which can be added to the program’s valid results, in contrast to the freeriders’ impacts (which reduce net savings attributable to the program).

In the Indiana Core programs, the evaluations can measure spillover by asking a sample of participants purchasing and receiving a rebate for a particular measure if, due to the program, they installed another efficient measure or undertook other energy efficiency activity. Respondents are typically asked to rate, for example on a scale of 0 through 10, the relative influence of the Core program and rebate on their decision to pursue additional savings. They may also be asked to explain why they chose not to pursue a rebate for additional measures installed.

Participants are also asked for details regarding the baseline equipment the new energy-efficient equipment replaced. Once the measures and the estimated baseline measures are determined (as best as is feasible within constraints of the survey), detailed measure attributes obtained from the survey questions can be used to establish the most appropriate savings value to assign to that action taken. In cases where the Indiana TRM do not have applicable energy savings values, the evaluation team will rely on either other accepted values and/or engineering calculations by the evaluation team.

A spillover percentage per program is also calculated by dividing the sum of the additional spillover savings reported by respondents for a given program by total rebated gross savings achieved by all respondents in the program, as follows:

$$Spillover\ \% = \frac{\sum \textbf{Spillover Measure kWh Savings for All Survey Respondents}}{\sum \textbf{Program Measure kWh Savings for All Survey Respondents}}$$

Market effects - non-participant spillover

The evaluations should also assess the level of energy impacts associated with the program’s/portfolio’s impacts on how the market functions. Energy programs change the way products are selected and priced for sales in areas where energy efficiency programs are operated. These savings are then added to the portfolio’s energy savings effects in a way that increases program level savings. In Indiana the Subcommittee has launched a series of market effects baseline studies that are replicated periodically. As these studies are completed the effects of the portfolio will be converted to kWh and kW impacts and added to the savings achieved directly by the program. The Evaluation Administrator will present the results of these studies to the DSMCC along with their recommended approach for allocating market effects savings to the programs that help produce those savings.

Use of Logic Models and Program Theories

Overview of Logic Models

A logic model serves as a graphic representation showing relationships between program inputs, outputs, and final desired outcomes. Program logic models offer a comprehensive way to identify and categorize the measurement of a program's progress toward the portfolio or program goals approved by the DSMCC. A well-designed logic model can help evaluation professionals design effective program evaluation plans because the logic model provides a roadmap for understanding logical relationships between program activities and final desired outcomes, and clarifies program design elements to ensure all operate properly for achieving a program's ultimate goals.

As seen in Figure 5 logic models can be used for planning as well as for evaluation purposes. Planning begins on the figure's right-hand side, including ultimate goals, outcomes needed for accomplishing final goals, and other planning elements. Evaluation starts on the figure's left-hand side, first checking program theory through examination of assumptions. The evaluation proceeds with a simple checklist of whether activities did or did not take place, and continues with more detailed evaluation activities to determine outcomes and goal achievements.

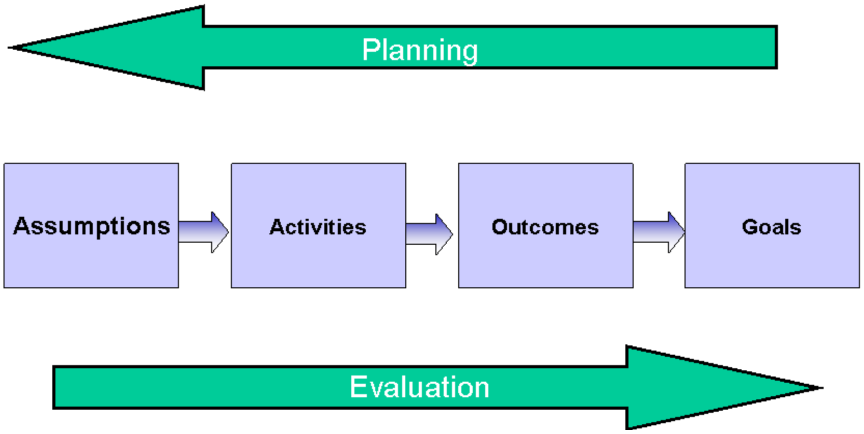


Figure 5 Logic Model Process

Often in an evaluation the initial logic models developed by the evaluators will serve as a guide for conducting evaluation research and discussions with program staff and implementers. Then revised and finalized logic models will also be an end product for the evaluation. Thus, the very process of building logic models can be used to establish consensus among stakeholders regarding program goals and methods for their achievement.

Value of Logic Models Across Broad Program Types

All evaluation efforts must, of course, be based on some model of what the program is trying to accomplish. However, use of program theories emphasizes the importance of a logic model spelling out in some detail the individual steps in the sequence of expected effects, their logical relationship to one another, and the causal mechanisms linking them. In the energy efficiency field to date, logic models and program theories have proven particularly well adapted to evaluating the effectiveness of market transformation initiatives. This is largely because transforming a market tends to take a relatively long time to occur, involves a relatively large number of causal steps and mechanisms, and encompasses changing the behavior of multiple categories of market actors, all of which makes it particularly fruitful to focus on specifying and testing a detailed and articulated program theory.

In contrast, logic models tend to have somewhat less value for understanding direct resource acquisition programs. For these types of programs, flow diagrams depicting program processes are likely to be adequate for understanding what the program is trying to accomplish and how the activities are expected to achieve direct energy impacts with end-use customers.

Logic Models in Process Evaluations

Process evaluation activities can, and should, assess whether a program is being delivered in a manner that is consistent with the underlying program theory. Divergences between the program theory and the manner in which the program is actually being delivered do often occur. Often these divergences represent pragmatic improvements based on actual field experience. However, it is important that process evaluation activities assess whether this is the case, and whether changes in the underlying program theory, and the long-term plan for testing this theory, are needed. Process evaluations informed by “theory-based evaluation” (TBE) are more likely to help explain not only where breakdowns in observed versus hypothesized market activities occur but why they occur.

Appendices

Appendix A: American Evaluation Association Guiding Principles

A. Systematic Inquiry: *Evaluators conduct systematic, data-based inquiries about whatever is being evaluated.*

1. Evaluators should adhere to the highest appropriate technical standards in conducting their work, whether that work is quantitative or qualitative in nature, so as to increase the accuracy and credibility of the evaluative information they produce.
2. Evaluators should explore with the client the shortcomings and strengths both of the various evaluation questions it might be productive to ask, and the various approaches that might be used for answering those questions.
3. When presenting their work, evaluators should communicate their methods and approaches accurately and in sufficient detail to allow others to understand, interpret, and critique their work. They should make clear the limitations of an evaluation and its results. Evaluators should discuss in a contextually appropriate way those values, assumptions, theories, methods, results, and analyses that significantly affect the interpretation of the evaluative findings. These statements apply to all aspects of the evaluation, from its initial conceptualization to the eventual use of findings.

B. Competence: *Evaluators provide competent performance to stakeholders.*

1. Evaluators should possess (or, here and elsewhere as appropriate, ensure that the evaluation team possesses) the education, abilities, skills, and experience appropriate to undertake the tasks proposed in the evaluation.
2. Evaluators should practice within the limits of their professional training and competence, and should decline to conduct evaluations that fall substantially outside those limits. When declining the commission or request is not feasible or appropriate, evaluators should make clear any significant limitations on the evaluation that might result. Evaluators should make every effort to gain the competence directly or through the assistance of others who possess the required expertise.
3. Evaluators should continually seek to maintain and improve their competencies, in order to provide the highest level of performance in their evaluations. This continuing professional development might include formal coursework and workshops, self-study, evaluations of one's own practice, and working with other evaluators to learn from their skills and expertise.

C. Integrity/Honesty: *Evaluators ensure the honesty and integrity of the entire evaluation process.*

1. Evaluators should negotiate honestly with clients and relevant stakeholders concerning the costs, tasks to be undertaken, limitations of methodology, scope of results likely to be obtained, and uses of data resulting from a specific evaluation. It is primarily the evaluator's responsibility to initiate discussion and clarification of these matters, not the client's.
2. Evaluators should record all changes made in the originally negotiated project plans, and the reasons why the changes were made. If those changes would significantly affect the scope and likely results of the evaluation, the evaluator should inform the client and other

important stakeholders in a timely fashion (barring good reason to the contrary, before proceeding with further work) of the changes and their likely impact.

3. Evaluators should seek to determine, and where appropriate be explicit about, their own, their clients', and other stakeholders' interests concerning the conduct and outcomes of an evaluation (including financial, political, and career interests).
4. Evaluators should disclose any roles or relationships they have concerning whatever is being evaluated that might pose a significant conflict of interest with their role as an evaluator. Any such conflict should be mentioned in reports of the evaluation results.
5. Evaluators should not misrepresent their procedures, data, or findings. Within reasonable limits, they should attempt to prevent or correct any substantial misuses of their work by others.
6. If evaluators determine that certain procedures or activities seem likely to produce misleading evaluative information or conclusions, they have the responsibility to communicate their concerns, and the reasons for them, to the client (the one who funds or requests the evaluation). If discussions with the client do not resolve these concerns, so that a misleading evaluation is then implemented, the evaluator may legitimately decline to conduct the evaluation if that is feasible and appropriate. If not, the evaluator should consult colleagues or relevant stakeholders about other proper ways to proceed (options might include, but are not limited to, discussions at a higher level, a dissenting cover letter or appendix, or refusal to sign the final document).
7. Barring compelling reason to the contrary, evaluators should disclose all sources of financial support for an evaluation, and the source of the request for the evaluation.

D. Respect for People: *Evaluators respect the security, dignity, and self-worth of the respondents, program participants, clients, and other stakeholders with whom they interact.*

1. Where applicable, evaluators must abide by current professional ethics and standards regarding risks, harms, and burdens that might be engendered to those participating in the evaluation; regarding informed consent for participation in evaluation; and regarding informing participants about the scope and limits of confidentiality. Examples of such standards include federal regulations about protection of human subjects, or the ethical principles of such associations as the American Anthropological Association, the American Educational Research Association, or the American Psychological Association. Although this principle is not intended to extend the applicability of such ethics and standards beyond their current scope, evaluators should abide by them where it is feasible and desirable to do so.
2. Because justified negative or critical conclusions from an evaluation must be explicitly stated, evaluations sometimes produce results that harm client or stakeholder interests. Under this circumstance, evaluators should seek to maximize the benefits and reduce any unnecessary harm that might occur, provided this will not compromise the integrity of the evaluation findings. Evaluators should carefully judge when the benefits from doing the evaluation or in performing certain evaluation procedures should be foregone because of the risks or harms. Where possible, these issues should be anticipated during the negotiation of the evaluation.
3. Knowing that evaluations often will negatively affect the interests of some stakeholders, evaluators should conduct the evaluation and communicate its results in a way that clearly respects the stakeholders' dignity and self-worth.

4. Where feasible, evaluators should attempt to foster the social equity of the evaluation, so that those who give to the evaluation can receive some benefits in return. For example, evaluators should seek to ensure that those who bear the burdens of contributing data and incurring any risks are doing so willingly, and that they have full knowledge of, and maximum feasible opportunity to obtain any benefits that may be produced from the evaluation. When it would not endanger the integrity of the evaluation, respondents or program participants should be informed if and how they can receive services to which they are otherwise entitled without participating in the evaluation.
5. Evaluators have the responsibility to identify and respect differences among participants, such as differences in their culture, religion, gender, disability, age, sexual orientation, and ethnicity, and to be mindful of potential implications of these differences when planning, conducting, analyzing, and reporting their evaluations.

E. Responsibilities for General and Public Welfare: *Evaluators articulate and take into account the diversity of interests and values that may be related to the general and public welfare.*

1. When planning and reporting evaluations, evaluators should consider including important perspectives and interests of the full range of stakeholders in the object being evaluated. Evaluators should carefully consider the justification when omitting important value perspectives or the views of important groups.
2. Evaluators should consider not only the immediate operations and outcomes of whatever is being evaluated, but also the broad assumptions, implications, and potential side effects of it.
3. Freedom of information is essential in a democracy. Hence, barring compelling reason to the contrary, evaluators should allow all relevant stakeholders to have access to evaluative information, and should actively disseminate that information to stakeholders if resources allow. If different evaluation results are communicated in forms that are tailored to the interests of different stakeholders, those communications should ensure that each stakeholder group is aware of the existence of the other communications. Communications that are tailored to a given stakeholder should always include all important results that may bear on interests of that stakeholder. In all cases, evaluators should strive to present results as clearly and simply as accuracy allows so that clients and other stakeholders can easily understand the evaluation process and results.
4. Evaluators should maintain a balance between client needs and other needs. Evaluators necessarily have a special relationship with the client who funds or requests the evaluation. By virtue of that relationship, evaluators must strive to meet legitimate client needs whenever it is feasible and appropriate to do so. However, that relationship can also place evaluators in difficult dilemmas when client interests conflict with other interests, or when client interests conflict with the obligation of evaluators for systematic inquiry, competence, integrity, and respect for people. In these cases, evaluators should explicitly identify and discuss the conflicts with the client and relevant stakeholders, resolve them when possible, determine whether continued work on the evaluation is advisable if the conflicts cannot be resolved, and make clear any significant limitations on the evaluation that might result if the conflict is not resolved.
5. Evaluators have obligations that encompass the public interest and good. These obligations are especially important when evaluators are supported by publicly generated funds; but clear threats to the public good should never be ignored in any evaluation. Because the public interest and good are rarely the same as the interests of any particular

group (including those of the client or funding agency), evaluators will usually have to go beyond an analysis of particular stakeholder interests when considering the welfare of society as a whole.

Appendix B. Data Needed for the Evaluation

This Appendix provides lists of the types of information evaluation contactors will need to support the evaluations of different types of programs. The following data should be readily available from the TPA.

Program Information

1. Full program descriptions, including operational or procedures manuals and activities descriptions and description of implementation territories;
2. Detailed descriptions of the tracking system and tracking system operations, including data dictionaries;
3. Program management and staff names, titles, work locations, phone numbers, fax numbers, email addresses;
4. Program theories and associated logic models if developed. If not developed a statement that they have not been developed with a projected date of delivery of the completed theories and logic models;
5. Market operations theories describing the operations of the markets in which the program operates and, if available, a description of how the program is to change the operations of the market;
6. A description of the size of the market targeted by the program, and a description of the baseline conditions at the measure/behavior level and a discussion of how the program is expected to change baseline measure/behavior conditions, if available;
7. A description of the pre-program technical potential at the measure/behavior level and a projection of the remaining technical potential at the end of the program cycle, if available; and
8. When the program relies on key market actors, trade allies and other stakeholders to deliver or support the program in order to reach the energy saving or outreach goals, the TPA should provide a listing, description of and contact information for these individuals/organizations.

Participant Data

For the purposes of this Framework a participant is defined as an individual or an organization that receives a program service or financial incentive. For most programs, participants are clearly defined in the program tracking systems. However, there are times when a participant is not clearly defined or is not easily identified. The DSMCC expects that the TPA will focus efforts on collecting participant information to the extent possible and practical for various types of programs or program services. Participants signing up for energy efficiency programs are generally easy to identify as they directly receive a service or a financial incentive. Participants in other programs, such as marketing and outreach programs can be harder to identify and report. This Framework does not act to require all programs to identify all participants. However when participant information is collected by the TPA or its subcontractor, much of this information will be of value to the evaluation efforts. It is the responsibility of the TPA to work with its subcontractors to assure that when possible and practical the following information should be collected and maintained.

The following participant data should be available in electronic form with supporting database dictionaries to the evaluation teams on request.

Non-residential program data requests for end-user focused programs

1. Name of program(s) or program component(s);
2. Name of firms participating in program or program component;
3. Service turn on date;
4. Primary and secondary NAICS codes associated with the participants if available;
5. Extent to which customer is a repeat participant or a participant in other programs over the previous five years, if available or accessible;
6. Pre-participation measure and measure-use information, descriptions and conditions;
7. Address(es) of the participating firms or key participation decision makers;
8. Address(es) where program-related action is taken or for the services received;
9. Listing or description of actions taken or services received for each location by measure and end-use according to standard measure and end-use definitions established herein. These lists and descriptions should, to the extent possible, be standardized so that all database developers use the same term for the same measure;
10. Individual participation contact information for each location to include:
    a. First and last name;
    b. Address;
    c. Telephone number;
    d. Fax number (if collected); and
    e. Email address (if collected).
11. Dates of key action/activity/installation steps associated with program participation:
    a. Program enrollment date(s);
    b. Rebate or incentive payment date(s);
    c. Measure install dates;
    d. Date of training received; and
    e. Post-installation measure inspection dates.
12. Financial assistance amounts paid to participant by measure or action taken;
13. Project description information;
14. Estimated savings for actions taken;
15. Summary characteristics of building on which actions are taken or the operational environment in which measures are installed if collected;
16. Account and meter numbers and consumption histories from utility bills from all relevant meters for at least twelve months prior to program enrollment date and through to current period. Note: The Evaluation Administrator will work with the TPA and the Subcommittee to understand what metered data is available for which

types of customers and the formats and time intervals associated with the metered data;

17. Rate classification; and
18. The size and operational characteristics of the market in which the program is to operate including the number of covered technologies operating in the market and their expected normal failure, change-out or replacement rates.

Residential program data requests for end-user focused programs

1. Name of program(s) or program component(s) of the participation;
2. Type of building or structure associated with the participant or the participation;
3. Pre-participation measure and measure use information, descriptions and conditions;
4. Service turn on date;
5. Name of individual enrolling in the program or receiving service;
6. Address of the participant;
7. Extent to which customer is a repeat participant or a participant in other programs over the previous five years, if available or accessible;
8. Address where action is taken or for the services received;
9. Listing or description of actions taken or services received according to standard measure and end-use definitions;
10. Individual participation contact information to include:
    a. First and last name;
    b. Address;
    c. Telephone number;
    d. Fax number;(if available and collected); and
    e. Email address (if available and collected).
11. Dates of key action/activity/installation steps associated with program participation:
    a. Program enrollment date(s);
    b. Rebate or incentive payment date(s);
    c. Measure install dates;
    d. Date of training received; and
    e. Post-installation inspection dates.
12. Financial assistance amounts paid to participant by measure or action taken;
13. Project description information;
14. Estimated savings for actions taken;
15. Account numbers and meter numbers and consumption histories from utility bills for all relevant meters for at least twelve months prior to program enrollment date and through to current. Note: The Evaluation Administrator will work with the TPA and the Subcommittee to understand what metered data is available for which types of customers and the formats and time intervals associated with the metered data;
16. Rate classification; and

17. The size and operational characteristics of the market in which the program is to operate including the number of covered technologies operating in the market and their expected normal failure, change-out or replacement rates.

Non-participant or rejecter data for end-user focused programs

1. Description of program services offered to customer;
2. Date of offering or contact;
3. Method of contact;
4. Name of contact;
5. Address of contact;
6. Telephone number of contact (if known); and
7. Email of contact (if known).

Program data for mid-stream and upstream focused programs

1. Name of program(s) or program component(s);
2. Name of firms participating in program or program component;
3. Primary and secondary NAICS codes associated with the participants if available;
4. Extent to which customer is a repeat participant or a participant in other programs over the previous five years, if available or accessible;
5. Pre participation/measure and measure use information, descriptions and conditions;
6. Address of the participating firms or key participation decision makers;
7. Address(es) where action is taken or for the services received;
8. Listing or description of actions taken or services received for each location;
9. Individual participation contact information to include:
    a. First and last name (if known) and company name if applicable;
    b. Address;
    c. Telephone number;
    d. FAX number (if collected); and
    e. Email address (if collected).
10. Dates of key action/activity/installation steps associated with program participation:
    a. Program enrollment date(s);
    b. Rebate or incentive payment date(s);
    c. Date of training received; and
    d. Dates, numbers and types of material received.
11. Financial assistance amounts paid to participant by action taken;
12. End-user information as is made available to the program;
13. The size and operational characteristics of the market in which the program is to operate including the number of covered technologies operating in the market and their expected normal failure, change-out or replacement rates; and

14. Names and copies of previous evaluations and market research efforts used by the program to plan and structure program offerings and implementation efforts.

Program data for information, education and advertising-focused programs

1. Name of program(s) or program component(s);
2. Target population description, size, source of identifying information and lists of population members used in outreach activities. The size and operational characteristics of the market in which the program is to operate including the number of covered technologies operating in the market and their expected normal failure, change-out or replacement rates;
3. Contact information where individual participants are identified to include:
    a. First and last name of key contacts for each location (if known);
    b. Address of individual contacts;
    c. Telephone number of individual contacts;
    d. Fax number of individuals (if collected); and
    e. Email address of individuals (if collected).
4. Marketing materials by numbers, types and distribution;
5. Education or Media plan as appropriate;
6. Execution records for training held; information venues used; program participation agreements, commitments or other similar agreements; post-buy analysis; and other documentation of actual output;
7. Records for dates, number, location, target audience and attendance of events held, Web site hits, call-in numbers and rates, reach, frequency, gross rating points (GRPs), impressions, click through rate, composition, coverage, earned media, value of public service announcements, and other tracking and monitoring information the program maintains, as appropriate to the effort and for each wave, campaign and targeted effort. Include definitions and calculation methods for monitoring statistics used;
8. End-user information available to the program; and
9. Study names and copies of previous evaluations and market research efforts used by the program to plan and structure program offerings and implementation efforts.

Appendix C: Establishing Effective Useful Life Values and Remaining Useful Life

The Indiana Approach for Establishing EULs and RULs

The effective useful life (EUL) of an energy efficient measure is the average number of years over which a measure is expected to provide savings. The effective useful life is set is at the estimated point at which 50% of an installed technology type is expected to be remain installed and working in the participant's facilities. Measure lives can vary greatly. An air conditioner installed in a business can last 30 or more years if it is well maintained. In other facilities it may be removed after three years during a remodeling or major equipment up-grade activity. However, it is not uncommon to find measures still installed and performing well beyond their estimated useful life and in some cases for twice the estimated effective useful life. This is because the EUL is set at the *average* number of years the technology is expected to perform.

The remaining useful life (RUL) is the period of time over which the old technology being replaced is expected to have remained in place and functioning if the program would not have been offered to encourage the replacement of that old equipment with a new high efficiency model. The RUL used in evaluation is the expected average RUL across a type or category of technology. In some cases the participant's equipment has failed and is being would have been replaced regardless of the program, in other cases the program can induce a participant to replace the inefficient equipment years before the end of its life.

To establish the EUL and RUL of equipment offered in the Indiana Core Program portfolio the Evaluation Administrator has established a set of EUL/RUL tables covering the type of equipment offered through the Core programs. To established these tables, the Evaluation Administrator has assessed the measure life metrics used in evaluation research from other jurisdictions and examined the EUL/RUL research available. From this review the Evaluation Administrator has established a set of standard EUL/RUL tables that have been approved by the EM&V Subcommittee. These tables are provided below in this Appendix and will be used in Indiana's Core program evaluations.

Updating the RUL and EUL tables

Periodically there will be a need to update, modify or expand the EUL/RUL tables. As EUL or RUL research is conducted and as more measures are added to the Core Programs the tables will need to be updated. The Subcommittee will initiate the up-dating process. The up-dating process will follow the process for formally adapting the original tables. That is, the recommended change will be brought to the attention of the Subcommittee and the Subcommittee will vote on that recommended change. The revised tables will be incorporated into an updated version of the Framework.

Part of the evaluation efforts of Core Programs will be to ask participants when they would have replaced the program incented technology in the absence of the program. As these data become available and are statistically stable, they will be used to modify the RUL part of the EUL/RUL tables.

Use of RUL and EUL in estimating energy impacts

The EUL/RUL tables establish the time period over which different energy impact baselines will be used to estimate energy savings. For the time period of the RUL the energy efficiency of the old unit being replaced will act as the energy impact baseline. The baseline for the rest of the EUL (EUL minus the RUL) will be established by the methods specified in this Framework for establishing baselines for the evaluation of energy efficiency programs.

All evaluations will use the EUL/RUL tables in there evaluations to estimate energy impacts. As EUL/RUL tables are updated, the changes will be used prospectively to assess the energy impacts for the next program cycle.

RUL and EUL tables approved February 2010

Commercial and Industrial RUL and EUL table

Commercial & Industrial Measures	**Indiana Framework EUL Estimate of January 2013**	**Remaining Useful Life for retrofits and replacements that would have occurred without the program is set at 25% of EUL and rounded to nearest full year for annualized savings. New construction does not use a RUL baseline calculation and measures that would not normally be changed out without the program do not have an RUL.**
Air Compressor Upgrade	15	4
Air Side economizer	10	3
Anti-sweat heater controls	12	3
Bi-level stairwell dimming lighting (automatic)	8	2
CFL bulb	3.2	RUL does not apply; use EUL
CFL fixture	12	3
Chilled water reset controls	10	3
Chiller	20	5
Chiller tune up	5	1
Commercial clothes washer	10	3
Commercial plug load smart strip plug outlets	8	2
Compressed Air Engineered Nozzle	15	4
Cool roof	15	RUL does not apply; use EUL
Electric heat pump water heater	10	3
Energy star combination oven	12	3
Energy star convection oven	12	3
Energy star fryers	12	3
Energy star griddle	12	3
Energy star hot food holding cabinet	12	3

Energy star ice machine	9	2
Energy star room air conditioner	12	3
Flue Gas Heat Recovery and Economizer	22	6
Furnaces and Boilers	20	5
High performance glazing	30	8
Injecting molding barrel wrap	5	RUL does not apply; use EUL
Insulated pellet dryers	5	1
Interior and Exterior Lighting	15	4
Interior Lighting controls	8	2
LED exit signs	20	5
LED Fixture Replacements Interior	20	5
LED Fixtures Exterior	20	5
Light tube commercial skylight	10	RUL does not apply; use EUL
Metal Halide Fixture Ceramic	15	4
Metal Halide Fixture Pulse Start	15	4
Natural gas fired infrared heater	15	4
Packaged air conditioners	15	4
Packaged air Source Heat Pumps	15	4
Pump High Efficiency 1.5 HP or less	15	4
Pump High Efficiency 1.6 HP - 10 HP	15	4
Pump High Efficiency 10.1 to 25HP	15	4
Pump High Efficiency 25.1 and larger	15	4
Refrigerated / freezer door gaskets	4	1
Refrigerated Case LEDs	8.1	2
Refrigerated case night covers	5	1
Refrigerators	12	3
Roof insulation	20	5
Spray nozzles for food service	5	1
Stack damper	12	3
Steam cookers	12	3
Strip curtain for walk-in coolers and freezers	6	2
T-5 High Efficiency Lighting	15	4
T-8 High Efficiency Lighting	15	4
Traffic signals (LED bulbs)	10	3
Variable Frequency Drive	15	4
Vending machine lighting controls	5	1
Ventilation - Demand controlled (DCV)	10	3
Window film	15	4

Residential RUL and EUL table

Residential Measures	**Indiana Framework EUL Estimate of January 2013**	**Remaining Useful Life for retrofits and replacements that would have occurred without the program is set at 25% of EUL and rounded to nearest full year for annualized savings. New construction does not use a RUL baseline calculation and measures that would not normally be changed out without the program do not have an RUL.**
Air leakage sealing	20	RUL does not apply; use EUL
Air filter alarm	5	RUL does not apply; use EUL
Boiler replacement	20	5
Ceiling fan with energy star light fixture	10	RUL does not apply; use EUL
Central air conditioning	18	5
Central Air Source heat pump	18	5
CFL bulb	5	RUL does not apply; use EUL
Clothes washers	11	3
Duct insulation and leakage sealing	20	RUL does not apply; use EUL
EC motors on furnace fans	18	5
Electric heat pump water heater	10	3
Energy Star dehumidifier	12	3
Energy Star Dishwasher	11	3
Energy star room air conditioner recycling	3 (RUL only)	3
Faucet Aerators	10	RUL does not apply; use EUL
Ground Source Heat Pump	18	5
High Performance Windows	25	RUL does not apply; use EUL
Hot Water Tank Insulation	5	RUL does not apply; use EUL
HVAC maintenance/tune up	5	RUL does not apply; use EUL
Instantaneous water heaters	13	3
LED bulbs	15	RUL does not apply; use EUL
Low Flow Showerheads	5	RUL does not apply; use EUL
Opaque Shell Insulation (attic or envelope)	25	RUL does not apply; use EUL
Pipe insulation	15	RUL does not apply; use EUL
Premium efficiency pool pump motor	10	3
Refrigerator and/or freezer retirement	8 (RUL only)	8
Refrigerator Replacements	17	4
Residential new construction	40	RUL does not apply; use EUL
Room air conditioners	9	2
Setback thermostat	15	RUL does not apply; use EUL

Smart strip power strip	4	RUL does not apply; use EUL
Solar water heater with electric backup	20	5
TV - Energy Star	10	3
Two speed/variable speed pool pumps	10	3
Water heater	13	3
Whole-house residential retrofit	20	RUL does not apply; use EUL

Appendix D: Changes and Updates to Framework and TRM

The following table presents the sequence of changes and updates that have made to the Framework or the TRM since their original acceptance. As the Subcommittee adopts a change to the Framework or the TRM each change will be documented by updating the following table, and included as an Appendix in the updated Framework or TRM.

Change #	Date of SC acceptance	Section of Framework/TRM	Summary of the change and reason for the change
1	February 2013	Framework Appendix C: RUL / EUL tables	The first set of effective useful life – remaining useful life tables have been accepted by majority vote of the DSMCC and are adopted and incorporated into the Framework.
2			
3			
4			
5			
6			
7			
8			
9			
10			

Change # is the one-up number used to track each change.
Date of SC acceptance is the date on which the DSMCC EM&V Subcommittee voted to adopt the change.
Section of Framework/TRM is the title of the section of the Framework/TRM within which the change was made or the name of a new section that was added.
Summary of the change and reason for the change is a brief narrative summary of the change that was made and the reason for the change.

Indiana Technical Reference Manual

Version 2.2

July 28, 2015

Prepared for the:
Indiana Demand Side Management
Coordination Committee
EM&V Subcommittee

CADMUS
Opinion Dynamics
Integral Analytics
BuildingMetrics Incorporated

The Cadmus Group, Inc.

An Employee-Owned Company • www.cadmusgroup.com

This page left blank.

Prepared by:

Cadmus

Indiana Statewide Evaluation Team

Table of Contents

Acronyms

Acronym	Definition
ASHP	Air-source heat pump
CDD	Cooling degree days
DEER	Database of Energy Efficiency Resources
DHW	Domestic hot water
DSMCC	Demand Side Management Coordination Committee
ECM	Electronically commuted motor
EISA	Energy Independence and Security Act of 2007
HDD	Heating degree days
HERS	Home Energy Rating System
HID	High-intensity discharge
HPWH	Heat pump water heater
IECC	International Energy Conservation Code
MEF	Modified energy factor
O&M	Operations and maintenance
RESNET	Residential Energy Services Network
SHGC	Solar Heat Gain Coefficient
SRCC	Solar Rating and Certification Company
TRM	Technical Reference Manual
UDRH	User Defined Reference Home

Introduction

This technical reference manual (TRM) was developed at the request of the Indiana Demand Side Management Coordination Committee (DSMCC). It is based on the *Draft Ohio TRM* developed by the Vermont Energy Investment Corporation (VEIC) under contract to the Public Utility Commission of Ohio (PUCO). The DSMCC directed Indiana utilities to use the *Draft Ohio TRM* to develop program plans and *ex-ante* savings estimates. This project was to update the *Draft Ohio TRM* with Indiana-specific data for climate-sensitive measures and parameters, add additional measures as needed to support the DSMCC, and update all measures with more current information.

The savings estimates are expected to serve as representative, recommended values for calculating savings based on program-specific information. All information is presented on a per-unit basis. When using the measure-specific TRM information, it is helpful to keep the following notes in mind:

- The TRM clearly identifies whether the measure impacts pertain to retrofit, time of sale,[1] or early retirement program designs.
- Additional information about the program design is sometimes included in the measure description when it can affect savings and other parameters.
- Savings algorithms are provided for each measure. Several measures provide prescriptive values for each variable along with the output from the algorithm. That output is the deemed savings assumption. Other measures provide prescriptive values for only some variables, directing to use the actual value for other variables. In these cases of deemed calculations,– users should input actual efficiency program data (e.g., capacities or rated efficiencies of central air conditioners) to compute savings. Note that the TRM often provides example calculations for measures requiring actual values for illustrative purposes only.
- All estimates are for annual savings; however, parameters for calculating Lifetime savings (such as measure life) are also included.
- Unless otherwise noted, the measure life is defined as the life of an energy consuming measure, including its equipment life and measure persistence.
- Where provided, deemed values represent average savings that could be expected from the average measures installed that year.
- For non-weather-sensitive measures, peak savings are estimated whenever possible as the average of savings between 3:00 p.m. and 6:00 p.m. across all summer weekdays (the Indiana summer on-peak period).
- Wherever possible, savings estimates and other assumptions are based on Indiana or regional data. However, a number of assumptions are based on sources from other regions of the country. While this information is not perfectly transferable (due to differences in the definition

---

[1] In some jurisdictions, this is called replace on burn-out. We use the term time of sale because not all new equipment purchases take place when older, existing equipment reaches the end of its life.

of peak periods as well as in geography, climate, and customer mix), it was used because it was the most transferable and usable source available at the time.

- This TRM presents a combination of engineering equations and building energy simulation results. Engineering equations convey information clearly and transparently, and are widely accepted in the industry. The equations provide flexibility for users to substitute locally specific information and update some or all parameters as they become available on an ad hoc basis. One limitation is that certain interaction effects between end uses, such as how reductions in waste heat impact space conditioning, are not universally captured in this TRM. Such interactive factors are included in calculations for lighting measures. For measures where simple engineering equations do not adequately predict energy savings, simulation model results are presented. Engineering equations may also use parameters derived from simulation modeling. A description of the prototypical building models used in the simulations is shown in Appendix A.
- Many commercial and industrial measures are based on building energy simulations. This was typically done for complex, highly interactive measures, such as envelope improvements or chilled water resets. The building prototype assumptions are primarily based on California DEER prototypes, with adjustments based on data published by the U.S. Energy Information Administration *Commercial Building Energy Consumption Survey*.
- Early replacement measures show two levels of savings:
    - For an initial period during which the existing inefficient unit would have continued to be used had it not been replaced (with savings claimed between the existing unit and the efficient replacement).
    - For the remainder of the measure life, where the existing unit would have been replaced with a standard baseline unit (so savings are claimed between the standard baseline and the efficient replacement).

    We assume that accounting for this step-down adjustment in annual savings is possible in the utilities’ tracking systems. This TRM also provides the impact of the deferred replacement payment that would have occurred at the end of the useful life of the existing equipment.
- In general, the baselines are intended to represent average conditions in Indiana. Some baselines are from Indiana specific data, such as household consumption characteristics being provided by the Energy Information Administration. Other baselines are extrapolated from secondary sources, when Indiana data are not available. When weather adjustments were needed in extrapolations, weather conditions in all major Indiana cities were generally used as representative for their regions.

TRM Updating Process

Updates to the Indiana TRM should be initiated when:

1. Indiana impact evaluations have established sufficient evidence to suggest that a change to a specific calculation or variable;
2. When a code or standard has changed at the state or federal level; or
3. If the energy industry has adopted a new value, such as the uniformed methods project (UMP).

As such, it is not recommended that a change be initiated unless agreed upon by the Evaluation Administrator and Subcommittee based on evidence that is consistent.

Following Subcommittee instructions, at the end of each program cycle, the Evaluation Administrator will compare the TRM estimated gross *ex ante* impacts with the *ex post* evaluated energy impact results to assess whether savings levels are statistically different. If the measure-specific savings are statically different, and the cause of that difference is associated with typical installation, use conditions, a change in baseline conditions, or with a change in the efficiency level, the Evaluation Administrator will develop and recommend a new *ex ante* estimation approach to the Subcommittee. A majority vote by the Subcommittee is required to accept the recommendation and update the TRM.

Each change to the TRM will be documented similarly to the change documentation approach for updating the Indiana Evaluation Framework. That is, each change will be recorded in a *TRM Changes and Updates* located in Appendix E.

TRM Changes and Updates

Measure	Edit #	Major Edit Description	Date

Adding New Measures to the TRM

The third-party Program Administrator or independent Evaluation Administrator can recommend to the Subcommittee to add new measures to the TRM. Likewise, based on a majority vote, the Subcommittee can instruct the Evaluation Administrator to include a new measure in the TRM. New measures can be added to the TRM at any time, subject to Subcommittee approval.

Each measure section of the TRM presents the *ex-ante* calculation approach for estimating the projected energy impacts from program implementation efforts undertaken following the release date of this document.

Residential Market Sector

Appliances

Refrigerator and/or Freezer Retirement (Early Retirement)

	Measure Details
Official Measure Code	Res-Appl-Refrig/Freez-Recycle-1
Measure Unit	Per refrigerator or freezer
Measure Category	Appliances
Sector(s)	Residential
Annual Energy Savings (kWh)	Varies by appliance
Peak Demand Reduction (kW)	Varies by appliance
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	Varies by appliance
Lifetime Fossil Fuel Savings (MMBtu)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	0
Incremental Cost	Varies by appliance
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is the removal of an existing inefficient primary or secondary refrigerator or freezer from service, prior to its natural end of life (early retirement).[2] This measure target units greater than 10 years old, though it is expected that the average age will be greater than 20 years based on other similar program performance. Savings are calculated for the estimated energy consumption during the remaining life of the existing unit.

Definition of Efficient Equipment

The efficient condition is removal of an existing inefficient primary or secondary refrigerator or freezer from service.

---

[2] This measure assumes that a mix of primary and secondary units will be replaced (and the savings are reduced accordingly). By definition, a kitchen refrigerator that satisfies the majority of the household demand for refrigeration is the primary refrigerator. One or more additional refrigerators in the household that satisfy supplemental needs for refrigeration are secondary units.

Definition of Baseline Equipment

The baseline condition is an existing, inefficient unit that is in working order prior to being removed from service.

Deemed Lifetime of Efficient Equipment

The remaining useful life of the retired unit is 8 years.[3]

Deemed Measure Cost

The incremental cost for this measure is the actual cost associated with removing and recycling the retired unit.

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\Delta\text{kWh} = \text{UEC}_{\text{RETIRED}} * \text{F}_{\text{RUN TIME}}$$

Refrigerators

$$\text{UEC}_{\text{RETIRED}}\text{[4]} = 365.25 * [0.769 + (0.008 * Age) + (0.827 * F_{BEFORE\ 1990}) + (0.083 * Size) + (-1.316 * F_{SINGLE\ DOOR}) + (0.862 * F_{SIDE-BY-SIDE}) + (0.642 * F_{PRIMARY}) + (0.031 * CDD * F_{OUTDOOR}) + (-0.049 * HDD * F_{OUTDOOR})]$$

Where:

$\text{UEC}_{\text{RETIRED}}$ = Average *in situ* energy consumption of retired unit

365.25 = Days of operation per year

$\text{F}_{\text{RUN TIME}}$ = Run time adjustment factor

Age = Unit age in years

$\text{F}_{\text{BEFORE 1990}}$ = Percentage of units manufactured before 1990

Size = Unit size in cubic feet

$\text{F}_{\text{SINGLE DOOR}}$ = Percentage of units with a single door

$\text{F}_{\text{SIDE-BY-SIDE}}$ = Percentage of side-by-side units

---

[3] KEMA. *Residential Refrigerator Recycling Ninth Year Retention Study*. 2004.

[4] Regression model developed by Cadmus for the 2006-2008 California Appliance Recycling Program evaluation. See: Cadmus. *Residential Retrofit High Impact Measure Evaluation Report*. 2010. Available online: http://www.calmac.org/publications/FinalResidentialRetroEvaluationReport_11.pdf. Summary of model constants are in the Reference Tables section for this measure.

$F_{PRIMARY}$ = Percentage of units that are for primary use

CDD = Local cooling degree days per day

$F_{OUTDOOR}$ = Fraction of units that are located in garages or outdoors

HDD = Local heating degree days per day

For example, refrigerator model parameters derived for the NIPSCO Appliance Recycling Program are shown in the table below.[5]

Refrigerator Model Parameters for NIPSCO Appliance Recycling Program

Parameter	Value
Age	18.78
Before 1990	0.27
Size	20.17
Single door	0.11
Side-by-side	0.13
Primary	0.33
CDD	2.225
HDD	17.244
Outdoor	0.62
Run-time adjustment	0.828

This leads to the following savings:

$$\text{Refrigerator } \Delta\text{kWh} = 365.25 * [0.769 + (0.008 * 18.78) + (0.827 * 0.27) + (0.083 * 20.17) + (-1.316 * 0.11) + (0.862 * 0.13) + (0.642 * 0.33) + (0.031 * 2.225 * 0.62) + (-0.049 * 17.244 * 0.62)] * 0.828 = 761 \text{ kWh}$$

Freezers

$$UEC_{RETIRED}{}^{6} = 365.25 * [-0.372 + (0.036 * Age) + (0.632 * F_{BEFORE\ 1990}) + (0.107 * Size) + (-0.293 * F_{CHEST}) + (0.047 * CDD * F_{OUTDOOR}) + (-0.052 * HDD * F_{OUTDOOR})]$$

Where:

F_{CHEST} = Percentage of chest freezer units

---

[5] TecMarket Works. *Evaluation of the NIPSCO Appliance Recycling Program*. 2012.

[6] Regression model developed by Cadmus for the 2006-2008 California Appliance Recycling Program evaluation. See: Cadmus. *Residential Retrofit High Impact Measure Evaluation Report.* 2010. Available online: http://www.calmac.org/publications/FinalResidentialRetroEvaluationReport_11.pdf. Summary of model constants are in the Reference Tables section for this measure.

This approach was applied to recycling program evaluations for NIPSCO, Vectren, and I&M. The unit energy-savings values varied in each program due to characteristics of the recycled units. The results are shown below.

Unit Energy Saving Results for Several Program Evaluations

Utility	Refrigerator (kWh/unit)	Freezer (kWh/unit)
NIPSCO	761	886
I&M	1,068	946
Vectren	1,093	993
Average	**1,036**	**942**

This TRM uses the average of the above values as the statewide savings estimate.

Summer Peak Coincident Demand Reduction

$$\Delta \text{kW} = \frac{\Delta kWh}{8,760} * TAF * LSAF$$

Where:

TAF = Temperature adjustment factor (= 1.21)[7]

LSAF = Load shape adjustment factor (= 1.063)[8]

This approach was applied to recycling program evaluations for NIPSCO, Vectren, and I&M. The unit demand reduction values vary due to characteristics of the recycled units. The results are shown in the table below.

Unit Demand Reduction Results for Several Program Evaluations

Utility	Refrigerator (kW/unit)	Freezer (kW/unit)
NIPSCO	0.112	0.130
I&M	0.157	0.139
Vectren	0.160	0.146
Average	**0.152**	**0.138**

This TRM uses the average of these values as the statewide savings estimate.

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.

---

[7] Blasnik, Michael. *Measurement and Verification of Residential Refrigerator Energy Use, Final Report, 2003-2004 Metering Study*. July 29, 2004. (p. 47 assumes that 85% of homes have air conditioning).

[8] Ibid. (p. 48, extrapolated by taking the ratio of existing summer to existing annual profile for hours ending 16 through 18, and multiplying by new annual profile).

Reference Tables

Regression Model Coefficients for Refrigerators*

Independent Variables	Coefficient	p-Value	VIF
Regression Model Intercept	0.769	<.0001	0
Age Coefficient (years)	0.008	0.016	2
Dummy: Unit Manufactured Pre-1990 Coefficient	0.827	<.0001	1.7
Size Coefficient (cubic feet)	0.083	<.0001	1.9
Dummy: Single Door Coefficient	-1.316	<.0001	1.3
Dummy: Side-by-Side Coefficient	0.862	<.0001	1.6
Dummy: Primary Appliance Coefficient	0.642	<.0001	1.5
CDD * Fraction Outdoor Coefficient	0.031	<.0001	1.3
HDD * Fraction Outdoor Coefficient	-0.049	<.0001	1.2

* Cadmus estimated this model for Vectren based on monitored data in California and Michigan.

Regression Model Coefficients for Freezers*

Independent Variables	Coefficient	p-Value	VIF
Regression Model Intercept	-0.372	0.043	0
Age Coefficient (years)	0.036	<.0001	2
Dummy: Unit Manufactured Pre-1990 Coefficient	0.632	<.0001	2.1
Size Coefficient (cubic feet)	0.107	<.0001	1.2
Dummy: Chest Freezer Coefficient	-0.293	<.0001	1.2
CDD * Fraction Outdoor Coefficient	0.047	<.0001	1.1
HDD * Fraction Outdoor Coefficient	-0.052	<.0001	1

* Cadmus estimated this model for Vectren based on monitored data in California and Michigan.

Efficient Refrigerator – ENERGY STAR and CEE TIER 2 (Time of Sale)

	Measure Details
Official Measure Code	Res-Appl-Refrig/Freez-TOS-1
Measure Unit	Per refrigerator
Measure Category	Appliances
Sector(s)	Residential
Annual Energy Savings (kWh)	Varies by appliance
Peak Demand Reduction (kW)	Varies by appliance
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	Varies by appliance
Lifetime Fossil Fuel Savings (MMBtu)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	17
Incremental Cost	Varies by appliance
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is installing a new refrigerator meeting either ENERGY STAR or CEE TIER 2 specifications (defined as requiring ≥ 20% and ≥25% less energy consumption than an equivalent unit meeting federal standard requirements, respectively).

Definition of Efficient Equipment

The efficient condition is a new refrigerator meeting either the ENERGY STAR or CEE TIER 2 efficiency standards.

Definition of Baseline Equipment

The baseline condition is a new refrigerator meeting the minimum federal efficiency standard for refrigerators.

Deemed Lifetime of Efficient Equipment

The measure life is 17 years.[9]

---

[9] This is consistent with Efficiency Vermont and New Jersey TRMs.

Deemed Measure Cost

The incremental cost for this measure is $30.00[10] for an ENERGY STAR unit and $140.00[11] for a CEE Tier 2 unit.

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\Delta\text{kWh} = UEC_{BASE} - UEC_{ES}$$

Where:

UEC_{BASE} = Annual energy consumption of baseline unit[12]

Bottom Freezer = 650 kWh

Top Freezer = 415 kWh

Side-by-Side = 729 kWh

UEC_{ES} = Annual energy consumption of ENERGY STAR unit (= 20% less than baseline)

Bottom Freezer = 520 kWh

Top Freezer = 332 kWh

Side-by-Side = 583 kWh

Or

= Annual energy consumption of CEE Tier 2 unit (= 25% less than baseline)

Bottom Freezer = 488 kWh

Top Freezer = 311 kWh

Side-by-Side = 547 kWh

---

[10] From ENERGY STAR calculator: http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Consumer_Residential_Refrig_Sav_Calc.xls

[11] Based on weighted average of units participating in Efficiency Vermont program and retail cost data provided in: U.S. Department of Energy. *TECHNICAL REPORT: Analysis of Amended Energy Conservation Standards for Residential Refrigerator-Freezers*. October 2005. Available online: http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/refrigerator_report_1.pdf

[12] This is the approximate average consumption of a typical baseline refrigerator at federal standard efficiency levels; see: http://www.energystar.gov/index.cfm?fuseaction=refrig.display_products_excel

The above equation leads to these savings from ENERGY STAR units:

Bottom Freezer = 650 – 520 (= 130 kWh)

Top Freezer = 415 – 332 (= 83 kWh)

Side-by-Side = 729 – 583 (= 146 kWh)

The above equation leads to these savings from CEE Tier 2 units:

Bottom Freezer = 650 – 488 (= 162 kWh)

Top Freezer = 415 – 311 (= 104 kWh)

Side-by-Side = 729 – 547 (= 182 kWh)

Summer Peak Coincident Demand Reduction

$$\Delta\text{kW} = \frac{\Delta kWh}{8{,}760} * TAF * LSAF$$

Where:

TAF = Temperature adjustment factor (= 1.21)[13]

LSAF = Load shape adjustment factor (= 1.124)[14]

The above equation leads to these demand reductions from ENERGY STAR units:

Bottom Freezer = $\frac{130}{8{,}760} * 1.21 * 1.124$ = 0.020 kW

Top Freezer = $\frac{83}{8{,}760} * 1.21 * 1.124$ = 0.013 kW

Side-by-Side = $\frac{146}{8{,}760} * 1.21 * 1.124$ = 0.023 kW

The above equation leads to these demand reductions from CEE Tier 2 units:

Bottom Freezer = $\frac{162}{8{,}760} * 1.21 * 1.124$ = 0.025 kW

Top Freezer = $\frac{104}{8{,}760} * 1.21 * 1.124$ = 0.016 kW

Side-by-Side = $\frac{182}{8{,}760} * 1.21 * 1.124$ = 0.028 kW

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.

---

[13] Blasnik, Michael. *Measurement and Verification of Residential Refrigerator Energy Use, Final Report, 2003-2004 Metering Study*. July 29, 2004. (p. 47 assumes that 85% of homes have central air conditioning).

[14] Ibid. (p. 48, extrapolated by taking the ratio of existing summer to existing annual profile for hours ending 16 through 18, and multiplying by new annual profile).

Reference Table

Deemed Measure Savings

Efficiency Level	Refrigerator Configuration	Average Annual kWh Savings per Unit	Average Summer Peak Coincident kW Savings per Unit	Average Annual Fossil Fuel Heating MMBtu Savings per Unit
ENERGY STAR	Bottom Freezer	130	0.020	n/a
	Top Freezer	83	0.013	
	Side-by-Side	146	0.023	
CEE Tier 2	Bottom Freezer	162	0.025	n/a
	Top Freezer	104	0.016	
	Side-by-Side	182	0.028	

Refrigerator Replacement (Low Income, Early Replacement)

	Measure Details
Official Measure Code	Res-Appl-Refrig-LI-1
Measure Unit	Per refrigerator
Measure Category	Appliances
Sector(s)	Residential
Annual Energy Savings (kWh)	Varies by measure age
Peak Demand Reduction (kW)	Varies by measure age
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	Varies by measure age
Lifetime Fossil Fuel Savings (MMBtu)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	17
Incremental Cost	$490.73
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is the early removal of an existing inefficient refrigerator from service, prior to its natural end of life, and replacement with a new ENERGY STAR-qualifying unit. This measure is suitable for low income and home performance programs. Savings are calculated for the estimated energy consumption during the remaining life of the existing unit.

Definition of Efficient Equipment

The efficient condition is a new replacement refrigerator meeting the ENERGY STAR efficiency standard (defined as requiring ≥ 20% less energy consumption than an equivalent unit meeting federal standard requirements).

Definition of Baseline Equipment

The baseline condition is the existing inefficient refrigerator being used for the remaining assumed useful life of the unit. Then, for the remainder of the measure life, the baseline becomes a new refrigerator meeting the minimum federal efficiency standard.

Deemed Lifetime of Efficient Equipment

The measure life is 17 years.[15]

---

[15] This is consistent with Efficiency Vermont and New Jersey TRMs.

The assumed remaining useful life of the existing refrigerator being replaced is 8 years.[16]

Deemed Measure Cost

The net present value of the deferred replacement cost (the cost associated with replacing the existing unit with a standard unit that would have had to occur in 8 years had the existing unit not been replaced) is $490.73.[17]

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\Delta\text{kWh for remaining life of existing unit (first 8 years)} = UEC_{EXISTING} - UEC_{ES}$$

$$\Delta\text{kWh for remaining measure life (next 9 years)} = UEC_{BASE} - UEC_{ES}$$

Where:

$UEC_{EXISTING}$ = Unit energy consumption of existing refrigerator (= 1,696 kWh)[18]

UEC_{ES} = Unit energy consumption of new ENERGY STAR refrigerator (= 397 kWh)[19]

UEC_{BASE} = Unit energy consumption of new baseline refrigerator (= 453 kWh)[20]

---

[16] KEMA. *Residential Refrigerator Recycling Ninth Year Retention Study*. 2004.

[17] Determined by calculating the net present value (with a 5% discount rate) of the annuity payments from years 9 to 17 of a deferred replacement of a standard efficiency unit costing $1,150.00 (from ENERGY STAR calculator, available online: http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Consumer_Residential_Refrig_Sav_Calc.xls).

[18] Navigant Consulting. *AEP Ohio Energy Efficiency/Demand Response Plan Year 1 (1/1/2009-12/31/2009) Program Year Evaluation Report: Appliance Recycling Program*. March 9, 2010. (Used regression-based savings estimates and part-use factors for primary refrigerators, multiplied by an in situ factor of 0.85 as discussed in the Refrigerator and/or Freezer Retirement (Early Retirement) measure section.)

[19] Approximate average consumption of typical ENERGY STAR refrigerator: http://www.energystar.gov/index.cfm?fuseaction=refrig.display_products_excel

[20] Approximate average consumption of typical baseline refrigerator at federal standard efficiency levels: http://www.energystar.gov/index.cfm?fuseaction=refrig.display_products_excel

ΔkWh for remaining life of existing unit (first 8 years) = 1,696 – 397 = 1,299 kWh

ΔkWh for remaining measure life (next 9 years) = 453 – 397 = 56 kWh

Summer Peak Coincident Demand Reduction

$$\Delta kW = \frac{\Delta kWh}{8{,}760} * TAF * LSAF$$

$$\Delta kW \text{ for existing unit remaining life (first 8 years)} = \left[\left(\frac{UEC_{EXISTING}}{8760} * LSAF_{EXIST}\right) - \left(\frac{UEC_{ES}}{8{,}760} * LSAF_{NEW}\right)\right] * TAF$$

$$\Delta kW \text{ for remaining measure life (next 9 years)} = \left(\frac{UEC_{EXISTING} - UEC_{ES}}{8{,}760}\right) * TAF * LSAF_{NEW}$$

Where:

TAF = Temperature adjustment factor (= 1.21)[21]

$LSAF_{exist}$ = Load shape adjustment factor for existing unit (= 1.063)[22]

$LSAF_{new}$ = Load shape adjustment factor for new unit (= 1.124)[23]

$$\Delta kW \text{ for existing unit remaining life (first 8 years)} = \frac{1{,}696}{8{,}760} * 1.21 * 1.063 - \frac{397}{8{,}760} * 1.21 * 1.124 = 0.187 \text{ kW}$$

$$\Delta kW \text{ for remaining measure life (next 9 years)} = \frac{56}{8{,}760} * 1.21 * 1.124 = 0.009 \text{ kW}$$

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.

---

[21] Blasnik, Michael. *Measurement and Verification of Residential Refrigerator Energy Use, Final Report, 2003-2004 Metering Study*. July 29, 2004. (p. 47 assumes 85% of homes have central air conditioning).

[22] Ibid. p. 48. Assumed existing unit summer average LSAF for hours ending 16 through 18.

[23] Ibid. p. 48. Extrapolated daily load shape adjustment factor by taking the ratio of existing summer to existing annual profile for hours ending 16 through 18, multiplied by the new annual profile.

Clothes Washer – ENERGY STAR and CEE TIER 3 (Time of Sale)

	Measure Details
Official Measure Code	Res-Appl-CloWash-1
Measure Unit	Per clothes washer
Measure Category	Appliances
Sector(s)	Residential
Annual Energy Savings (kWh)	Varies by efficiency level
Peak Demand Reduction (kW)	Varies by efficiency level
Annual Fossil Fuel Savings (MMBtu)	Varies by efficiency level
Lifetime Energy Savings (kWh)	Varies by efficiency level
Lifetime Fossil Fuel Savings (MMBtu)	Varies by efficiency level
Water Savings (gal/yr)	Varies by efficiency level
Effective Useful Life (years)	11
Incremental Cost	Varies by efficiency level
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is purchasing (time of sale) and installing a clothes washer exceeding either the ENERGY STAR or CEE Tier 2 minimum qualifying efficiency standards presented in the table below.

Minimum Qualifying ENERGY STAR or CEE Tier 2 Efficiency Standards

Efficiency Level	Modified Energy Factor	Water Factor
Federal Standard	≥ 1.26	No requirement
ENERGY STAR (as of January 1, 2011)	≥ 2.00	≤ 6.0
CEE Tier 2	≥ 2.20	≤ 4.5

The MEF measures the total energy consumption of the laundry cycle (washing and drying). It indicates the number of cubic feet of laundry that can be washed and dried with one kilowatt-hour of electricity; the higher the number, the greater the efficiency.

The water factor is the number of gallons needed for each cubic foot of laundry. A lower number indicates lower consumption and a more efficient use of water.

Definition of Efficient Equipment

The efficient condition is a clothes washer meeting either the ENERGY STAR or CEE Tier 2 efficiency criteria presented in the table above.

Definition of Baseline Equipment

The baseline condition is a clothes washer at the minimum federal baseline efficiency presented in the table above.

Deemed Lifetime of Efficient Equipment

The measure life is 11 years.[24]

Deemed Measure Cost

The incremental cost is $210.12 for an ENERGY STAR unit and $215.90 for a CEE Tier 2 unit. [25]

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

Savings are determined by applying the proportion of consumption used for water heating and clothes washer and clothes dryer operation to MEF assumptions, then to the mix of DHW heating fuels and dryer fuels (while factoring in savings from reduced water usage).

The key assumptions and their sources are:

Washer Volume = 3.23 cubic feet[26]
Baseline MEF = 1.26
ENERGY STAR MEF = 2.0
CEE Tier 2 MEF = 2.2
Number of cycles per year = 320[27]
Percentage of energy consumption for water heating and clothes washer and dryer operation = 26%, 7%, and 67% (respectively)[28]

---

[24] "ENERGY STAR Certified Products." http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=CW

[25] Itron, Inc. 2010-2012 WO017 Ex Ante Measure Cost Study Final Report. May 27, 2014. Submitted to the California Public Utilities Commission.

[26] Average unit size from Efficiency Vermont program.

[27] U.S. Energy Information Administration. 2005 Residential Energy Consumption Survey (RECS) for East North Central Census Division. Available online: http://www.eia.doe.gov/emeu/recs/recs2005/hc2005_tables/hc8waterheating/pdf/tablehc12.8.pdf (weighted average).

[28] U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy. Clothes Washer Technical Support Document. Chapter 4 Engineering Analysis, Table 4.1, Page 4-5. Available online: http://www.eere.energy.gov/buildings/appliance_standards/residential/pdfs/chapter_4_engineering.pdf

Average gallons of water savings per load[29] = ENERGY STAR = 19.6; CEE Tier 2= 22.4

Community/municipal water and wastewater pump savings per gallon water saved = 0.0039 kWh[30]

Indiana Domestic Hot Water Fuel Mix

Fuel	Percentage of Homes*
Electric	27%
Natural Gas	63%
Other	10%

* U.S. Energy Information Administration. *2005 Residential Energy Consumption Survey (RECS) for East North Central Census Division*. Available online: http://www.eia.doe.gov/emeu/recs/recs2005/hc2005_tables/hc8waterheating/pdf/tablehc12.8.pdf

Indiana Dryer Fuel Mix

Fuel	Percentage of Homes*
Electric	66%
Natural Gas	34%

* U.S. Energy Information Administration. *2005 Residential Energy Consumption Survey (RECS) for East North Central Census Division*. Available online: http://www.eia.doe.gov/emeu/recs/recs2005/hc2005_tables/hc8waterheating/pdf/tablehc12.8.pdf

$$\Delta kWh_{ENERGY\ STAR} = 202\ kWh$$

$$\Delta kWh_{CEE\ TIER\ 2} = 233\ kWh$$

Summer Peak Coincident Demand Reduction

$$\Delta kW = \frac{\Delta\, kWh}{Hours} * CF$$

---

[29] Determined by dividing gallons per load assumption from ENERGY STAR calculator by water factor (gallons per cubic foot) to determine cubic feet assumption, then multiplying by each efficient case water factor.

[30] Efficiency Vermont. (Analysis revealed 0.0024 kWh pump energy consumption per gallon of water supplied, and 0.0015 kWh consumption per gallon for waste water treatment.)

Where:

Hours = Assumed run hours of clothes washer (= 320)[31]

CF = Summer peak coincidence factor (= 0.045)[32]

$$\Delta kW_{ENERGY\ STAR} = \frac{202}{320} * 0.045 = 0.028\ kW$$

$$\Delta kW_{CEE\ TIER\ 2} = \frac{233}{320} * 0.045 = 0.033\ kW$$

Fossil Fuel Impact Descriptions and Calculation

Fossil fuel savings are based on the mix of DHW heating fuels and dryer fuels.

- ENERGY STAR unit savings = 0.447 MMBtu
- CEE Tier 2 unit savings = 0.516 MMBtu

Water Impact Descriptions and Calculation

- ENERGY STAR unit savings = 6,265 gallons
- CEE Tier 2 unit savings = 7,160 gallons

Reference Table

Deemed Measure Savings

	Average Annual kWh Savings per Unit	Average Summer Peak Coincident kW Savings per Unit	Average Annual Fossil Fuel Heating MMBtu Savings per Unit	Average Annual Water Gallon Savings per Unit
ENERGY STAR	202	0.028	0.447	6,265
CEE Tier 2	233	0.033	0.516	7,160

---

[31] U.S. Energy Information Administration. *2005 Residential Energy Consumption Survey (RECS) for East North Central Census Division.* Available online: http://www.eia.doe.gov/emeu/recs/recs2005/hc2005_tables/hc10homeappliaceindicators/pdf/tablehc11.10.pdf (used weighted average number of cycles from CW worksheet and 1 hour average per cycle).

[32] Calculated from Itron eShapes, which is 8,760 hourly data by end use for Upstate New York, adjusted for Ohio peak definitions.

ENERGY STAR Dishwasher

	Measure Details
Official Measure Code	Res-Appl-DishWash-1
Measure Unit	Per dishwasher
Measure Category	Appliances
Sector(s)	Residential
Annual Energy Savings (kWh)	77 (natural gas water heater) 150 (electric water heater)
Peak Demand Reduction (kW)	0.027 (natural gas water heater) 0.052 (electric water heater)
Annual Fossil Fuel Savings (MMBtu)	1.3
Lifetime Energy Savings (kWh)	777 (natural gas water heater) 1,650 (electric water heater)
Lifetime Fossil Fuel Savings (MMBtu)	14.3
Water Savings (gal/yr)	TBD
Effective Useful Life (years)	11
Incremental Cost	$211.00
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is a residential dishwasher meeting the minimum ENERGY STAR qualifying efficiency standards. These dishwashers are assumed to be located within a residential unit.

Definition of Efficient Equipment

The efficient condition is a new dishwasher meeting the ENERGY STAR Tier 2 requirements (EF ≥ 0.68).

Definition of Baseline Equipment

The baseline condition is a new dishwasher meeting minimum federal appliance standards (EF = 0.46).

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 11 years.

Deemed Measure Cost

The incremental cost for this measure is $211.00.

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

Energy savings and demand reduction were determined using the U.S. Environmental Protection Agency ENERGY STAR dishwasher calculator.[33]

Annual kWh Savings = 77 kWh (natural gas water heater)
= 150 kWh (electric water heater)

Summer Peak Coincident Demand Reduction

Summer peak coincident factor savings = 0.027 kW (natural gas water heater)
= 0.052 kW (electric water heater)

Fossil Fuel Impact Descriptions and Calculation

Annual MMBtu savings = 1.300 (natural gas water heater only)

---

[33] Available online: www.energystar.gov

ENERGY STAR Dehumidifier (Time of Sale)

	Measure Details
Official Measure Code	Res-Appl-ES Dehumid-1
Measure Unit	Per dehumidifier
Measure Category	Appliances
Sector(s)	Residential
Annual Energy Savings (kWh)	Varies by capacity
Peak Demand Reduction (kW)	Varies by capacity
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	Varies by capacity
Lifetime Fossil Fuel Savings (MMBtu)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	12
Incremental Cost	$45.00
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is purchasing and installing a dehumidifier meeting the minimum ENERGY STAR qualifying efficiency standard established on October 1, 2006 in a residential setting in place of a unit that meets the minimum federal standard efficiency.

Definition of Efficient Equipment

To qualify, the new dehumidifier must meet the ENERGY STAR standards as of October 1, 2006, outlined in the table below.

Minimum ENERGY STAR Dehumidifier Standards

Capacity (pints/day)	ENERGY STAR Criteria (L/kWh)
≤ 25	≥ 1.20
> 25 to ≤ 35	≥ 1.40
> 35 to ≤ 45	≥ 1.50
> 45 to ≤ 54	≥ 1.60
> 54 to ≤ 75	≥ 1.80
> 75 to ≤ 185	≥ 2.50

Definition of Baseline Equipment

The baseline condition is a new dehumidifier that meets the federal efficiency standards outlined in the table below.

Minimum Federal Dehumidifier Standards

Capacity (pints/day)	Federal Standard Criteria (L/kWh)
≤ 25	≥ 1.10
> 25 to ≤ 35	≥ 1.20
> 35 to ≤ 45	≥ 1.20
> 45 to ≤ 54	≥ 1.23
> 54 to ≤ 75	≥ 1.55
> 75 to ≤ 185	≥ 1.90

Deemed Lifetime of Efficient Equipment

The assumed lifetime of the measure is 12 years.[34]

Deemed Measure Cost

The assumed incremental capital cost for this measure is $45.00.[35]

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\Delta kWh = C * \frac{0.473}{24} * \frac{Hours}{\frac{L}{kWh}}$$

Where:

C = Average capacity of dehumidifier in pints per day

0.473 = Constant to convert pints to liters

24 = Hours in a day

Hours = Run hours per year (= 1,620)[36]

L/kWh = Liters of water consumed per kilowatt-hour (= based on capacity; see tables above)

---

[34] ENERGY STAR Dehumidifier Calculator http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDehumidifier.xls

[35] Based on available data from the U.S. Department of Energy's lifecycle cost analysis spreadsheet available from: http://www1.eere.energy.gov/buildings/appliance_standards/residential/docs/lcc_dehumidifier.xls

[36] ENERGY STAR Dehumidifier Calculator http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDehumidifier.xls

The annual kilowatt-hour calculation results for each capacity class are presented in the table below.

Annual Dehumidifier Savings by Capacity

Capacity Range	Pints Used Per Day	ENERGY STAR	Federal Standard	Savings (kWh)
≤ 25	22.4	596	650	54
> 25 to ≤ 35	30	684	798	114
> 35 to ≤ 45	40	851	1,064	213
> 45 to ≤ 54	49.5	988	1,285	297
> 54 to ≤ 75	64.5	1,144	1,329	185
> 75 to ≤ 185	92.8	1,185	1559	374

Summer Peak Coincident Demand Reduction

$$\Delta\text{kW} = \frac{\Delta kWh}{Hours} * CF$$

Where:

CF = Summer peak coincidence factor (= 0.37)[37]

The peak coincident demand calculation results for each capacity class is presented in the table below.

Summer Peak Coincident Demand Reduction by Capacity

Capacity Range	Pints Used per Day	ENERGY STAR	Federal Standard	Demand Reduction (kW)
≤ 25	22.4	0.136	0.148	0.012
> 25 to ≤ 35	30	0.156	0.182	0.027
> 35 to ≤ 45	40	0.194	0.242	0.048
> 45 to ≤ 54	49.5	0.225	0.293	0.068
> 54 to ≤ 75	64.5	0.261	0.303	0.042
> 75 to ≤ 185	92.8	0.270	0.355	0.085

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.

---

[37] Based on usage being evenly distributed day vs. night and weekend vs. weekday, and dehumidifier being used from April through September (for 4,392 possible hours). The ENERGY STAR Dehumidifier Calculator lists 1,620 operating hours; therefore the summer peak coincidence is: 1,620/4,392 = 36.9%.

ENERGY STAR Room Air Conditioner (Time of Sale)

	Measure Details
Official Measure Code	Res-Appl-ES RAC-TOS-1
Measure Unit	Per air conditioning unit
Measure Category	Appliances
Sector(s)	Residential
Annual Energy Savings (kWh)	Varies by location
Peak Demand Reduction (kW)	Varies by location
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	Varies by location
Lifetime Fossil Fuel Savings (MMBtu)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	9
Incremental Cost	
Important Comments	$40.00
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is purchasing and installing a room air conditioning unit that meets either the ENERGY STAR or CEE Tier 1 minimum qualifying efficiency specifications, in place of a baseline unit meeting minimum federal standard efficiency ratings presented in the table below.

Minimum Qualifying Room Air Conditioner Efficiency Specifications

Product Class (Btu/hr)	Federal Standard (EER)	ENERGY STAR (EER)	CEE Tier 1 (EER)
8,000 to 13,999	≥ 10.9	≥ 11.3	≥ 11.3

Definition of Efficient Equipment

The efficient condition is a new room air conditioning unit meeting either the ENERGY STAR of CEE Tier 1 efficiency standards presented in the table above.

Definition of Baseline Equipment

The baseline condition is a new room air conditioning unit meeting the minimum federal efficiency standards presented in the table above.

Deemed Lifetime of Efficient Equipment

The measure life is 9 years.[38]

Deemed Measure Cost

Until 2013, the incremental cost was $40.00 for an ENERGY STAR unit and $80.00 for a CEE Tier 1 unit.[39] Now that each share efficiency standards, the incremental cost for each is determined to be $40.00

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\Delta kWh = EFLH_{COOL} * Btuh * \frac{\frac{1}{EER_{BASE}} - \frac{1}{EER_{EE}}}{1{,}000}$$

Where:

$EFLH_{COOL}$ = Equivalent full load hours of room air conditioning unit (= depends on location;[40] see table below)

Equivalent Full Load Hours by City

City	$EFLH_{COOL}$
Indianapolis	332
South Bend	288
Evansville	445
Ft. Wayne	257
Terre Haute	391

---

[38] This value was based on the ENERGY STAR value for room air conditioners: www.energystar.gov

[39] Based on field study conducted by Efficiency Vermont.

[40] Based on CDD adjusted values from: RLW Analytics. *Final Report Coincidence Factor Study Residential Room Air Conditioners.* June 23, 2008.

Btuh = Average size of rebated unit (=11,357)[41]

EER_{BASE} = Efficiency of baseline unit (= 10.9)[42]

EER_{EE} = Efficiency of new unit (= 11.3 for ENERGY STAR; = 11.3 for CEE Tier 1)[43]

For example, the energy savings from installing a room air conditioning unit in Indianapolis would be:

$$\Delta kWh_{ENERGY\ STAR} = 332 * 11{,}357 * \frac{\frac{1}{10.9} - \frac{1}{11.3}}{1{,}000} = 12$$

$$\Delta kWh_{CEE\ TIER\ 1} = 332 * 11{,}357 * \frac{\frac{1}{10.9} - \frac{1}{11.3}}{1{,}000} = 12$$

Summer Peak Coincident Demand Reduction

$$\Delta kW = Btuh * \frac{\frac{1}{EER_{BASE}} - \frac{1}{EER_{eEE}}}{1{,}000} * CF$$

Where:

CF = Summer peak coincidence factor (= 0.3)[44]

For example, the energy savings from installing a room air conditioning unit in Indianapolis would be:

$$\Delta kW_{ENERGY\ STAR} = 11{,}357 * \frac{\frac{1}{10.9} - \frac{1}{11.3}}{1{,}000} * 0.3 = 0.011\ kW$$

$$\Delta kW_{CEE\ TIER\ 1} = 11{,}357 * \frac{\frac{1}{10.9} - \frac{1}{11.3}}{1{,}000} * 0.3 = 0.011\ kW$$

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.

---

[41] ENERGY STAR. "ENERGY STAR Certified Room Air Conditioners." http://www.energystar.gov/productfinder/product/certified-room-air-conditioners/.

[42] Minimum Federal Standard for capacity range. 2015 Federal Energy Conservation Standard for Room ACs (e-CFR Title 10, Chapter II, Subchapter D, Part 430, Subpart C, Section 430.32)

[43] This is the minimum qualifying standards. http://library.cee1.org/sites/default/files/library/9296/CEE_ResApp_RoomAirConditionerSpecification_2003_Updated_Again.pdf

[44] RLW Analytics. *Final Report Coincidence Factor Study Residential Room Air Conditioners*. June 23, 2008. Available online: http://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/117_RLW_CF%20Res%20RAC.pdf

ENERGY STAR Room Air Conditioner Replacement (Low Income, Early Replacement)

	Measure Details
Official Measure Code	Res-Appl-ES RAC-LI-1
Measure Unit	Per air conditioning unit
Measure Category	Appliances
Sector(s)	Residential
Annual Energy Savings (kWh)	Varies by location
Peak Demand Reduction (kW)	Varies by location
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	Varies by location
Lifetime Fossil Fuel Savings (MMBtu)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	12
Incremental Cost	Varies by efficiency rating
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is the early removal of an existing inefficient room air conditioner unit from service, prior to its natural end of life, and replacing with a new ENERGY STAR qualifying unit. This measure is suitable for low income and home performance programs. Savings are calculated as the difference between existing unit and efficient unit consumption during the remaining life of the existing unit, and between the new baseline unit and efficient unit consumption for the remainder of the measure life.

Definition of Efficient Equipment

The efficient condition is a new replacement room air conditioning unit meeting the ENERGY STAR efficiency standard (i.e., an efficiency rating greater than or equal to 10.8 EER).

Definition of Baseline Equipment

The baseline condition is the existing inefficient room air conditioning unit for the remaining assumed useful life of the unit; then, for the remainder of the measure life, the baseline becomes a new replacement unit meeting the minimum federal efficiency standard (i.e., an efficiency rating greater than or equal to 9.8 EER).

Deemed Lifetime of Efficient Equipment

The measure life is 12 years.[45]

For dual baseline purposes, the assumed remaining useful life of the existing room air conditioning unit being replaced is 3 years.[46]

Deemed Measure Cost

The actual measure cost for removing the existing unit and installing the new unit should be used.

Deemed O&M Cost Adjustments

The net present value of the deferred replacement cost (the cost associated with replacing the existing unit with a standard unit that would have occurred within three years had the existing unit not been replaced) should be calculated as:

Cost of ENERGY STAR unit - $50 (incremental cost of ENERGY STAR unit over baseline unit)[47] * 69%[48]

Savings Algorithm

Energy Savings

$$\Delta\text{kWh for remaining life of existing unit (first 3 years)} = EFLH_{COOL} * BtuH * \frac{\frac{1}{EER_{EXIST}} - \frac{1}{EER_{EE}}}{1{,}000}$$

$$\Delta\text{kWh for remaining measure life (next 9 years)} = EFLH_{COOL} * BtuH * \frac{\frac{1}{EER_{BASE}} - \frac{1}{EER_{EE}}}{1{,}000}$$

---

[45] GDS Associates. *Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures*. June 2007. Available online: http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf

[46] Based on Connecticut TRM; Connecticut Energy Efficiency Fund; CL&P and UI Program Savings Documentation for2008 Program Year

[47] Per the ENERGY STAR calculator, ENERGY STAR units are $220.00 while baseline units are $170.00; see http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerRoomAC.xls

[48] This 69% is the ratio of the net present value (with a 5% discount rate) of the annuity payments from years 4 to 12 of a deferred replacement of a standard efficiency unit costing $170.00, divided by the standard efficiency unit cost (also $170.00). The calculation allows for use of the known ENERGY STAR replacement cost to calculate an appropriate baseline replacement cost.

Where:

$EFLH_{COOL}$ = Equivalent full load hours of room air conditioning unit (= dependent on location;[49] see table below)

Equivalent Full Load Hours by Location

City	$\text{EFLH}_{\text{COOL}}$
Indianapolis	332
South Bend	288
Evansville	445
Ft. Wayne	257
Terre Haute	391

Btuh = Average size of rebated unit (= 11,357)[50]

$\text{EER}_{\text{EXIST}}$ = Efficiency of existing unit (= 7.7)[51]

EER_{BASE} = Efficiency of baseline unit that will be replacing exiting unit (= 10.9)[52]

EER_{EE} = Efficiency of ENERGY STAR unit (= 11.3)[53]

For example, the energy savings from installing a room air conditioner in Indianapolis would be:

$$\Delta\text{kWh for remaining life of existing unit (first 3 years)} = 332 * 11{,}357 * \frac{\frac{1}{7.7} - \frac{1}{11.3}}{1{,}000} = 156\ \text{kWh}$$

$$\Delta\text{kWh for remaining measure life (next 9 years)} = 332 * 11{,}357 * \frac{\frac{1}{10.9} - \frac{1}{11.3}}{1{,}000} = 12\ \text{kWh}$$

---

[49] Based on CDD adjusted values from: RLW Analytics. *Final Report Coincidence Factor Study Residential Room Air Conditioners.* June 23, 2008. Available online: http://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/117_RLW_CF%20Res%20RAC.pdf

[50] ENERGY STAR. "ENERGY STAR Certified Room Air Conditioners." http://www.energystar.gov/productfinder/product/certified-room-air-conditioners/

[51] Nexus Market Research Inc. and RLW Analytics. *Impact, Process, and Market Study of the Connecticut Appliance Retirement Program: Overall Report*. December 2005.

[52] Minimum Federal Standard for capacity range. 2015 Federal Energy Conservation Standard for Room ACs (e-CFR Title 10, Chapter II, Subchapter D, Part 430, Subpart C, Section 430.32)

[53] This is the minimum qualifying ENERGY STAR standard. http://www.energystar.gov/index.cfm?c=roomac.pr_crit_room_ac

Summer Peak Coincident Demand Reduction

$$\Delta\text{kW for remaining life of existing unit (first 3 years)} = BtuH * \frac{\frac{1}{EER_{EXIST}} - \frac{1}{EER_{EE}}}{1{,}000} * CF$$

$$\Delta\text{kW for remaining measure life (next 9 years)} = BtuH * \frac{\frac{1}{EER_{BASE}} - \frac{1}{EER_{EE}}}{1{,}000} * CF$$

Where:

CF = Summer peak coincidence factor (= 0.3)[54]

$$\Delta\text{kW for remaining life of existing unit (1}^{st}\text{ 3 years)} = 11{,}357 * \frac{\frac{1}{7.7} - \frac{1}{11.3}}{1{,}000} * 0.3 = 0.141\text{ kW}$$

$$\Delta\text{kW for remaining measure life (next 9 years)} = 11{,}357 * \frac{\frac{1}{10.9} - \frac{1}{11.3}}{1{,}000} * 0.3 = 0.011\text{ kW}$$

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.

---

[54] RLW Analytics. *Final Report Coincidence Factor Study Residential Room Air Conditioners.* June 23, 2008.

ENERGY STAR Room Air Conditioner Recycling (Early Retirement)

	Measure Details
Official Measure Code	Res-Appl-ES RAC-Recycle-1
Measure Unit	Per air conditioning unit
Measure Category	Appliances
Sector(s)	Residential
Annual Energy Savings (kWh)	Varies by location
Peak Demand Reduction (kW)	Varies by location
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	Varies by location
Lifetime Fossil Fuel Savings (MMBtu)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	3
Incremental Cost	$129.00
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is a drop-off service that takes existing inefficient room air conditioner units from service prior to their natural end of life. The measure savings are based on a percentage of these units being replaced with a baseline standard efficiency unit (note that units actually replaced by a new ENERGY STAR qualifying unit record the savings increment between the baseline and ENERGY STAR).

Definition of Efficient Equipment

There is no efficient condition; this measure relates to retiring an existing inefficient unit.

Definition of Baseline Equipment

The baseline condition is the existing inefficient room air conditioning unit.

Deemed Lifetime of Equipment

The assumed remaining useful life of the early replacement existing room air conditioning unit being retired is 3 years.

Deemed Measure Cost

The actual implementation cost for recycling the existing unit plus the cost for replacing some of the units is $129.00.[55]

Deemed O&M Cost Adjustments

The net present value of the deferred replacement cost (the cost associated with replacing units with a standard unit that would have occurred within three years had the existing unit not been replaced) is $89.36.[56]

Savings Algorithm

Energy Savings

$$\Delta kWh = \frac{EFLH_{COOL} * Btuh}{1{,}000} * \left(\frac{1}{EER_{EXIST}} - \frac{\%\ \text{replaced}}{EER_{NEWBASE}}\right)$$

Where:

$EFLH_{COOL}$ = Equivalent full load hours of room air conditioning unit (= dependent on location; see table below)*

Equivalent Full Load Hours by City

City	$EFLH_{COOL}$
Indianapolis	332
South Bend	288
Evansville	445
Ft. Wayne	257
Terre Haute	391

Based on CDD adjusted values from: RLW Analytics. *Final Report Coincidence Factor Study Residential Room Air Conditioners.* June 23, 2008. Available online: http://www.puc.nh.gov/Electric/Monitoring%20and %20Evaluation%20Reports/National%20Grid/117_RLW_CF%20Res%20RAC.pdf

---

[55] This is calculated by multiplying the percentage assumed to be replaced (76% based on: Nexus Market Research Inc. and RLW Analytics. *Impact, Process, and Market Study of the Connecticut Appliance Retirement Program: Overall Report*. December 2005.) by the assumed cost of a standard efficiency unit ($170.00 from: ENERGY STAR calculator. http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerRoomAC.xls). .

[56] Determined by calculating the net present value (with a 5% discount rate) of the annuity payments from years 4 to 12 for a deferred replacement of a standard efficiency unit costing $170.00 multiplied by the 76%, the percentage of units being replaced (0.76 * $170 = $129.20). Baseline cost from ENERGY STAR calculator: http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerRoomAC.xls

Btuh = Average capacity of rebated unit (= 11,357)[57]

EER_{EXIST} = Efficiency of existing unit (= 7.7)[58]

% replaced = Percentage of units dropped off that are replaced (= 76%)[59]

$EER_{NEWBASE}$ = Efficiency of baseline unit that replaces exiting unit (= 10.9)[60]

For example, the energy savings from removing a room air conditioning unit in Indianapolis would be:

$$\Delta kWh = \frac{332 * 11{,}357}{1{,}000} * \left(\frac{1}{7.7} - \frac{0.76}{10.9}\right) = 227$$

Summer Peak Coincident Demand Reduction

$$\Delta kW = \frac{Btuh * CF}{1{,}000} * \left(\frac{1}{EER_{EXIST}} - \frac{\%\text{ replaced}}{EER_{NEWBASE}}\right)$$

Where:

CF = Summer peak coincidence factor (= 0.3)[61]

For example, the demand reduction from removing a room air conditioner in Indianapolis would be:

$$\Delta kWh = \frac{11{,}357 * 0.3}{1{,}000} * \left(\frac{1}{7.7} - \frac{0.76}{10.9}\right) = 0.205$$

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.

---

[57] ENERGY STAR. “ENERGY STAR Certified Room Air Conditioners.” http://www.energystar.gov/productfinder/product/certified-room-air-conditioners/

[58] Nexus Market Research Inc. and RLW Analytics. *Impact, Process, and Market Study of the Connecticut Appliance Retirement Program: Overall Report*. December 2005.

[59] Ibid. Report states that 63% of units were replaced with ENERGY STAR units and 13% with non-ENERGY STAR. However, this formula assumes that all units are non-ENERGY STAR since the increment of savings between baseline units and ENERGY STAR unit would be recorded for the Efficient Products Program when the new unit is purchased.

[60] This is the minimum federal standard for capacity range. Department of Energy. *2015 Federal Energy Conservation Standard for Room ACs*. e-CFR Title 10, Chapter II, Subchapter D, Part 430, Subpart C, Section 430.32. June 2015

[61] RLW Analytics. *Final Report Coincidence Factor Study Residential Room Air Conditioners*. June 23, 2008. Available online: http://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/117_RLW_CF%20Res%20RAC.pdf

Smart Strip Power Strip (Time of Sale)

	Measure Details
Official Measure Code	Res-Appl-Strip-1
Measure Unit	Per power strip
Measure Category	Appliances
Sector(s)	Residential
Annual Energy Savings (kWh)	23
Peak Demand Reduction (kW)	0.002
Annual Fossil Fuel Savings (MMBtu)	-0.041
Lifetime Energy Savings (kWh)	92
Lifetime Fossil Fuel Savings (MMBtu)	-0.164
Water Savings (gal/yr)	0
Effective Useful Life (years)	4
Incremental Cost	\$16.00 for a 5-plug \$26.00 for a 7-plug
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is controlled power strips (also known as smart strips), which are multi-plug power strips with the ability to automatically disconnect specific connected loads depending on the power draw of a control load, also plugged into the strip. Power is disconnected from the switched (controlled) outlets when the control load power draw is reduced below a certain adjustable threshold, thus turning off the appliances plugged into the switched outlets. By disconnecting, the overall standby load of a centralized group of equipment (i.e. entertainment centers and home office) can be reduced. Uncontrolled outlets are also provided that are not affected by the control device and are always providing power to any device plugged in. This measure provides savings from controllable peripheral devices associated with home computers and television sets.

Definition of Efficient Equipment

The efficient condition is the use of a smart strip.

Definition of Baseline Equipment

The baseline condition is a standard power strip that does not control connected loads.

Deemed Lifetime of Efficient Equipment

The assumed lifetime of the smart strip is 4 years.[62]

Deemed Measure Cost

The incremental cost over a standard power strip with surge protection is $16.00 for a 5-plug smart strip and $26.00 for a 7-plug smart strip.[63]

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\sum^{Peripherals} W_{STANDBY} * F_{HOMES} * F_{CONTROL} * H * \frac{1 + WHF_E}{1{,}000}$$

Where:

$W_{STANDBY}$= Power use in standby mode

F_{HOMES} = Percentage of homes with peripherals (= see tables below)

F_{CONTOL} = Percentage of peripherals controlled (= see tables below)

H = Number of hours per year peripherals are controlled (= 7,474 for computer peripherals; = 6,784 for television peripherals) [64]

WHF_E = Waste heat factor for energy to account for HVAC interactions with efficient lighting (= - 0.059 as weighted average across all HVAC systems and cities; see Appendix B)

---

[62] David Rogers, Power Smart Engineering. *Smart Strip Electrical Savings and Usability.* October 2008. p. 22.

[63] New York State Energy Research and Development Authority. *Measure Characterization for Advanced Power Strips*. August 2011. p. 4.

[64] Ibid.

Assumptions for Home Computer Peripherals

Peripheral	$W_{STANDBY}$	$F_{CONTROL}$	F_{HOMES}
Flat Panel Monitor	1.29	100.0%	69.3%
CRT Monitor	0.72	100.0%	25.1%
Printer	2.32	80.0%	43.1%
Multifunction Printer (without fax)	7.81	66.7%	4.0%
Multifunction Printer (with fax)	7.57	57.3%	8.3%
Speakers	4.76	100.0%	0.6%
Scanner	1.42	95.5%	7.4%
Copier	0.32	58.1%	4.8%
Modem	6.46	90.4%	8.1%
Router	5.07	93.3%	9.9%
External Hard Drive	1.13	100.0%	0.3%

Assumptions for Television Peripherals

Peripheral	$W_{STANDBY}$	$F_{CONTROL}$	F_{HOMES}
DVD Player	2.12	93.3%	53.3%
VCR	5.92	97.9%	21.3%
Stereo	4.07	50.7%	30.9%
Speakers	11.07	86.2%	2.1%
Video Game Console	0.57	98.0%	5.3%
Computer Used for Video	17.77	66.7%	0.3%

For example, the energy savings would be calculated as:

$$\Delta kWh_{COMPUTER} = ((1.29 * 1.0 * 0.693) + (0.72 * 1.0 * 0.251) + (2.32 * 0.80 * 0.431) + (7.81 * 0.667 * 0.04) + (7.57 * 0.573 * 0.083) + (4.76 * 1.0 * 0.006) + (1.42 * 0.955 * 0.074) + (0.32 * 0.581 * 0.048) + (6.46 * 0.904 * 0.081) + (5.07 * 0.933 * 0.099) + (1.13 * 1.0 * 0.003)) * 7{,}474 * \frac{(1 - 0.059)}{1{,}000} = 24.8 \text{ kWh}$$

$$\Delta kWh_{TELEVISION} = ((2.12 * 0.933 * 0.533) + (5.92 * 0.979 * 0.213) + (4.07 * 0.507 * 0.309) + (11.07 * 0.862 * 0.021) + (0.57 * 0.98 * 0.053) + (17.77 * 0.667 * 0.003)) * 6{,}784 * \frac{1 - 0.059}{1{,}000} = 20.4$$

$$\Delta kWh = \frac{\Delta kWh_{COMPUTER} + \Delta kWh_{TELEVISION}}{2} = \frac{24.8+20.4}{2} = 23$$

Summer Peak Coincident Demand Reduction

$$\Delta kW = \sum_{1}^{Peripherals} W_{STANDBY} * F_{HOMES} * F_{CONTROL} * CF * \frac{1+WHF_D}{1{,}000}$$

Where:

WHF_D = Waste heat factor for demand to account for HVAC interactions with efficient lighting (= 0.057 as weighted average value across all HVAC systems and cities; see Appendix B)

CF = Summer peak coincidence factor (= 0.50)

Using default data from above, the demand reduction would be calculated as:

$$\Delta kW_{COMPUTER} = ((1.29 * 1.0 * 0.693) + (0.72 * 1.0 * 0.251) + (2.32 * 0.80 * 0.431) + (7.81 * 0.667 * 0.04) + (7.57 * 0.573 * 0.083) + (4.76 * 1.0 * 0.006) + (1.42 * 0.955 * 0.074) + (0.32 * 0.581 * 0.048) + (6.46 * 0.904 * 0.081) + (5.07 * 0.933 * 0.099) + (1.13 * 1.0 * 0.003)) * 0.5 * \frac{(1 + 0.057)}{1{,}000} = 0.002$$

$$\Delta kW_{TELEVISION} ((2.12 * 0.933 * 0.533) + (5.92 * 0.979 * 0.213) + (4.07 * 0.507 * 0.309) + 11.07 * 0.862 * 0.021) + (0.57 * 0.98 * 0.053) + (17.77 * 0.667 * 0.003)) * 0.5 * \frac{1 + 0.057}{1{,}000} = 0.002$$

$$\Delta kW = \frac{\Delta\, kW_{COMPUTER} + \Delta\, kW_{TELEVISION}}{2} = \frac{0.002+0.002}{2} = 0.002$$

Fossil Fuel Impact Descriptions and Calculation

$$\Delta MMBtu_{WH} = \Delta kWh * WHF_G = 23 * (-0.0018) = -0.041$$

Where:

$\Delta MMBtu_{WH}$ = Gross customer annual heating MMBtu fuel increased usage from the reduction in lighting heat

WHF_G = Waste heat factor for fossil fuels to account for HVAC interactions with efficient lighting (=-0.0018 as weighted average value across all HVAC systems and cities; see Appendix B)

Building Shell

Envelope Insulation (Retrofit)

	Measure Details
Official Measure Codes	Res-Shell-RoofInsul-1, Res-Shell-WallIns-1
Measure Unit	Per square foot
Measure Category	Building shell
Sector(s)	Residential
Annual Energy Savings (kWh)	Varies by location
Peak Demand Reduction (kW)	Varies by location
Annual Fossil Fuel Savings (MMBtu)	Varies by location
Lifetime Energy Savings (kWh)	Varies by location
Lifetime Fossil Fuel Savings (MMBtu)	Varies by location
Water Savings (gal/yr)	0
Effective Useful Life (years)	25
Incremental Cost	TBD
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is installing additional insulation in the attic, roof, ceiling, or wall of a residential building. The energy savings are based on an auditor, contractor, or utility staff member being on location to measure and record the existing and new insulation depth and type (to calculate R-values), and the surface area of insulation added.

Definition of Efficient Equipment

The new insulation should meet any qualification criteria required for participation in the program. The new insulation R-value should include the effective R-value of any existing insulation left in situ, as well as installation conditions, such as insulation compression and void fraction.

Definition of Baseline Equipment

The existing insulation R-value should include appropriate adjustment factors for insulation compression and void fraction. The R-value should include the insulation layer only; air gaps and other building materials are accounted for in the simulation models.

Deemed Lifetime of Efficient Equipment

The measure life is 25 years.[65]

Deemed Measure Cost

The actual insulation installation measure cost should be used.

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\Delta\text{kWh} = kSF * \frac{\Delta kWh}{kSF}$$

Where:

kSF = Area of installed insulation in 1,000 square feet

$\frac{\Delta\text{kWh}}{\text{kSF}}$ = Unit energy savings (= dependent on city; see tables in Reference Tables section)

Summer Peak Coincident Demand Reduction

$$\Delta\text{kW}_\text{S} = kSF * \frac{\Delta kW}{kSF} * CF$$

Where:

$\frac{\Delta\text{kW}}{\text{kSF}}$ = Unit demand reduction (= dependent on city; see tables in Reference Tables section)

CF = Summer peak coincidence factor (= 0.88)[66]

Fossil Fuel Impact Descriptions and Calculation

Space Heating Savings Calculation

$$\Delta MMBtu = kSF * \frac{\Delta MMBtu}{kSF}$$

---

[65] GDS Associates. *Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures*. June 2007. Available online: http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf

[66] Duke Energy. Load shape data for residential air conditioner loads from DSMore cost-effectiveness tool. Available online: www.integralanalytics.com

Where:

$\frac{\Delta \text{MMBtu}}{\text{kSF}}$ = Unit fossil fuel energy savings (=dependent on city; see tables in Reference Tables section)

General Calculation Methodology

Unit energy savings values are provided in the Reference Tables sections for a set of baseline and measure R-values, for certain HVAC system types. These values are for homes with and without cooling, and for homes with natural gas, heat pump, or electric resistance heating systems. The R-values are for the insulation layer only; R-values of building materials are included in the simulation model. Interpolation within the tables is permissible for R-values not explicitly listed. The baseline and measure R-values should consider installation conditions, such as insulation compression and coverage. Insulation compression adjustment factors (F_{COMP}) are shown in the table below.

Insulation Compression Adjustment Factor Lookup

Compression Percentage	F_{COMP}
0%	1.00
5%	0.97
10%	0.93
15%	0.89
20%	0.85

An additional adjustment should be taken for the insulation coverage. This factor (F_{VOID}) is determined by the installation grade or void fraction, and the ratio of the insulation R-value (R_{MFG}) to the full assembly R-value (R_{TOTAL}). The insulation coverage adjustment is shown in the table below.

Insulation Void Factor Lookup

$\frac{R_{MFG} * F_{COMP}}{R_{TOTAL}}$	F_{VOID}	
	2% Void (Grade II)	5% Void (Grade III)
0.50	0.96	0.90
0.55	0.96	0.90
0.60	0.95	0.88
0.65	0.94	0.87
0.70	0.94	0.85
0.75	0.92	0.83
0.80	0.91	0.79
0.85	0.88	0.74
0.90	0.83	0.66
0.95	0.71	0.49
0.99	0.33	0.16

The adjusted R-value is the nominal R-value multiplied by the adjustment factors:

$$R_{ADJ} = R_{NOMINAL} * F_{COMP} * F_{VOID}$$

Calculations are given below for the following example project: 2,000 square feet of attic floor insulation is installed in an average Indianapolis home. The home started with uncompressed R-11 insulation with a 5% void fraction. The final R-value (including the original insulation) is R-38, with a 2% void fraction. The building materials and attic air space represent an additional R-5.

Initial Adjusted R-Value Calculation

$$\frac{R_{MFG}\ *\ F_{COMP}}{R_{TOTAL}} = \frac{11\ *\ 1}{11+5} = 0.69$$

$F_{VOID} = 0.85$

The adjusted initial R-value is:

$$R_{ADJ} = R_{NOMINAL} * F_{COMP} *\ F_{VOID} = 11 *\ 1\ *\ 0.85 = 9.4$$

Final Adjusted R-Value Calculation

$$\frac{R_{MFG}\ *\ F_{COMP}}{R_{TOTAL}} = \frac{38\ *\ 1}{38+5} = 0.88$$

$F_{VOID} = 0.85$ (interpolated)

The adjusted final R-value is:

$$R_{ADJ} = R_{NOMINAL} * F_{COMP} *\ F_{VOID} = 38 * 1 * .85 = 32.3$$

Overall Savings Calculations

The following savings are calculated for the example project using values from tables in the Reference Tables section:

$$\Delta kWh = kSF * \frac{\Delta kWh}{kSF} = 2 * 774.6 = 1{,}550\ kWh$$

$$\Delta kW\ = kS * \frac{\Delta kW}{kSF} * CF\ = 2 * 0.1179 * 0.88 = 0.118\ kW$$

$$\Delta \mathrm{MMBtu} = kS * \frac{\Delta MMBtu}{kSF} = 2 * 8.05 = 16.100\ MMBtu$$

Reference Tables

Building: Single Family
City: Indianapolis
HVAC: Weighted Average
Measure: Roof/Attic/Ceiling Installation

Base R_{ADJ}	0			11			19		
New R_{ADJ}	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	2,253.3	0.2109	23.00	N/A	N/A	N/A	N/A	N/A	N/A
19	2,519.1	0.2669	25.77	265.8	0.0557	2.81	N/A	N/A	N/A
30	2,673.3	0.2924	27.43	420.1	0.0813	4.42	154.3	0.0255	1.67
38	2,730.7	0.3093	28.05	477.6	0.0984	5.03	211.7	0.0424	2.28
49	2,783.0	0.3136	28.58	529.9	0.1027	5.64	264.2	0.0468	2.83
60	2,817.8	0.3136	28.96	564.7	0.1027	5.95	298.8	0.0468	3.19

Base R_{ADJ}	30			38		
New R_{ADJ}	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	N/A	N/A	N/A	N/A	N/A	N/A
19	N/A	N/A	N/A	N/A	N/A	N/A
30	N/A	N/A	N/A	N/A	N/A	N/A
38	57.5	0.0169	0.62	N/A	N/A	N/A
49	109.8	0.0212	1.22	52.3	0.0043	0.53
60	144.6	0.0212	1.53	87.1	0.0043	0.91

Building: Single Family
City: South Bend
HVAC: Weighted Average
Measure: Roof/Attic/Ceiling Installation

Base R_{ADJ}	0			11			19		
New R_{ADJ}	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	2,222.2	0.1062	23.16	N/A	N/A	N/A	N/A	N/A	N/A
19	2,486.0	0.1399	25.98	263.7	0.0337	2.83	N/A	N/A	N/A
30	2,636.0	0.1603	27.59	413.8	0.0541	4.50	150.1	0.0204	1.67
38	2,693.5	0.1611	28.26	471.3	0.0549	5.11	207.5	0.0212	2.29
49	2,745.3	0.1647	28.81	522.9	0.0585	5.65	259.3	0.0248	2.83
60	2,779.0	0.1647	29.19	556.7	0.0585	6.02	292.9	0.0248	3.21

Base R_{ADJ}	**30**			**38**		
New R_{ADJ}	**kWh/ kSF**	**kW/ kSF**	**MMBtu/ kSF**	**kWh/ kSF**	**kW/ kSF**	**MMBtu/ kSF**
11	N/A	N/A	N/A	N/A	N/A	N/A
19	N/A	N/A	N/A	N/A	N/A	N/A
30	N/A	N/A	N/A	N/A	N/A	N/A
38	57.6	0.008	0.62	N/A	N/A	N/A
49	109.2	0.0043	1.22	51.8	0.0036	0.61
60	142.8	0.0043	1.60	85.3	0.0036	0.91

Building: Single Family
City: Evansville
HVAC: Weighted Average
Measure: Roof/Attic/Ceiling Installation

Base R_{ADJ}	**0**			**11**			**19**		
New R_{ADJ}	**kWh/ kSF**	**kW/ kSF**	**MMBtu/ kSF**	**kWh/ kSF**	**kW/ kSF**	**MMBtu/ kSF**	**kWh/ kSF**	**kW/ kSF**	**MMBtu/ kSF**
11	1,870.3	0.4391	18.44						
19	2,096.1	0.5081	20.80	226	0.0682	2.29			
30	2,225.6	0.5544	22.11	355.5	0.1144	3.66	129.7	0.0462	1.37
38	2,275.4	0.5713	22.64	405.3	0.132	4.19	179.3	0.0631	1.90
49	2,318.4	0.5846	23.09	448.3	0.1453	4.65	222.5	0.0764	2.36
60	2,346.5	0.6007	23.40	476.4	0.1616	4.95	250.4	0.0923	2.66

Base R_{ADJ}	**30**			**38**		
New R_{ADJ}	**kWh/ kSF**	**kW/ kSF**	**MMBtu/ kSF**	**kWh/ kSF**	**kW/ kSF**	**MMBtu/ kSF**
11	N/A	N/A	N/A	N/A	N/A	N/A
19	N/A	N/A	N/A	N/A	N/A	N/A
30	N/A	N/A	N/A	N/A	N/A	N/A
38	49.7	0.0169	0.53	N/A	N/A	N/A
49	92.8	0.0301	0.99	43	0.0133	0.46
60	120.9	0.0462	1.29	71.1	0.0294	0.76

Building: Single Family
City: Ft Wayne
HVAC: Weighted Average
Measure: Roof/Attic/Ceiling Installation

Base R_{ADJ}	0			11			19		
New R_{ADJ}	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	2,279.7	0.1639	24.32	N/A	N/A	N/A	N/A	N/A	N/A
19	2,546.1	0.1976	27.27	266.3	0.0337	2.96	N/A	N/A	N/A
30	2,699.8	0.2305	28.96	420	0.0666	4.71	153.7	0.0329	1.75
38	2,761.2	0.2305	29.64	481.5	0.0666	5.40	215.1	0.0329	2.43
49	2,814.6	0.2465	30.25	534.9	0.0827	6.00	268.5	0.049	3.04
60	2,848.5	0.2473	30.63	568.7	0.0835	6.38	302.4	0.0498	3.42

Base R_{ADJ}	30			38		
New R_{ADJ}	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	N/A	N/A	N/A	N/A	N/A	N/A
19	N/A	N/A	N/A	N/A	N/A	N/A
30	N/A	N/A	N/A	N/A	N/A	N/A
38	61.4	0.000	0.68	N/A	N/A	N/A
49	115	0.0161	1.29	53.5	0.0161	0.61
60	148.8	0.0169	1.67	87.3	0.0169	0.99

Building: Single Family
City: Terre Haute
HVAC: Weighted Average
Measure: Roof/Attic/Ceiling Installation

Base R_{ADJ}	0			11			19		
New R_{ADJ}	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	2,289.2	0.1863	24.24	N/A	N/A	N/A	N/A	N/A	N/A
19	2,559.1	0.2032	27.21	269.9	0.0169	2.96	N/A	N/A	N/A
30	2,715.2	0.22	28.96	425.9	0.0337	4.71	156	0.0169	1.75
38	2,778.0	0.2359	29.64	488.9	0.0506	5.40	218.8	0.0337	2.43
49	2,828.3	0.2359	30.25	539.1	0.0506	6.00	269.2	0.0337	3.04
60	2,863.8	0.2376	30.63	574.7	0.0513	6.38	304.8	0.0345	3.42

Base R_{ADJ}	30			38		
New R_{ADJ}	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	N/A	N/A	N/A	N/A	N/A	N/A
19	N/A	N/A	N/A	N/A	N/A	N/A
30	N/A	N/A	N/A	N/A	N/A	N/A
38	62.8	0.0169	0.68	N/A	N/A	N/A
49	113.2	0.0169	1.29	50.4	0.000	0.61
60	148.8	0.0176	1.67	85.9	0.008	0.99

Building: Single Family
City: Indianapolis
HVAC: Weighted Average
Measure: Wall Installation

Base R_{ADJ}	0			11			13		
New R_{ADJ}	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	563.6	0.0871	6.16						
13	643.7	0.0918	7.07	80.1	0.0047	0.91			
17	769.2	0.1144	8.45	205.6	0.0273	2.28	125.5	0.0225	1.37
19	815.0	0.1152	8.98	251.4	0.0282	2.81	171.3	0.0233	1.90
21	852.4	0.1322	9.42	288.8	0.0451	3.27	208.8	0.0406	2.36
25	913.4	0.1330	10.05	349.8	0.0461	3.89	269.7	0.0414	2.98
27	937.2	0.1377	10.35	373.6	0.0506	4.18	293.5	0.0461	3.27

Base R_{ADJ}	17			19		
New R_{ADJ}	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	N/A	N/A	N/A	N/A	N/A	N/A
13	N/A	N/A	N/A	N/A	N/A	N/A
17	N/A	N/A	N/A	N/A	N/A	N/A
19	45.8	0.008	0.53	N/A	N/A	N/A
21	83.4	0.0178	0.91	37.4	0.0170	0.46
25	144.2	0.0187	1.60	98.4	0.0178	1.08
27	168.0	0.0233	1.90	122.3	0.0225	1.37

Building: Single Family
City: South Bend
HVAC: Weighted Average
Measure: Wall Installation

Base R_{ADJ}	0			11			13		
New R_{ADJ}	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	558.4	0.0583	6.23	N/A	N/A	N/A	N/A	N/A	N/A
13	644.5	0.0591	7.22	86.3	0.008	0.99	N/A	N/A	N/A
17	770.7	0.0770	8.60	212.4	0.0187	2.37	126.2	0.0178	1.38
19	815.1	0.0770	9.13	256.9	0.0187	2.89	170.6	0.0178	1.90
21	851.4	0.0770	9.51	293.1	0.0187	3.34	206.8	0.0178	2.36
25	912.2	0.0808	10.20	353.9	0.0225	4.03	267.7	0.0216	2.98
27	936.6	0.0816	10.50	378.2	0.0233	4.27	292.1	0.0225	3.27

Base R_{ADJ}	17			19		
New R_{ADJ}	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	N/A	N/A	N/A	N/A	N/A	N/A
13	N/A	N/A	N/A	N/A	N/A	N/A
17	N/A	N/A	N/A	N/A	N/A	N/A
19	44.4	0.000	0.53	N/A	N/A	N/A
21	80.7	0.000	0.91	36.1	0.000	0.46
25	141.5	0.0037	1.60	97.1	0.0037	1.08
27	165.9	0.0047	1.90	121.4	0.0047	1.37

Building: Single Family
City: Evansville
HVAC: Weighted Average
Measure: Wall Installation

Base R_{ADJ}	0			11			13		
New R_{ADJ}	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	456.6	0.1089	5.00	N/A	N/A	N/A	N/A	N/A	N/A
13	531.1	0.1267	5.78	74.4	0.0178	0.84	N/A	N/A	N/A
17	639.6	0.1594	6.92	182.9	0.0505	1.98	108.5	0.0319	1.14
19	676.6	0.1642	7.37	220.0	0.0554	2.36	145.6	0.0366	1.60
21	707.9	0.1775	7.68	251.4	0.0686	2.74	177.0	0.0505	1.90
25	756.9	0.1820	8.27	300.2	0.0732	3.27	225.8	0.0554	2.43
27	777.3	0.1953	8.44	320.6	0.0864	3.50	246.2	0.0686	2.66

Base R_{ADJ}	17			19		
New R_{ADJ}	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	N/A	N/A	N/A	N/A	N/A	N/A
13	N/A	N/A	N/A	N/A	N/A	N/A
17	N/A	N/A	N/A	N/A	N/A	N/A
19	37.0	0.0047	0.38	N/A	N/A	N/A
21	68.3	0.0178	0.76	31.5	0.0132	0.38
25	117.3	0.0225	1.29	80.3	0.0178	0.91
27	137.7	0.0357	1.52	100.7	0.0310	1.14

Building: Single Family
City: Ft Wayne
HVAC: Weighted Average
Measure: Wall Installation

Base R_{ADJ}	0			11			13		
New R_{ADJ}	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	361.1	0.0322	4.03	N/A	N/A	N/A	N/A	N/A	N/A
13	417.3	0.0416	4.64	56.2	0.0104	0.61	N/A	N/A	N/A
17	496.2	0.0526	5.55	135.1	0.0213	1.52	78.9	0.0110	0.91
19	525.1	0.0526	5.93	163.9	0.0213	1.82	107.7	0.0110	1.22
21	548.9	0.0526	6.16	187.8	0.0213	2.13	131.6	0.0110	1.52
25	587.9	0.0526	6.61	226.8	0.0213	2.58	170.7	0.0110	1.90
27	602.5	0.0530	6.76	241.5	0.0218	2.74	185.3	0.0114	2.13

Base R_{ADJ}	17			19		
New R_{ADJ}	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	N/A	N/A	N/A	N/A	N/A	N/A
13	N/A	N/A	N/A	N/A	N/A	N/A
17	N/A	N/A	N/A	N/A	N/A	N/A
19	28.9	0.000	0.30	N/A	N/A	N/A
21	52.8	0.000	0.61	23.8	0.000	0.30
25	91.6	0.000	1.06	62.8	0.000	0.68
27	106.4	0.005	1.22	77.5	0.005	0.85

Building: Single Family
City: Terre Haute
HVAC: Weighted Average
Measure: Wall Installation

Base R_{ADJ}	0			11			13		
New R_{ADJ}	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	349.1	0.0328	3.88	N/A	N/A	N/A	N/A	N/A	N/A
13	404.7	0.0328	4.56	55.6	0.00	0.61	N/A	N/A	N/A
17	487.0	0.0427	5.40	137.9	0.011	1.52	82.3	0.0110	0.91
19	513.8	0.0427	5.71	164.7	0.011	1.82	109.1	0.0110	1.22
21	538.5	0.0427	6.00	189.5	0.011	2.13	133.8	0.0110	1.46
25	575.7	0.0535	6.46	226.7	0.0218	2.51	171.0	0.0218	1.90
27	592.1	0.0535	6.61	243.0	0.0218	2.66	187.4	0.0218	2.05

Base R_{ADJ}	17			19		
New R_{ADJ}	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	N/A	N/A	N/A	N/A	N/A	N/A
13	N/A	N/A	N/A	N/A	N/A	N/A
17	N/A	N/A	N/A	N/A	N/A	N/A
19	26.8	0.000	0.30	N/A	N/A	N/A
21	51.7	0.000	0.61	24.8	0.00	0.30
25	88.7	0.0110	0.99	61.9	0.011	0.68
27	105.0	0.0110	1.20	78.2	0.011	0.84

Air Sealing - Reduce Infiltration (Retrofit)

	Measure Details
Official Measure Code	Res-Shell-AirSeal-1
Measure Unit	Per Installation
Measure Category	Building shell
Sector(s)	Residential
Annual Energy Savings (kWh)	Varies by heating and cooling system
Peak Demand Reduction (kW)	Varies by heating and cooling system
Annual Fossil Fuel Savings (MMBtu)	Varies by heating and cooling system
Lifetime Energy Savings (kWh)	Varies by heating and cooling system
Lifetime Fossil Fuel Savings (MMBtu)	Varies by heating and cooling system
Water Savings (gal/yr)	0
Effective Useful Life (years)	15
Incremental Cost	Varies by heating and cooling system
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is improving a building's air barrier, which together with insulation defines the thermal boundary of the conditioned space. Air leakage in buildings represents between 5% and 40% of the space conditioning costs,[67] but is also very difficult to control. The measure savings are based on a trained auditor, contractor, or utility staff member being on location to measure and record the existing air leakage rate[68] and post-air sealing leakage using a blower door.

Definition of Efficient Equipment

Air sealing materials and diagnostic testing should meet all eligibility program qualification criteria. The initial and final leakage rates should be tested in such a manner such that the identified reductions can be properly discerned, particularly in situations wherein multiple building envelope measures may be implemented simultaneously.

---

[67] Krigger, J. and C. Dorsi. *Residential Energy*. 2004. p. 73.

[68] In accordance with industry best practices per: Building Performance Institute. *Building Analyst and Envelope Professional Standards*. Available online: http://www.bpi.org/standards_approved.aspx

Definition of Baseline Equipment

The existing air leakage should be determined through approved and appropriate test methods. The baseline condition of a building upon first inspection significantly impacts the opportunity for cost-effective energy savings through air sealing.

Deemed Lifetime of Efficient Equipment

The measure life is 15 years.[69]

Deemed Measure Cost

The actual air sealing measure cost should be used.

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\mathrm{kWh} = \frac{\mathrm{CFM50_{EXIST}} - \mathrm{CFM50_{NEW}}}{\mathrm{N-factor}} * \frac{\mathrm{kWh}}{\mathrm{CFM}}$$

Where:

$\mathrm{CFM50_{EXIST}}$ = Existing cubic feet per minute at 50 Pascal pressure differential as measured by the blower door before air sealing (= actual)

$\mathrm{CFM50_{NEW}}$ = New cubic feet per minute at 50 Pascal pressure differential as measured by the blower door after air sealing (= actual)

N-factor = Conversion factor from 50 Pascal airflows to natural airflow (= dependent on exposure level, see table below;[70] if exposure is unknown, assume "Normal;" if number of stories is unknown, use average value for stories 1-2; if both unknown, use 16.3)

N-Factor by Exposure Level and Number of Stories

Exposure	1 Story	1.5 Stories	2 Stories	3 Stories
Well Shielded	22.2	20.0	17.8	15.5
Normal	18.5	16.7	14.8	13.0
Exposed	16.7	15.0	13.3	11.7

---

[69] GDS Associates. *Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures*. June 2007. Available online: http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf

[70] Krigger, J and C. Dorsi. "Residential Energy" 2004 p. 286.

ΔkWh/CFM = kWh impacts per CFM of infiltration rate reduction (= dependent on home cooling and heating types; see tables in Reference Tables section)

For example, the energy savings from reducing air leakage in a well-shielded, 1-story Ft Wayne home with central air conditioning and natural gas heat, from 5,000 CFM_{50} to 3,500 CFM_{50}, would be:

$$\Delta kWh = \frac{5{,}000-3{,}500}{22.2} * 2.1 = 142 \text{ kWh}$$

Summer Peak Coincident Demand Reduction

$$kW = \frac{CFM50_{EXIST} - CFM50_{NEW}}{N - factor} * \frac{\Delta\, kW}{CFM} * CF$$

Where:

ΔkW/CFM = kW impacts per CFM of infiltration rate reduction

CF = Summer peak coincidence factor (= 0.88)

For example, the demand reduction from reducing air leakage in a well-shielded, 2-story Indianapolis home with central air conditioning and natural gas heat, from 5,000 CFM_{50} to 3,500 CFM_{50}, would be:

$$\Delta kW = \frac{5{,}000-3{,}500}{17.8} * .001 * 0.88 = 0.074$$

Fossil Fuels Impact Descriptions and Calculation

$$\Delta MMBtu = \frac{CFM50Exist - CFM50New}{N - factor} * \frac{\Delta \text{MMBtu}}{\text{CFM}}$$

Where:

ΔMMBtu/CFM = Fossil fuel impacts per CFM of infiltration rate reduction

For example, the fossil fuel savings from reducing air leakage in a well-shielded, 2-story Indianapolis home with central air conditioning and natural gas heat, from 5,000 CFM_{50} to 3,500 CFM_{50}, would be:

$$\Delta MMBtu = \frac{5{,}000-3{,}500}{17.8} * 0.21 = 17.697 \text{ MMBtu}$$

Reference Tables

Electricity and Fossil Fuel Impacts of Air Leakage Sealing*

City	AC Natural Gas Heat			Heat Pump		AC Electric Heat	
	kWh/cfm	kW/cfm	MMBtu/cfm	kWh/cfm	kW/cfm	kWh/cfm	kW/cfm
Indianapolis	2.4	0.001	0.21	30.9	0.003	50.1	0.006
South Bend	1.7	0.001	0.20	30.0	0.003	47.6	0.003
Evansville	3.0	0.005	0.16	20.5	0.007	40.3	0.009
Ft Wayne	2.1	0.001	0.24	36.0	0.002	54.1	0.001
Terre Haute	3.0	0.00	0.19	24.8	0.003	43.5	0.00

* Infiltration unit savings derived from residential simulation models. See Appendix A.

City	Natural Gas Heat Only			Electric Heat Only	
	kWh/cfm	kW/cfm	MMBtu/cfm	kWh/cfm	kW/cfm
Indianapolis	1.1	0.00	0.22	48.2	0.00
South Bend	1.0	0.00	0.21	46.5	0.00
Evansville	0.8	0.00	0.17	36.9	0.00
Ft Wayne	1.2	0.00	0.24	53.1	0.00
Terre Haute	0.9	0.00	0.19	41.4	0.00

* Infiltration unit savings derived from residential simulation models. See Appendix A.

Weighted Average by City

City	kWh/cfm	kW/cfm	MMBtu/cfm
Indianapolis	12.87	0.0018	0.1609
South Bend	11.90	0.0013	0.1533
Evansville	10.81	0.0051	0.1229
Ft Wayne	13.72	0.009	0.1824
Terre Haute	11.66	0.001	0.1444

Duct Sealing and Insulation (Retrofit)

	Measure Details
Official Measure Code	Res-HVAC-DTS-1
Measure Unit	Per installation
Measure Category	Building shell
Sector(s)	Residential
Annual Energy Savings (kWh)	Varies by location
Peak Demand Reduction (kW)	Varies by location
Annual Fossil Fuel Savings (MMBtu)	Varies by location
Lifetime Energy Savings (kWh)	Varies by location
Lifetime Fossil Fuel Savings (MMBtu)	Varies by location
Water Savings (gal/yr)	0
Effective Useful Life (years)	20
Incremental Cost	$71.45
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is performing duct sealing and insulation upgrades. Duct sealing is done using mastic sealant or metal tape to the distribution system of homes with either central air conditioning or a ducted heating system. The methodology requires either measuring the amount of duct leakage and observing the duct insulation R-value, or evaluating three duct characteristics (listed) below using the Building Performance Institute *Distribution Efficiency Look-Up Table*:[71]

1. Percentage of duct work within the conditioned space
2. Duct leakage evaluation
3. Duct insulation evaluation

Definition of Efficient Equipment

The efficient condition is sealed and/or insulated duct work throughout the home's unconditioned space.

Definition of Baseline Equipment

The baseline condition is leaky and/or uninsulated duct work within the home's unconditioned space.

---

[71] This look-up table is available online: http://www.bpi.org/files/pdf/DistributionEfficiencyTable-BlueSheet.pdf

Deemed Lifetime of Efficient Equipment

The lifetime of this measure is 20 years.[72]

Deemed Measure Cost

The incremental cost for the duct sealing measure is $71.45 per dwelling.[73]

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\Delta kWh_{COOLING} = \frac{DE_{AFTER} - DE_{BEFORE}}{DE_{AFTER}} * \frac{EFLH_{COOL} * Btuh_{COOL}}{SEER * 1{,}000}$$

Where:

DE_{AFTER} = Distribution efficiency after duct sealing (= actual; based on total leakage and R-value; see tables in Reference Tables section or determine by evaluating duct system before and after duct sealing and insulation using BPI *Distribution Efficiency Look-Up Table*)

DE_{BEFORE} = Distribution efficiency before duct sealing (= actual; based on total leakage and R-value; see tables in Reference Tables section or determine by evaluating duct system before and after duct sealing and insulation using BPI *Distribution Efficiency Look-Up Table*)

$EFLH_{COOL}$ = Equivalent full load cooling hours (= dependent on location; see table below)

---

[72] GDS Associates. *Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures*. June 2007. Available online: http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf

[73] Itron, Inc. *2010-2012 WO017 Ex Ante Measure Cost Study Final Report*. Submitted to the California Public Utilities Commission. May 27, 2014.

Equivalent Full Load Cooling Hours by City

Location	$EFLH_{COOL}$*
Indianapolis	487
South Bend	431
Evansville	600
Ft. Wayne	373
Terre Haute	569

* Based on prototypical building simulations. See Appendix A.

$Btuh_{COOL}$ = Cooling capacity of equipment in Btuh (= actual; otherwise assume 28,994 Btuh; note: 1 ton = 12,000 Btuh)[74]

SEER = Seasonal average efficiency of air conditioning equipment in SEER (= actual; otherwise assume 11.15)[75]

For example, the energy savings from adding duct sealing to a house in Indianapolis with a 3-ton, SEER 11 central air conditioning and the following duct evaluation results would be:

$$DE_{AFTER} = 0.92$$

$$DE_{BEFORE} = 0.85$$

$$\Delta kWh = \frac{0.92-0.85}{0.92} * 487 * \frac{36{,}000}{11*1{,}000} = 121\ kWh$$

The heating savings for homes with electric heat (heat pump or resistance) would be:

$$kWh_{HEATING} = \frac{DE_{AFTER} - DE_{BEFORE}}{DE_{AFTER}} * \frac{EFLH_{HEAT} * Btuh_{HEAT}}{3{,}412 * \eta_{HEAT}}$$

Where:

$EFLH_{HEAT}$ = Equivalent full load heating hours (= actual; dependent on location, see table below)

---

[74] TecMarket Works, et al. *Residential Baseline Report Final*. Prepared for the Indiana Demand Side Management Coordination Committee Core Programs. November 2, 2012.

[75] Ibid.

Equivalent Full Load Heating Hours by City

Location	$EFLH_{HEAT}$*
Indianapolis	1,341
South Bend	1,427
Evansville	982
Ft. Wayne	1,356
Terre Haute	804

* Heating EFLH extracted from simulations. See Appendix A.

$Btuh_{HEAT}$ = Heating capacity (output) of equipment in Btuh (= actual)

η_{HEAT} = Efficiency in COP of heating equipment (= actual; otherwise based on table below)

COP Estimates by System Type

System Type	Age of Equipment	HSPF Estimate	COP Estimate
Heat Pump	Before 2006	6.8	2.00
	After 2006	7.7	2.26
Resistance	N/A	N/A	1.00

3,412 = Conversion from Btuh to kW

For example, the energy savings from adding duct sealing to a house in Indianapolis with a 100,000 Btu/hr, 6.8 HSPF heat pump and the following duct evaluation results would be:

$$DE_{AFTER} = 0.92$$

$$DE_{BEFORE} = 0.85$$

$$\Delta kWh = \frac{0.92-0.85}{0.92} * 1{,}341 * \frac{100{,}000}{2*3{,}412} = 1{,}495 \text{ kWh}$$

Summer Coincident Peak kW savings

$$\Delta kW = \frac{DE_{PK,AFTER} - DE_{PK,BEFORE}}{DE_{PK,AFTER}} * \frac{Btuh_{COOL}}{EER*1{,}000} * CF$$

Where:

$DE_{PK,AFTER}$ = Distribution efficiency under peak summer conditions after duct sealing

$DE_{PK,BEFORE}$ = Distribution efficiency under peak summer conditions before duct sealing

CF = Summer peak coincidence factor (= 0.88)[76]

EER = Peak efficiency in EER of Air Conditioning equipment (= actual; otherwise calculate as SEER * 0.9)

Fossil Fuel Impact Descriptions and Calculation

The fossil fuel savings for homes with fossil fuel heating would be:

$$\Delta\text{MMBtu} = \frac{DE_{AFTER} - DE_{BEFORE}}{DE_{AFTER}} * \frac{EFLH_{HEAT} * Btuh_{FF}}{1{,}000{,}000}$$

Where:

$Btuh_{FF}$ = Heating capacity of equipment in Btuh input (= actual; otherwise assume 77,386 Btuh)[77]

1,000,000 = Conversion from Btu to MMBtu

For example, the fossil fuel savings from adding duct sealing in a house in Indianapolis with a 100,000 Btu/hr, 84 AFUE natural gas furnace with the following duct evaluation results would be:

$$DE_{AFTER} = 0.92$$

$$DE_{BEFORE} = 0.85$$

$$\Delta\text{MMBtu} = \frac{0.92 - 0.85}{0.92} * 1{,}341 * \frac{100{,}000}{1{,}000{,}000} = 10.203\text{ MMBtu}$$

Reference Tables

Distribution efficiencies, as based on observed R-values and measured leakage rates, are shown in the tables below.[78]

Single Family Distribution System Efficiency, Ducts Located in Unconditioned Basement

Total Duct Leakage	Duct System R-Value (supply and return)	Cooling		Heating
		DE_{COOL}	DE_{PK}	DE_{HEAT}
8%	Uninsulated	0.88	0.86	0.74
10%	Uninsulated	0.87	0.84	0.73
15%	Uninsulated	0.84	0.82	0.71
20%	Uninsulated	0.82	0.79	0.68

---

[76] Duke Energy. Data for residential air conditioning loads.

[77] TecMarket Works, et al. *Residential Baseline Report Final*. Prepared for the Indiana Demand Side Management Coordination Committee Core Programs. November 2, 2012.

[78] Distribution efficiencies were calculated using Indianapolis climate data and according to: ASHRAE Standard 152-2004. "Method of Test for Determining the Design and Seasonal Efficiencies of Residential Thermal Distribution Systems."

Total Duct Leakage	Duct System R-Value (supply and return)	Cooling		Heating
		DE_{COOL}	DE_{PK}	DE_{HEAT}
25%	Uninsulated	0.80	0.76	0.66
30%	Uninsulated	0.77	0.73	0.64
8%	R-4.2	0.91	0.90	0.88
10%	R-4.2	0.90	0.89	0.87
15%	R-4.2	0.88	0.86	0.84
20%	R-4.2	0.86	0.83	0.82
25%	R-4.2	0.83	0.80	0.79
30%	R-4.2	0.81	0.78	0.77
8%	R-8	0.92	0.91	0.90
10%	R-8	0.91	0.89	0.89
15%	R-8	0.88	0.86	0.86
20%	R-8	0.86	0.84	0.83
25%	R-8	0.84	0.81	0.81
30%	R-8	0.81	0.78	0.78

Single Family Distribution System Efficiency, Ducts Located in Unconditioned Attic

Total Duct Leakage	Duct System R-Value (supply and return)	Cooling		Heating
		DE_{COOL}	DE_{PK}	DE_{HEAT}
8%	Uninsulated	0.68	0.54	0.69
10%	Uninsulated	0.66	0.52	0.68
15%	Uninsulated	0.62	0.47	0.65
20%	Uninsulated	0.58	0.42	0.63
25%	Uninsulated	0.55	0.37	0.60
30%	Uninsulated	0.51	0.32	0.58
8%	R-4.2	0.84	0.79	0.86
10%	R-4.2	0.83	0.77	0.85
15%	R-4.2	0.78	0.71	0.82
20%	R-4.2	0.74	0.65	0.79
25%	R-4.2	0.70	0.59	0.76
30%	R-4.2	0.66	0.54	0.73
8%	R-8	0.86	0.82	0.88
10%	R-8	0.84	0.79	0.87
15%	R-8	0.80	0.73	0.84
20%	R-8	0.76	0.67	0.81
25%	R-8	0.71	0.62	0.78
30%	R-8	0.67	0.56	0.75

ENERGY STAR Windows (Time of Sale)

	Measure Details
Official Measure Code	Res-Shell-ESWind-1
Measure Unit	Per square foot
Measure Category	Building shell
Sector(s)	Residential
Annual Energy Savings (kWh)	Varies by location
Peak Demand Reduction (kW)	Varies by location
Annual Fossil Fuel Savings (MMBtu)	Varies by location
Lifetime Energy Savings (kWh)	Varies by location
Lifetime Fossil Fuel Savings (MMBtu)	Varies by location
Water Savings (gal/yr)	0
Effective Useful Life (years)	25
Incremental Cost	$150.00 per 100 square feet of windows
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is purchasing and installing ENERGY STAR windows meeting the minimum requirement for the North Central region (Evansville) or Northern region (Indianapolis, South Bend, Ft. Wayne, and Terre Haute) at the natural time of replacement or during new construction. This does not relate to a window retrofit program.

Definition of Efficient Equipment

To qualify for this measure, the new window must meet ENERGY STAR criteria for the North Central region (u factor ≤ 0.32; SHGC ≤ 0.40) or Northern region (u factor ≤ 0.30). There is no minimum SHGC criterion for windows in the North region, so a medium gain window with SHGC of 0.40 is assumed.

Definition of Baseline Equipment

The baseline condition is a code-compliant window in IECC Climate Zone 4 (u factor = 0.35, SHGC = 0.40) or IECC Climate Zone 3 (u factor = 0.32). SHGC is not specified in climate zone 3, so a medium gain window with SHGC of 0.40 is assumed.

Deemed Lifetime of Efficient Equipment

The measure life is 25 years.[79]

---

[79] GDS Associates. *Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures*. June 2007. Available online: http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf

Deemed Measure Cost

The incremental cost for this measure is $150.00 per 100 square feet of windows.[80]

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\Delta\text{kWh} = \frac{SF}{100} * \frac{\Delta kWh}{100SF}$$

Where:

SF = Area of installed windows

$\frac{\Delta kWh}{100SF}$ = Unit energy savings (= dependent on type of HVAC system and city; see table in Reference Tables section)

For example, the energy savings from installing 200 square feet of ENERGY STAR windows in a home in Indianapolis with central air conditioning and natural gas heat would be:

$$\Delta kWh = \frac{200}{100} * \ 44 = 88 \text{ kWh}$$

Summer Peak Coincident Demand Reduction

$$\Delta\text{kW} = \frac{SF}{100} * \frac{\Delta kW}{100SF} * CF_S$$

Where:

$\frac{\Delta kW}{100SF}$ = Unit demand reduction (= dependent on type of HVAC system and city; see table in Reference Tables section)

CF_S = Summer peak coincidence factor (= 0.88)[81]

For example, the demand reduction from installing 200 square feet of ENERGY STAR windows in a home in Indianapolis with central air conditioning and natural gas heat would be:

$$\Delta\text{kW} = \frac{200}{100} * 0.1 * 0.88 = \ 0.176 \text{ kW}$$

---

[80] Alliance to Save Energy Efficiency Windows Collaborative Report, December 2007

[81] Duke Energy. Load shape data for residential air conditioning loads from DSMore cost-effectiveness tool. Available online: www.integralanalytics.com

Fossil Fuels Impact Descriptions and Calculation

$$\Delta\text{MMBtu} = \frac{SF}{100} * \frac{\Delta MMBtu}{100SF}$$

Where:

$\frac{\Delta MMBtu}{100SF}$ = Unit fossil fuel energy savings (= dependent on type of HVAC system and city; see table in Reference Tables section)

For example, the fossil fuel savings from installing 200 square feet of ENERGY STAR windows in a home in Indianapolis with central air conditioning and natural gas heat would be:

$$\Delta\text{MMBtu} = \frac{200}{100} * \ 1.07 \ = \ 2.140$$

Reference Tables

Electricity and Fossil Fuel Impacts of Window Upgrades*HVAC System	kWh/100 Square Feet	kW/100 Square Feet	MMBtu/100 Square Feet
Indianapolis			
AC Natural Gas Heat	44	0.1	1.07
Heat Pump	1,378	0.2	0
AC Electric Heat	2,399	0.1	0
Electric Heat Only	2,380	0	0
Natural Gas Heat Only	55	0	1.09
South Bend			
AC Natural Gas Heat	70	0.1	1.01
Heat Pump	1,265	0.1	0
AC Electric Heat	2,252	0.1	0
Electric Heat Only	2,246	0	0
Natural Gas Heat Only	50	0	1.01
Evansville			
AC Natural Gas Heat	45	0	0.84
Heat Pump	838	0.1	0
AC Electric Heat	1,812	0.1	0
Electric Heat Only	1,787	0	0
Natural Gas Heat Only	40	0	0.85
Ft Wayne			
AC Natural Gas Heat	44	0	1.1
Heat Pump	1,428	0.1	0
AC Electric Heat	2,431	0	0
Electric Heat Only	2,443	0	0
Natural Gas Heat Only	53	0	1.1

Electricity and Fossil Fuel Impacts of Window Upgrades*HVAC System	kWh/100 Square Feet	kW/100 Square Feet	MMBtu/100 Square Feet
Terre Haute			
AC Natural Gas Heat	62	0.1	0.9
Heat Pump	1,036	0.1	0
AC Electric Heat	1,967	0.1	0
Electric Heat Only	1,949	0	0
Natural Gas Heat Only	43	0	0.9

HVAC System Weighted Average*

City	kWh/100 Square Feet	kW/100 Square Feet	MMBtu/100 Square Feet
Indianapolis	569.4	0.0890	0.8158
South Bend	551.5	0.0850	0.7676
Evansville	429.0	0.0220	0.6397
Ft Wayne	578.2	0.0040	0.8360
Terre Haute	479.1	0.0850	0.6840

* Infiltration unit savings derived from residential simulation models. See Appendix A.

Domestic Hot Water

Heat Pump Water Heaters (Time of Sale)

	Measure Details
Official Measure Code	Res-DHW-HPWH-1
Measure Unit	Per heat pump
Measure Category	Domestic hot water
Sector(s)	Residential
Annual Energy Savings (kWh)	Varies by heating system
Peak Demand Reduction (kW)	Varies by heating system
Annual Fossil Fuel Savings (MMBtu)	-7.380
Lifetime Energy Savings (kWh)	Varies by heating system
Lifetime Fossil Fuel Savings (MMBtu)	-73.80
Water Savings (gal/yr)	0
Effective Useful Life (years)	10
Incremental Cost	$700.00
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is installing a heat pump DHW heater in place of a standard electric hot water heater. This is a time of sale measure. Savings are presented dependent on the heating system installed in the home.

Definition of Efficient Equipment

To qualify for this measure, the installed equipment must be a heat pump DHW heater.

Definition of Baseline Equipment

The baseline condition is a standard electric hot water heater.

Deemed Lifetime of Efficient Equipment

The measure life is 10 years.[82]

Deemed Measure Cost

The incremental cost for this measure is $700.00[83]

---

[82] ENERGY STAR. *Residential Water Heaters, Final Criteria Analysis*. Available online: http://www.energystar.gov/ia/partners/prod_development/new_specs/downloads/water_heaters/WaterHeaterDraftCriteriaAn alysis.pdf

[83] Duke Energy. *Measure Cost Data*. 2012.

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\Delta \mathrm{kWh} = kWh_{BASE} * \frac{COP_{NEW} - COP_{BASE}}{COP_{NEW}} + kWh_{COOLING} - kWh_{HEATING}$$

Where:

$\mathrm{kWh}_{\mathrm{BASE}}$ = Average electric DHW consumption (= 3,460)[84]

$\mathrm{COP}_{\mathrm{NEW}}$ = Coefficient of performance (efficiency) of heat pump water heater (= 2.0)[85]

$\mathrm{COP}_{\mathrm{BASE}}$ = Coefficient of performance (efficiency) of standard electric water heater (= 0.904)[86]

$\mathrm{kWh}_{\mathrm{COOLING}}$ = Cooling savings from conversion of heat in home to water heat (= 180)[87]

$\mathrm{kWh}_{\mathrm{heating}}$ = Heating cost from conversion of heat in home to water heat (= dependent on heating system as follows)[88]

---

[84] U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy. *Residential Water Heaters Technical Support Document for the January 17, 2001, Final Rule.* DOE/EE-0317. Table 9.3.9, p. 9-34. May 2007. Available online: http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/09.pdf

[85] ENERGY STAR. *Residential Water Heaters, Final Criteria Analysis.* Available online: http://www.energystar.gov/ia/partners/prod_development/new_specs/downloads/water_heaters/WaterHeaterDraftCriteriaAn alysis.pdf

[86] Ibid.

[87] Determined by: (1) calculating the MMBtu removed from the air, (2) applying the REM Rate-determined percentage of lighting savings that result in reduced cooling loads (35%; lighting is used as a proxy for DHW heating since load shapes suggest their seasonal usage patterns are similar), (3) assuming a SEER 11 central air conditioning unit, (4) multiplying by 64% to adjust for the percentage of Indiana homes with cooling (Energy Information Administration. *2005 Residential Energy Consumption Survey*. East North Central census division. Available online: http://www.eia.doe.gov/emeu/recs/recs2005/hc2005_tables/hc6airconditioningchar/pdf/tablehc12.6.pdf), and (5) applying a discretionary usage adjustment of 0.75 (Energy Center of Wisconsin. *Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research*. p. 31. May 2008).

[88] Determined by applying the REM Rate-determined percentage of lighting savings that result in increased heating loads (45%) to the calculated MMBtu removed from the air, then converting to kilowatt-hours and dividing by the heating system efficiency (1.0 for electric resistance, 2.0 for heat pump).

Heading System	$\text{kWh}_{\text{heating}}$
Electric resistance	1,577
Heat pump COP 2.0	779
Fossil fuel	0

$$\Delta\text{kWh electric resistance heat} = 3460 * \frac{2.0-0.904}{2.0} + 180 - 1577 = 499\ \text{kWh}$$

$$\Delta\text{kWh heat pump heat} = 3460 * \frac{2.0-0.904}{2.0} + 180 - 779 = 1{,}297\ \text{kWh}$$

$$\Delta\text{kWh fossil fuel heat} = 3460 * \frac{2.0-0.904}{2.0} + 180 - 0 = 2{,}076\ \text{kWh}$$

Summer Peak Coincident Demand Reduction

$$\Delta\text{kW} = \frac{\Delta\, kWh}{Hours} * CF$$

Where:

Hours = Equivalent full load hours of hot water heater (= 2,533)[89]

CF = Summer peak coincidence factor (= 0.346)[90]

$$\Delta\text{kW electric resistance heat} = \frac{499}{2{,}533} * 0.346 = 0.068\ \text{kW}$$

$$\Delta\text{kW heat pump heat} = \frac{1{,}297}{2{,}533} * 0.346 = 0.177\ \text{kW}$$

$$\Delta\text{kW fossil fuel heat} = \frac{2{,}076}{2{,}533} * 0.346 = 0.284\ \text{kW}$$

---

[89] Efficiency Vermont. Load shape calculated from Itron eShapes.

[90] Calculated from Itron eShapes, which is 8,760 hourly data by end use for Upstate New York, adjusted for Ohio peak definitions. The resulting peak coincident kilowatts are consistent with result shown in: U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy. *Field Testing of Pre-Production Prototype Residential Heat Pump Water Heaters*. DOE/EE-0317. May 2007. Available online: http://www1.eere.energy.gov/femp/pdfs/tir_heatpump.pdf

Fossil Fuel Impact Descriptions and Calculation

$$\Delta MMBtu = -7.380\ MMBtu^{91}$$

---

[91] This is the additional energy consumption (therefore a negative value) required to replace the heat removed from the home during the heating season by the heat pump water heater. Determined by: (1) calculating the MMBtu removed from the air, (2) applying the REM Rate-determined percentage of lighting savings that result in increased heating loads (45%; lighting is used as a proxy for DHW heating since load shapes suggest their seasonal usage patterns are similar), and (3) dividing by the efficiency of the heating system (estimated assuming that natural gas central furnace heating is typical for Indiana residences; 65% of East North Central homes have a natural gas furnace (Energy Information Administration. *2005 Residential Energy Consumption Survey*. Available online: http://www.eia.doe.gov/emeu/recs/recs2005/hc2005_tables/hc4spaceheating/pdf/tablehc12.4.pdf).
In 2000, 40% of furnaces purchased in Indiana were condensing (based on data from GAMA, provided to U.S. Department of Energy during the federal standard setting process). Assuming typical efficiencies for condensing and non-condensing furnace and duct losses, the average heating system efficiency is estimated as: (0.4 * 0.92) + (0.6 * 0.8) * (1 - 0.15) = 0.72.

Low-Flow Faucet Aerator (Time of Sale or Early Replacement)

	Measure Details
Official Measure Code	Res-DHW-Aerator-1
Measure Unit	Per aerator
Measure Category	Domestic hot water
Sector(s)	Residential
Annual Energy Savings (kWh)	Varies by space, building type, and location
Peak Demand Reduction (kW)	Varies by space, building type, and location
Annual Fossil Fuel Savings (MMBtu)	Varies by space, building type, and location
Lifetime Energy Savings (kWh)	Varies by space, building type, and location
Lifetime Fossil Fuel Savings (MMBtu)	Varies by space, building type, and location
Water Savings (gal/yr)	Varies by space, building type, and location
Effective Useful Life (years)	10
Incremental Cost	$2.00
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is installing a low-flow (1.0 - 1.5 GPM) kitchen or bathroom faucet aerator in a home. This could be a retrofit direct install measure or a new installation. Both electric and fossil fuel savings are provided, although only savings corresponding to the hot water heating fuel should be claimed.

Definition of Efficient Equipment

The efficient equipment is a low-flow faucet aerator.

Definition of Baseline Equipment

The baseline equipment is a standard faucet aerator using > 2 GPM.

Deemed Lifetime of Efficient Equipment

The measure life is 10 years.[92]

Deemed Measure Cost

As a retrofit measure, the cost will be the actual cost for the aerator and installation.

---

[92] California Public Utilities Commission. *Database for Energy Efficient Resources.* Assumption for faucet aerators. Available online: www.deeresources.com

As a measure distributed to and installed by participants, the cost is the price of the aerator and distribution, determined to be $2.00.[93]

Deemed O&M Cost Adjustments

When a retrofit measure, there would be a very small O&M benefit associated with the deferral of the next replacement, but this has conservatively not been characterized.

Savings Algorithm

Energy Savings

The energy savings from homes with an electric DHW heater would be:

$$\Delta\text{kWh} = ISR * (GPM_{BASE} - GPM_{LOW}) * MPD * \frac{PH}{FH} * DR * 8.3 * (T_{MIX} - T_{IN}) * \frac{365}{RE * 3{,}412}$$

Where:

ISR = In-service rate, or fraction of units that get installed (= 1.0 for retrofit/direct install; = 0.48 for customer self-install)[94]

GPM_{BASE} = Gallons per minute of baseline faucet aerator (= 1.90 for bathrooms, = 2.44 for kitchens)[95]

GPM_{LOW} = Gallons per minute of low-flow faucet aerator (= 1.01 for bathrooms, = 1.49 for kitchens)[96]

MPD = Average minutes of faucet use per person per day (= 1.6 for bathrooms, = 4.5 for kitchens)[97]

PH = Average number of people per household (= 2.64 for single family, = 1.83 for multifamily, = 2.47 for unknown housing type)[98]

---

[93] Navigant Consulting and Ontario Energy Board. *Measures and Assumptions for Demand Side Management (DSM) Planning.* April 2009.

[94] EGD_2009_DSM_Annual Report from table 27 survey of Install rates: Overall averages of 62% and 34% for kitchen and bath aerators respectively are averaged to get 48%. There is significant variation in rates by building type, aerator type, and distribution so surveying participants is encouraged

[95] Cadmus. *2011 IPL Residential Core Plus Evaluation, Multifamily Direct Install Program.* 2012.

[96] Ibid.

[97] Cadmus and Opinion Dynamics. *Showerhead and Faucet Aerator Meter Study.* Memorandum prepared for Michigan Evaluation Working Group. 2013.

[98] Census data from Ferret Software for Indiana uses ACS three-year public-use microdata (2008-2010). Weighted values by housing type of 79% for single family and 21% for multifamily) determined from: U.S. Energy Information Administration. *Residential Energy Consumption Surveys.* 2009.

FH = Average faucets per household (= dependent on sink and housing type; see table below)[99]

Quantity of Faucets by Sink and Housing Type

Housing Type	Bathroom	Kitchen
Single-Family	2.04	1.00
Multifamily	1.43	1.00
Unknown	1.91	1.00

365 = Days of faucet use per year

DR = Percentage of water flowing down drain (= 50% for kitchens, = 70% for bathrooms;[100] if water is collected in a sink, a faucet aerator will not result in any saved water)

8.3 = Specific weight of water in pounds per gallon, which is then multiplied by the specific water temperature ($1.0\ \frac{Btu}{lb*°F}$)

T_{MIX} = Mixed water temperature exiting faucet (= 86.0°F for bathrooms, = 93.0°F for kitchens)[101]

T_{IN} = Cold water temperature entering the DWH system (= dependent on climate, see table below)

---

[99] Cadmus and Opinion Dynamics. *Showerhead and Faucet Aerator Meter Study.* Memorandum prepared for Michigan Evaluation Working Group. 2013. “Unknown” housing type percentages of 79% for single family and 21% for multifamily are weighted averages from: U.S. Energy Information Administration. *Residential Energy Consumption Surveys*. 2009.

[100] Navigant Consulting and Ontario Energy Board. *Measures and Assumptions for Demand Side Management (DSM) Planning.* April 2009.

[101] Cadmus and Opinion Dynamics. *Showerhead and Faucet Aerator Meter Study.* Memorandum prepared for Michigan Evaluation Working Group. 2013.

Cold Water Entering Temperature by City*

City	Groundwater Temperature (°F)
Indianapolis	58.1
South Bend	57.4
Terre Haute	60.5
Evansville	62.8
Ft Wayne	55.6

* Burch, J. and C. Christensen, National Renewable Energy Lab. White paper: “Towards Development of an Algorithm for Mains Water Temperature.” Prepared for American Solar Energy Society. 2007.

RE = Recovery efficiency of electric hot water heater (= 0.98)[102]

3,412 = Constant to convert Btu to kWh

For example, the energy savings from a 1.5 GPM direct-installation bathroom aerator in a single family Indianapolis home with an electric water heater would be:

$$\Delta\text{kWh} = 1.0 * (1.90 - 1.01) * 1.6 * \frac{2.64}{2.04} * 0.70 * 8.3 * (86 - 58.1) * \frac{365}{0.98 * 3{,}412} = 33\text{ kWh}$$

Summer Peak Coincident Demand Reduction

$$\Delta\text{kW} = ISR * (GPM_{BASE} - GPM_{LOW}) * 60 * DR * 8.3 * \frac{T_{MIX} - T_{IN}}{RE * 3{,}412} * CF$$

Where:

60 = Minutes per Hour

CF = Summer peak coincidence factor (= 0.0012 for bathrooms, = 0.0033 for kitchens)[103]

For example, the demand reduction from a 1.5 GPM direct-installation bathroom aerator in a multifamily home in South Bend with an electric water heater would be:

$$\Delta\text{kW} = 1.0 * (1.90 - 1.01) * 60 * 0.70 * 8.3 * \frac{(86 - 57.4)}{0.98 * 3{,}412} * 0.0012 = 0.003\text{ kW}$$

Fossil Fuel Impact Descriptions and Calculation

Homes with a fossil fuel DHW heater have the following MMBtu savings:

$$\Delta\text{MMBtu} = ISR * (GPM_{BASE} - GPM_{LOW}) * MPD * \frac{PH}{FH} * DR * 8.3 * (T_{MIX} - T_{IN}) * \frac{365}{RG * 1{,}000{,}000}$$

---

[102] NREL, Building America Research benchmark definition, 2009, p. 12. http://www.nrel.gov/docs/fy10osti/47246.pdf.

[103] Cadmus. *Wisconsin Technical Reference Manual.* Prepared for Wisconsin Focus on Energy. January 2015.

Where:

RG = Recovery efficiency of natural gas hot water heater (= 0.76)[104]

1,000,000 = Constant to convert Btu to MMBtu

For example, the fossil fuel savings from a 1.5 GPM direct-installation kitchen aerator in a single family home in Evansville with a natural gas water heater would be:

$$\Delta\text{MMBtu} = 1.0 * (2.44 - 1.49) * 4.5 * \frac{2.64}{1.00} * 0.50 * 8.3 * (93.0 - 62.8) * \frac{365}{0.76 * 1{,}000{,}000} = 0.679$$

Water Impact Descriptions and Calculation

$$\text{Water Savings} = ISR * (GPM_{BASE} - GPM_{LOW}) * MPD * \frac{PH}{FH} * DR * 365$$

For example, the water savings from a 1.5 GPM direct-installation bathroom aerator in an unknown home type would be:

$$\text{Water Savings} = 1.0 * (1.90 - 1.01) * 1.6 * \frac{2.47}{1.91} * 0.70 * 365 = 470.5 \text{ gallons}$$

---

[104] NREL, Building America Research benchmark definition, 2009, p. 12.

http://www.nrel.gov/docs/fy10osti/47246.pdf.

Low-Flow Showerhead (Time of Sale or Early Replacement)

	Measure Details
Official Measure Code	Res-DHW-SH-1
Measure Unit	Per showerhead
Measure Category	Domestic hot water
Sector(s)	Residential
Annual Energy Savings (kWh)	Varies by building type and location
Peak Demand Reduction (kW)	Varies by building type and location
Annual Fossil Fuel Savings (MMBtu)	Varies by building type and location
Lifetime Energy Savings (kWh)	Varies by building type and location
Lifetime Fossil Fuel Savings (MMBtu)	Varies by building type and location
Water Savings (gal/yr)	Varies by building type and location
Effective Useful Life (years)	10
Incremental Cost	$18.50
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is installing a low-flow showerhead in a home. This is a retrofit direct install measure or for a new installation. Both electric and fossil fuel savings are provided, although only savings corresponding to the hot water heating fuel should be claimed.

Definition of Efficient Equipment

The efficient condition is a low-flow showerhead of 1.74 GPM or less.

Definition of Baseline Equipment

The baseline is a standard showerhead with a flow of 2.63 GPM (the baseline in Indiana).

Deemed Lifetime of Efficient Equipment

The measure life is 10 years.

Deemed Measure Cost

As a retrofit measure, the incremental cost will be the cost of the showerhead including its installation.

As a measure distributed to and installed by participants, the cost is the price of the showerhead and for distribution, or $18.50[105].

---

[105] Itron, Inc. *2010-2012 WO017 Ex Ante Measure Cost Study Final Report*. May 27, 2014. Submitted to the California Public Utilities Commission.

Deemed O&M Cost Adjustments

When a retrofit measure, there would be a very small O&M benefit associated with the deferral of the next replacement, but this has conservatively not been characterized.

Savings Algorithm

Energy Savings

The energy savings from homes with an electric domestic hot water heater would be:

$$\Delta\text{kWh} = ISR * (GPM_{BASE} - GPM_{LOW}) * MS * SPD * \frac{PH}{SH} * 8.3 * (T_{MIX} - T_{IN}) * \frac{365}{RE * 3{,}412}$$

Where:

ISR = In-service rate, or fraction of units that get installed (= 1.0 for retrofit/direct install; = 0.81 for customer self-install)

GPM_{BASE} = Gallons per minute of baseline showerhead (= 2.63)[106]

GPM_{LOW} = Gallons per minute of low-flow showerhead (= actual; otherwise = 1.74)[107]

MS = Average minutes per shower event (= 7.8)[108]

SPD = Average number of shower events per person per day (= 0.6)[109]

PH = Average number of people per household (= 2.64 for single family, = 1.83 for multifamily, = 2.47 for unknown housing type)[110]

SH = Average number of showerheads per household (= 1.6 for single family,[111] = 1.2 for multifamily)[112]

365 = Days of shower use per year

---

[106] Cadmus. *2011 IPL Residential Core Plus Evaluation, Multifamily Direct Install Program*. 2012.

[107] Ibid.

[108] Cadmus and Opinion Dynamics. *Showerhead and Faucet Aerator Meter Study.* Memorandum prepared for Michigan Evaluation Working Group. 2013.

[109] Ibid.

[110] Census data from Ferret Software for Indiana Uses ACS three-year public use microdata (2008-2010). Weighted values by housing type of 79% for single family and 21% for multifamily determined from: U.S. Energy Information Administration. *Residential Energy Consumption Surveys.* 2009.

[111] TecMarket Works, et al. *Residential Baseline Report Final*. November 2, 2012. Prepared for the Indiana Demand Side Management Coordination Committee Core Programs

[112] Cadmus. *2011 IPL Residential Core Plus Evaluation, Multifamily Direct Install Program*. 2012.

8.3 = Specific weight of water in pounds per gallon, which is multiplied by the specific heat of water ($1.0\,\frac{Btu}{lb*°F}$)

T_{MIX} = Average mixed temperature of water used for shower (= 101°F) [113]

T_{IN} = Cold water temperature entering the DWH system (= depending on climate, see table below)

Cold Water Temperature by City

City	Groundwater Temperature (°F)
Indianapolis	58.1
South Bend	57.4
Terre Haute	60.5
Evansville	62.8
Ft Wayne	55.6

* Burch, J. and C. Christensen, National Renewable Energy Lab. White paper: "Towards Development of an Algorithm for Mains Water Temperature." Prepared for American Solar Energy Society. 2007.

RE = Recovery efficiency of electric hot water heater (= 0.98)[114]

3412 = Constant to convert Btu to kWh

For example, the energy savings from a 2.0 GPM direct installation in an Indianapolis single family home would be:

$$\Delta kWh = 1.0 * (2.63 - 2.0) * 7.8 * 0.6 * \frac{2.64}{1.6} * 8.3 * (101 - 58.1) * \frac{365}{0.98*3{,}412} = 189$$

Summer Peak Coincident Demand Reduction

The demand reduction from homes with an electric DHW heater would be:

$$\Delta kW = ISR * (GPM_{BASE} - GPM_{LOW}) * 60 * 8.3 * \frac{(T_{MIX} - T_{IN})}{RE * 3{,}412} * CF$$

Where:

60 = Minutes per hour

CF = Summer peak coincidence factor (= 0.0023)[115]

---

[113] Cadmus and Opinion Dynamics Evaluation Team, *Showerhead and Faucet Aerator Meter Study* [Memorandum]. Michigan Evaluation Working Group, 2013

[114] NREL, Building America Research benchmark definition, 2009, p. 12. http://www.nrel.gov/docs/fy10osti/47246.pdf.

[115] Cadmus. *Wisconsin Technical Reference Manual.* Prepared for Wisconsin Focus on Energy. January 2015.

For example, the demand reduction from a 2.0 GPM direct-installation in an Indianapolis multifamily home would be:

$$\Delta \text{kW} = 1.0 * (2.63 - 2.0) * 60 * 8.3 * \frac{(101-58.1)}{0.98 * 3{,}412} * 0.0023 = 0.009$$

Fossil Fuel Impact Descriptions and Calculation

The fossil fuel savings for homes with a fossil fuel DHW heater would be:

$$\Delta \text{MMBtu} = ISR * (GPM_{BASE} - GPM_{LOW}) * MS * SPD * \frac{PH}{SH} * 8.3 * (T_{MIX} - T_{IN}) * \frac{365}{RG * 1{,}000{,}000}$$

Where:

RG = Recovery efficiency of natural gas hot water heater (= 0.76)[116]

1,000,000 = Conversion from Btu to MMBtu

For example, the fossil fuel savings from a 2.0 GPM direct-installation in an Indianapolis multifamily home would be:

$$\Delta \text{MMBtu} = 1.0 * (2.63 - 2.0) * 7.8 * 0.6 * \frac{1.83}{1.2} * 8.3 * (101 - 58.1) * \frac{365}{0.76 * 1{,}000{,}000} = 0.318$$

Water Impact Descriptions and Calculation

$$\text{Water Savings} = ISR * (GPM_{BASE} - GPM_{LOW}) * MS * SPD * \frac{PH}{SH} * 365$$

For example, the water savings from a 2.0 GPM direct installation in an Indianapolis multifamily home would be:

$$\text{Water Savings} = 1.0 * (2.63 - 2.0) * 7.8 * 0.6 * \frac{1.83}{1.2} * 365 = 1{,}641 \text{ gallons}$$

---

[116] NREL, Building America Research benchmark definition, 2009, p. 12.

http://www.nrel.gov/docs/fy10osti/47246.pdf.

Domestic Hot Water Pipe Insulation (Retrofit)

	Measure Details
Official Measure Code	Res-DHW-PipeIns-1
Measure Unit	Per installation
Measure Category	Domestic hot water
Sector(s)	Residential
Annual Energy Savings (kWh)	Varies by pipe length
Peak Demand Reduction (kW)	Varies by pipe length
Annual Fossil Fuel Savings (MMBtu)	Varies by pipe length
Lifetime Energy Savings (kWh)	Varies by pipe length
Lifetime Fossil Fuel Savings (MMBtu)	Varies by pipe length
Water Savings (gal/yr)	0
Effective Useful Life (years)	15
Incremental Cost (per linear foot)	$8.98
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is adding insulation to uninsulated DHW pipes. The measure savings are based on the pipe wrap being installed to the first length of both the hot and cold pipe up to the first elbow.

Definition of Efficient Equipment

The efficient condition is installing pipe wrap insulation to a length of hot water carrying copper pipe.

Definition of Baseline Equipment

The baseline is an uninsulated hot water carrying copper pipe.

Deemed Lifetime of Efficient Equipment

The measure life is 15 years.[117]

Deemed Measure Cost

The measure cost including material and installation is $8.98 per linear foot. [118].

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

---

[117] GDS Associates. *Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures*. June 2007. Available online: http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf

[118] Itron, Inc. *2010-2012 WO017 Ex Ante Measure Cost Study Final Report*. May 27, 2014. Submitted to the California Public Utilities Commission.

Savings Algorithm

Energy Savings

The energy savings for homes with an electric DHW system would be:

$$\Delta \text{kWh} = \left(\frac{1}{R_{EXIST}} - \frac{1}{R_{NEW}}\right) * \frac{L * C * \Delta T * 8{,}760}{\eta_{DHW} * 3{,}412}$$

Where:

R_{EXIST} = Pipe heat loss coefficient (R-value) of uninsulated pipe existing (= 1.0 $\frac{°F * hr * ft^2}{Btu}$)[119]

R_{NEW} = Pipe heat loss coefficient (R-value) of insulated pipe (= actual; otherwise = 3)[120]

L = Feet of pipe from water heating source covered by pipe wrap (= actual)

C = Circumference of pipe in feet (= actual; = π * diameter)

ΔT = Average temperature difference between supplied water and ambient air temperature (= 65°F)[121]

8,760 = Hours per year

η_{DHW} = Recovery efficiency of electric hot water heater (= 0.98)[122]

3,412 = Conversion from Btu to kWh

For example, the energy savings from insulating 5 feet of 0.75-inch pipe with R-4 wrap would be:

$$\Delta kWh = \left(\frac{1}{1} - \frac{1}{5}\right) * \frac{5 * \left(\pi * \frac{0.75}{12}\right) * 65 * 8{,}760}{0.98 \; * \; 3{,}412} = 134 \; kWh$$

Summer Peak Coincident Demand Reduction

$$\Delta \text{kW} = \frac{\Delta kWh}{8{,}760}$$

---

[119] Navigant Consulting and Ontario Energy Board. *Measures and Assumptions for Demand Side Management (DSM) Planning.* "Appendix C Substantiation Sheets." P. 77. April 2009.

[120] Assumes standard 0.5-inch insulation with 4 $\frac{°F * hr * ft^2}{Btu * in}$ in addition to R-value of uninsulated pipe, based on: ASHRAE Fundamentals Chapter 23-Table 2.

[121] Assumes 130°F average water temperature leaving the hot water tank and average basement temperature of 65°F.

[122] Electric water heater have recovery efficiency of 98%: http://www.ahrinet.org/ARI/util/showdoc.aspx?doc=576

Where:

ΔkWh = kWh savings from pipe wrap installation

8,760 = Number of hours in a year

For example, the demand savings from insulating 5 feet of 0.75-inch pipe with R-4 wrap would be:

$$\Delta kW = \frac{133}{8,760} = 0.015\ kW$$

Fossil Fuel Impact Descriptions and Calculation

The fossil fuel savings for homes with a fossil fuel DHW system would be:

$$\Delta MMBtu = \left(\frac{1}{R_{EXIST}} - \frac{1}{R_{NEW}}\right) * \frac{L * C * \Delta T * 8,760}{\eta_{DHW} * 1,000,000}$$

Where:

η_{DHW} = Recovery efficiency of natural gas hot water heater (= 0.75)[123]

1,000,000 = Conversion from Btu to MMBtu

For example, the fossil fuel savings from insulating 5 feet of 0.75-inch pipe with R-4 wrap would be:

$$\Delta MMBtu = \left(\frac{1}{1} - \frac{1}{5}\right) * \frac{5 * 0.196 * 65 * 8,760}{0.75 * 1,000,000} = 0.596\ MMBtu$$

---

[123] Per AHRI directory, the range of recovery efficiency ratings for new natural gas DHW units is 70% to 87%, so the average of existing units is estimated as 75%.

Natural Gas Water Heaters (Time of Sale)

	Measure Details
Official Measure Code	Res-DHW-StorWH-1
Measure Unit	Per water heater
Measure Category	Domestic hot water
Sector(s)	Residential
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Fossil Fuel Savings (MMBtu)	Varies by location
Lifetime Energy Savings (kWh)	0
Lifetime Fossil Fuel Savings (MMBtu)	Varies by location
Water Savings (gal/yr)	0
Effective Useful Life (years)	13
Incremental Cost	Varies by technology
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is purchasing and installing an efficient natural gas water heater meeting or exceeding ENERGY STAR criteria[124] for the water heater category.

Definition of Efficient Equipment

The efficient condition is a natural gas water heater meeting the minimum efficiency ENERGY STAR qualification criteria, listed by category in the table below[125].

ENERGY STAR Criteria by Water Heater Type

Water Heater Type	Energy Factor
Natural Gas Storage ≤ 55 gallons	0.67
Natural Gas Storage > 55 gallons	0.77
Natural Gas Tankless (whole house)	0.90

---

[124] ENERGY STAR. "Residential Water Heaters Key Product Criteria." 2015http://www.energystar.gov/index.cfm?c=water_heat.pr_crit_water_heaters

[125] Ibid.

Definition of Baseline Equipment

The baseline condition is a 50-gallon conventional natural gas storage water heater with the federal minimum rating of 0.58 EF.

Deemed Lifetime of Efficient Equipment

The measure life is 13 years.[126]

Deemed Measure Cost

The deemed measure cost by water heater type is given in the table below.

Incremental cost by Water Heater Type

Water Heater Type	Incremental Cost*
Natural Gas Storage (0.67 EF)	$400
Natural Gas Storage Condensing (0.80 EF)	$685
Natural Gas Tankless (whole house; 0.82 EF)	$605

* U.S. Environmental Protection Agency. *ENERGY STAR Water Heater Criteria Final Analysis*. Used the low end of the cited range for the tankless category due to age of report.

Deemed O&M Cost Adjustments

There is no justification at this time for O&M cost adjustments.

Savings Algorithm

Energy Savings

$$\Delta\text{MMBtu} = GPD * 365 * 8.3 * \frac{\Delta T}{1{,}000{,}000} * \left(\frac{1}{EF_{BASE}} - \frac{1}{EF_{EFF}}\right)$$

Where:

GPD = Average daily hot water consumption (= see table)

8.3 = Constant (Btu/gal-°F)

Hot water use varies by family size. Estimates of hot water use per person as a function of number of people in the home are shown in the table below.

---

[126] The life expectancy of each water heater depends on local variables, such as water chemistry and homeowner maintenance. While there is currently insufficient data to determine tankless water heaters lifetimes, preliminary data show lifetimes up to 20 years. This value of 13 years is the weighted average lifetime for this measure category in aggregate and is supported by the findings in: http://www.aceee.org/consumerguide/WH_LCC_1107.pdf

Hot Water Use by Family Size

Number of People	Gallons per Person per Day	Gallons per Day per Household
1	29.4	29
2	22.8	46
3	20.6	62
4	19.5	78
5	18.9	94
6	18.5	111

ΔT = Water temperature difference between water heater setpoint and entering cold water

The water heater setpoint for residential buildings is usually between 120°F and 140°F. The average cold water entering temperature varies by climate, as shown in the table below.

City	Groundwater Temperature (°F)
Indianapolis	58.1
South Bend	57.4
Terre Haute	60.5
Evansville	62.8
Ft Wayne	55.6

* Burch, J. and C. Christensen, National Renewable Energy Lab. White Paper: “Towards Development of an Algorithm for Mains Water Temperature.” 2007.

EF_{BASE} = Energy factor for baseline equipment (= 0.594)

EF_{EFF} = Energy factor for efficient equipment (= actual)

For example, the energy savings from installing a new tankless unit with an EF of 0.82 in a four person home in Indianapolis would be:

$$\Delta\text{MMBtu} = GPD * 365 * 8.3 * \frac{\Delta T}{1{,}000{,}000} * \left(\frac{1}{EF_{BASE}} - \frac{1}{EF_{EFF}}\right)$$

$$= 78 * 365 * 8.3 * \frac{140-58.1}{1{,}000{,}000} * \left(\frac{1}{0.594} - \frac{1}{0.82}\right) = 8.98\ \text{MMBtu}$$

Summer Peak Coincident Demand Reduction

There is no expected peak demand reduction associated with this measure.

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.

Water Heater Wrap (Direct Install)

	Measure Details
Official Measure Code	Res-DHW-TankWrap-1
Measure Unit	Per wrap
Measure Category	Domestic hot water
Sector(s)	Residential
Annual Energy Savings (kWh)	79
Peak Demand Reduction (kW)	0.009
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	393
Lifetime Fossil Fuel Savings (MMBtu)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	5
Incremental Cost	TBD
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is wrapping tank wrap or an insulation blanket around the outside of a hot water tank to reduce standby losses. This measure savings only apply to homes with an electric water heater that is not already well insulated. Generally this can be determined based on the appearance of the tank and whether it is insulated by foam (which is newer, rigid, and more effective) or fiberglass (which is older and gives to gently pressure).

Definition of Efficient Equipment

The efficient condition is properly installed insulating tank wrap that reduces standby energy losses from the tank to the surrounding ambient area.

Definition of Baseline Equipment

The baseline condition is a standard electric DHW tank without additional tank wrap. Natural gas storage water heaters are excluded due to the limitations of retrofit wrapping and the associated impacts on reduced savings and safety.

Deemed Lifetime of Efficient Equipment

The measure life is 5 years.[127]

---

[127] This estimate is based on tank wrap being installed on an existing unit with 5 years of remaining life. On average when retrofitting an existing tank, the tank would be roughly halfway through its 13 to 15 year life, but qualifying baseline tanks with fiberglass (rather than foam insulation) are older on average by a few years.

Deemed Measure Cost

The incremental cost is the actual material cost of procuring and labor cost of installing the tank wrap.

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

This calculation is based on the finding that a poorly insulated electric resistance water heater with a pre-wrap EF of 0.86 has a new and more effective EF of 0.88 after being properly wrapped with supplemental insulation. The impacts of waste heat on heating and cooling savings are not included.

Energy Savings

$$\Delta\text{kWh} = kWh_{BASE} * \frac{EF_{NEW} - EF_{BASE}}{EF_{NEW}}$$

Where:

kWh_{BASE} = Average kilowatt-hour consumption of electric DHW tank (= 3,460)[128]

EF_{NEW} = Assumed efficiency of electric tank with tank wrap installed (= 0.88)[129]

EF_{BASE} = Assumed efficiency of electric tank without tank wrap installed (= 0.86)

$$\Delta\text{kWh} = 3{,}460 * \frac{0.88 - 0.86}{0.88} = 79\text{ kWh}$$

Summer Peak Coincident Demand Reduction

$$\Delta\text{kW} = \frac{\Delta kWh}{8{,}760}$$

Where:

ΔkWh = Kilowatt-hour savings from tank wrap installation

8,760 = Number of hours in a year

$$\Delta\text{kW} = \frac{79}{8{,}760} = 0.009\text{ kW}$$

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.

---

[128] U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy. *Residential Water Heaters Technical Support Document for the January 17, 2001, Final Rule.* DOE/EE-0317. Table 9.3.9, p. 9-34. May 2007. Available online: http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/09.pdf

[129] Oak Ridge National Laboratory. *Meeting the Challenge: The Prospect of Achieving 30 percent Energy Savings Through the Weatherization Assistance Program*. May 2002. Available online: http://www.cee1.org/eval/db_pdf/309.pdf. Study predicted that wrapping a 40-gallon water heater would increase the electric DHW tank energy factor by 0.02 (from 0.86 to 0.88).

Solar Water Heater with Electric Backup (Retrofit)

	Measure Details
Official Measure Code	Res-DHW-SWH-1
Measure Unit	Per system
Measure Category	Domestic hot water
Sector(s)	Residential
Annual Energy Savings (kWh)	Varies by project
Peak Demand Reduction (kW)	Varies by project
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	Varies by project
Lifetime Fossil Fuel Savings (MMBtu)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	20
Incremental Cost	$9,506.00
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is installing a new solar water heater system with electric backup meeting the SRCC OG-300 performance standards presented below. This measure relates to installing a new system in an existing home.

Definition of Efficient Equipment

The efficient equipment is an SRCC OG-300 certified solar water heater with a solar energy factor meeting the ENERGY STAR specification.

Definition of Baseline Equipment

The baseline equipment is a standard electric water heater meeting or exceeding the minimum energy factor set in the 2004 federal conservation standard for water heaters.

Deemed Lifetime of Efficient Equipment

The expected measure life is 20 years.[130]

---

[130] ENERGY STAR. *Residential Water Heaters, Final Criteria Analysis.* Available online: http://www.energystar.gov/ia/partners/prod_development/new_specs/downloads/water_heaters/WaterHeaterDraftCriteriaAn alysis.pdf

Deemed Measure Cost

The cost for this measure is $9,506.00.[131]

Deemed O&M Cost Adjustments

The deemed O&M cost adjustment for this measure is $344.00.[132]

Savings Algorithm

Energy Savings

$$\Delta \text{kWh} = \left(\frac{1}{EF} - \frac{1}{SEF}\right) * Q_{DEL}$$

Where:

EF = Minimum energy factor for residential electric water heater (= 0.96 - (0.003 * Rated Storage Volume in gallons) = 0.945 for 50-gallon residential tank)[133]

SEF = Minimum system performance for solar water heaters (= actual)[134]

Q_{DEL} = Annual energy delivered to hot water load (= $23{,}470 * (135 - T_{IN}) * \frac{8.3}{3{,}412}$)

Where:

23,470 = Average gallons of water drawn per year, assuming 365 days per year operation[135]

135 = Average hot water supply temperature [136]

---

[131] Green Energy Ohio. "GEO Solar Thermal Rebate Program." http://www.greenenergyohio.org/page.cfm?pageID=2712. The average cost of a fully installed solar thermal system is $9,506, ranging from $6,825 to $11,850.

[132] Vermont Energy Investment Corporation. *Appendix 2 APS-Incentives for Photovoltaic Distributed Generation*. 2010. This value reflects the net present value of future costs including glycol, pump, and tank replacement. Because this retrofit measure replaces an existing water tank with some years remaining, this net present value conservatively overstates the O&M costs to the degree that the existing tank would have required replacement a few years earlier.

[133] 2015 Federal Energy Conservation Standard for water heaters (e-CFR Title 10, Chapter II, Subchapter D, Part 430, Subpart C, Section 430.32).

[134] Based on SRCC annual system performance rating for solar water heaters (OG-300 7/28/2010). ENERGY STAR specifications require a solar fraction greater than 0.5, which equates to a minimum solar energy factor of 1.8.

[135] Based on U.S. DOE and SRCC test procedure assumptions.

[136] Based on U.S. DOE and SRCC test procedure assumptions.

T_{IN} = Average cold water entering home (= depending on location; see table below)

Average Cold Water Temperature Entering Home by City*

City	Groundwater Temperature (°F)
Indianapolis	58.1
South Bend	57.4
Terre Haute	60.5
Evansville	62.8
Ft Wayne	55.6

* Burch, J. and C. Christensen, National Renewable Energy Lab. White paper: "Towards Development of an Algorithm for Mains Water Temperature." Prepared for American Solar Energy Society. 2007.

8.3 = Specific weight of water in pounds per gallon, multiplied by the specific heat of water ($1.0 \frac{Btu}{lb*°\text{F}}$)

3,412 = Conversion constant (1 kWh = 3,412 Btu)

For example, the energy savings from installing a solar water heater system with solar EF rating of 1.8 in Indianapolis would be:

$$\Delta\text{kWh} = \left(\frac{1}{0.945} - \frac{1}{1.8}\right) * 23{,}470 * (135 - 58.1) * \frac{8.3}{3{,}412} = 2{,}207\ \text{kWh}$$

Summer Peak Coincident Demand Reduction

$$\Delta\text{kW} = \frac{1}{EF} * \frac{Q_{DEL}}{Hours} * CF$$

Where:

Hours = Equivalent full load hours of water heater (= 2,533)[137]

CF = Summer peak coincidence factor for measure (= 0.203)[138]

For example, the demand reduction from installing a solar water heater system with solar EF rating of 1.8 in Indianapolis would be:

---

[137] Efficiency Vermont. Load shape calculated from Itron eShapes.

[138] Calculated from Itron eShapes, which has 8,760 hourly data by end use for Upstate New York.

$$\Delta\text{kW} = \frac{1}{0.945} * \frac{23{,}470 * (135 - 58.1) * \frac{8.3}{3{,}412}}{2{,}533} * 0.203 = 0.372\ kW^{139}$$

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.

---

[139] The resultant demand reduction from the Itron eShapes is consistent with the results of the ADM whitepaper for FirstEnergy's solar water heater program in Pennsylvania, in which the demand reduction is based on the system being designed to meet 100% of a home's hot water need during the summer months and is the product of two factors: (1) the annual baseline energy usage of an electric water heater and (2) the fraction of energy usage during the coincident peak times of 3:00 p.m. to 6:00 p.m. during the months of June thru August. The fractional usage was calculated from: PJM. *Deemed Savings Estimates for Legacy Air Conditioning and Water Heating Direct Load Control Programs in PJM Region*. Available online: http://www.pjm.com/~/media/committees-groups/working-groups/lrwg/20070301/20070301-pjm-deemed-savings- report.ashx

HVAC

Residential HVAC Maintenance/Tune-Up (Retrofit)

	Measure Details
Official Measure Code	Res-HVAC-AC/Furn Tuneup-1
Measure Unit	Per tune-up
Measure Category	HVAC
Sector(s)	Residential
Annual Energy Savings (kWh)	Varies by location
Peak Demand Reduction (kW)	Varies by location
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	Varies by location
Lifetime Fossil Fuel Savings (MMBtu)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	5
Incremental Cost	$64.00
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is (1) measuring refrigerant charge levels and airflow over the central air conditioning or heat pump unit coil, (2) correcting any problems found, and (3) re-measuring the levels and airflow post-treatment. Measurements must be performed with standard industry tools and the results tracked by the efficiency program.

Savings from this measure are based on a reputable Wisconsin study. It is recommended that future evaluation be conducted in Indiana to generate a more locally appropriate characterization.

Definition of Efficient Equipment

The efficient condition is measuring, correcting, and verifying the refrigerant charge levels and airflow over the central air conditioning or heat pump unit coil.

Definition of Baseline Equipment

The measure savings are based on the existing unit being regularly maintained being either a residential central air conditioning unit or an air-source heat pump.

Deemed Lifetime of Efficient Equipment

The measure life is 5 years.[140]

Deemed Measure Cost

If the implementation mechanism involves delivering and paying for the tune-up service, the actual cost should be used. If the customer receives a rebate and the private contractors perform the work, the measure cost is $64.00.[141]

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\Delta\text{kWh}_{CAC} = EFLH_{COOL} * Btuh_{COOL} * \frac{1}{SEER_{CAC} * 1{,}000} * MF_E$$

$$\Delta\text{kWh}_{ASHP} = \left(EFLH_{COOL} * Btuh_{COOL} * \frac{1}{SEER_{ASHP}} + EFLH_{HEAT} * Btuh_{HEAT} * \frac{1}{HSPF_{ASHP}}\right) * \frac{MF_E}{1{,}000}$$

Where:

$EFLH_{COOL}$ = Equivalent full load cooling hours (= dependent on location; see table below)

Equivalent Full Load Cooling Hours by City

Location	$EFLH_{COOL}$*
Indianapolis	487
South Bend	431
Evansville	600
Ft. Wayne	373
Terre Haute	569

* Based on prototypical building simulations. See Appendix A.

---

[140] GDS Associates. *Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures* June 2007.

[141] A survey of Dayton-area HVAC contractors revealed inspection and tune-up cost of $160.00. Given that inspection costs are $96.00, the tune-up cost is $64.00.

$Btuh_{COOL}$ = Cooling capacity of equipment in Btuh (= actual; otherwise = 28,994 Btuh;[142] Note: 1 ton = 12,000 Btuh)

$SEER_{CAC}$ = SEER efficiency of existing central air conditioning unit receiving maintenance (= actual; otherwise use 11.15)[143]

1,000 = Conversion from Wh to kWh

MF_E = Maintenance energy savings factor (= 0.05)[144]

$SEER_{ASHP}$ = SEER efficiency of existing air-source heat pump unit receiving maintenance (= actual; otherwise use 11.15)[145]

$EFLH_{HEAT}$ = Equivalent full load heating hours (= actual; dependent on location, see table below)

Equivalent Full Load Heating Hours by City

Location	$EFLH_{HEAT}$*
Indianapolis	1,341
South Bend	1,427
Evansville	982
Ft. Wayne	1,356
Terre Haute	804

* Extracted from simulations. See Appendix B.

$Btuh_{HEAT}$ = Heating capacity of equipment in Btuh (= actual)

$HSPF_{BASE}$ = Heating season performance factor of existing air-source heat pump unit receiving maintenance (= actual; otherwise use 6.8)[146]

For example, the energy savings from conducting maintenance on a 3-ton, SEER 10 air conditioning unit in Indianapolis would be:

$$\Delta kWh_{CAC} = 487 * 36{,}000 * \frac{1}{10*1{,}000} * 0.05 = 88 \text{ kWh}$$

---

[142] TecMarket Works, et al. *Residential Baseline Report Final*. November 2, 2012. Prepared for the Indiana Demand Side Management Coordination Committee Core Programs

[143] Ibid.

[144] Energy Center of Wisconsin. *Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research*. May 2008. Note: the MF_E for heat pumps is set to the MF_E for air conditioners, pending EM&V review.

[145] TecMarket Works, et al. *Residential Baseline Report Final*. November 2, 2012. Prepared for the Indiana Demand Side Management Coordination Committee Core Programs

[146] This was the minimum federal standard between 1992 and 2006.

For example, the energy savings from conducting maintenance on a 3-ton (cooling and heating) , SEER 10, HSPF 6.8 air-source heat pump unit in Indianapolis would be:

$$\Delta kWh_{ASHP} = \frac{487 * 36{,}000 * \frac{1}{10}}{1{,}000} * 0.05 + 1{,}341 * 36{,}000 * \frac{1}{6.8*1{,}000} * 0.05 = 443 \text{ kWh}$$

Summer Peak Coincident Demand Reduction

$$\Delta kW = Btuh_{COOL} * \frac{1}{EER*1{,}000} * MF_D * CF$$

Where:

EER = EER efficiency of existing unit receiving maintenance (= actual; otherwise calculate using SEER * 0.9)

MF_D = Maintenance demand reduction factor (= 0.05)[147]

CF = Summer peak coincidence factor (= 0.88)[148]

For example, the demand reduction from conducting maintenance on 3-ton, SEER 10 (equals EER 9.0) unit would be:

$$\Delta kW = 36{,}000 * \frac{1}{9.0*1{,}000} * 0.05 * 0.88 = 0.176 \text{ kW}$$

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.

---

[147] Data are sparse for this parameter. Set equal to MF_E, subject to EM&V review.

[148] Duke Energy. Data for residential AC loads.

Residential Boiler Tune-Up

	Measure Details
Official Measure Code	Res-HVAC-Boiler Tuneup-1
Measure Unit	Per tune-up
Measure Category	HVAC
Sector(s)	Residential
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Fossil Fuel Savings (MMBtu)	Varies by location
Lifetime Energy Savings (kWh)	0
Lifetime Fossil Fuel Savings (MMBtu)	Varies by location
Water Savings (gal/yr)	0
Effective Useful Life (years)	5
Incremental Cost	$140.00
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is the tune-up of an existing residential boiler to improve the seasonal heating efficiency.

Definition of Efficient Equipment

The efficient condition is the boiler after a tune up is performed.

Definition of Baseline Equipment

The baseline condition is the existing boiler before a tune up.

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 5 years.

Deemed Measure Cost

The incremental cost for this measure is $140.00 per boiler.

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

There are no expected energy savings associated with this measure.

Summer Peak Coincident Demand Reduction

There is no expected peak demand reduction associated with this measure.

Fossil Fuel Impact Descriptions and Calculation

$$\text{Annual MMBtu Savings} = EFLH_{HEAT} * Btuh * ESF * 10^{-6}$$

Where:

Btuh = Size of equipment in Btuh input capacity (= actual; otherwise = 77,386)[149]

$EFLH_{HEAT}$ = Equivalent full load heating hours (= dependent on location; see table below)

Equivalent Full Load Heating Hours by City

Location	$EFLH_{HEAT}$*
Indianapolis	1,341
South Bend	1,427
Evansville	982
Ft. Wayne	1,356
Terre Haute	804

* Heating EFLH extracted from simulations. See Appendix B.

ESF = Energy savings factor (= 0.05)[150]

For example, the fossil fuel savings from tuning up a 100 kBtu/hr boiler installed in Indianapolis would be:

$$\text{Annual MMBtu Savings} = EFLH_{HEAT} * BtuH * ESF * 10^{-6} = 1{,}341 * 100{,}000 * 0.05 * 10^{-6}$$
$$= 6.7 \text{ MMBtu per year}$$

---

[149] TecMarket Works, et al. *Residential Baseline Report Final*. November 2, 2012. Prepared for the Indiana Demand Side Management Coordination Committee Core Programs

[150] *Michigan Efficiency Measures Database*. Report uses energy savings of 5% for residential boiler tune ups.

Central Air Conditioning (Early Replacement)

	Measure Details
Official Measure Code	Res-HVAC-AC-ER-1
Measure Unit	Per unit
Measure Category	HVAC
Sector(s)	Residential
Annual Energy Savings (kWh)	Varies by location
Peak Demand Reduction (kW)	Varies by location
Annual Fossil Fuel Savings (MMBtu)	Varies by location
Lifetime Energy Savings (kWh)	Varies by location
Lifetime Fossil Fuel Savings (MMBtu)	Varies by location
Water Savings (gal/yr)	0
Effective Useful Life (years)	18
Incremental Cost	Varies by location
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is the early removal of an existing inefficient central air conditioning unit from service, prior to its natural end of life, and replacing with a new ENERGY STAR-qualifying unit. Savings are calculated between the existing unit and efficient unit consumption during the remaining life of the existing unit, and between the new baseline unit and efficient unit consumption for the remainder of the measure life.

Definition of Efficient Equipment

The efficient equipment is a ducted, split central air conditioning unit meeting the minimum ENERGY STAR efficiency level standards of 14.5 SEER and 12 EER.

Definition of Baseline Equipment

The baseline condition is the existing inefficient central air conditioning unit for the remaining assumed useful life of the unit, then for the remainder of the measure life the baseline becomes a new replacement unit meeting the minimum federal efficiency standard of 13 SEER and 11 EER.

Deemed Lifetime of Efficient Equipment

The expected measure life is 18 years.[151]

---

[151] GDS Associates. *Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures*. June 2007. Available online: http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf

The assumed remaining useful life of the existing central air conditioning unit being replaced is 5 years.[152]

Deemed Measure Cost

The actual measure cost for removing the existing unit and installing the new should be used.

Deemed O&M Cost Adjustments

The net present value of the deferred replacement cost (the cost associated with replacing the existing unit with a standard unit that would have had to have occurred after 5 years, had the existing unit not been replaced) should be calculated as: Actual Cost of ENERGY STAR unit - incremental cost of ENERGY STAR unit over baseline unit (depending on SEER; see table below)[153] * 63%.[154]

Deemed O&M Cost Adjustments per Ton by SEER

Efficiency Level	Cost per Ton
SEER 14	$119
SEER 15	$238
SEER 16	$357
SEER 17	$476
SEER 18	$596
SEER 19	$715
SEER 20	$834
SEER 21	$908

Savings Algorithm

Energy Savings

$$\Delta\text{kWh for remaining life of existing unit (first 5 years)} = EFLH_{COOL} * Btuh * \frac{\frac{1}{SEER_{EXIST}} - \frac{1}{SEER_{EE}}}{1{,}000}$$

---

[152] This value is a parameter estimate.

[153] California Public Utilities Commission. *Database for Energy Efficient Resources.* 2008. Available online: www.deeresources.com.

[154] This 63% is the ratio of the net present value (with a 5% discount rate) of the annuity payments from years 6 to 18 of a deferred replacement of a standard efficiency unit costing $2,857.00, divided by the standard efficiency unit cost ($2,857.00). This way of calculating savings allows for using the known ENERGY STAR replacement cost to calculate an appropriate baseline replacement cost. The standard unit cost based on: ENERGY STAR. "Central Air Conditioning Calculator." http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls

ΔkWh for remaining measure life (next 13 years) = $EFLH_{COOL} * Btuh * \frac{\frac{1}{SEER_{BASE}} - \frac{1}{SEER_{EE}}}{1,000}$

Where:

EFLH$_{COOL}$ = Equivalent full load cooling hours (= dependent on location; see table below)

Equivalent Full Load Cooling Hours by City

Location	EFLH$_{COOL}$*
Indianapolis	487
South Bend	431
Evansville	600
Ft. Wayne	373
Terre Haute	569

* Based on prototypical building simulations. See Appendix A.

Btuh = Size of equipment in Btuh (= actual; otherwise assume 28,994;[155] note: 1 ton = 12,000 Btuh)

SEER$_{EXIST}$ = Seasonal average efficiency of existing unit (= actual; otherwise assume 11.15)[156]

SEER$_{EE}$ = SEER efficiency of ENERGY STAR unit (= actual)

SEER$_{BASE}$ = SEER efficiency of baseline unit (= 13)[157]

For example, the energy savings from replacing a 3-ton, SEER 10 unit with a new SEER 14.5 unit in Indianapolis would be:

ΔkWh for remaining life of existing unit (first 5 years) =$487 * 36,000 * \frac{\frac{1}{10} - \frac{1}{14.5}}{1,000}$ = 544 kWh

ΔkWh for remaining measure life (next 13 years) = $487 * 36,000 * \frac{\frac{1}{13} - \frac{1}{14.5}}{1,000}$ = 139.5 kWh

Summer Peak Coincident Demand Reduction

ΔkW for remaining life of existing unit (first 5 years) = $Btuh * \frac{\frac{1}{EER_{EXIST}} - \frac{1}{EER_{EE}}}{1,000} * CF$

---

[155] TecMarket Works, et al. *Residential Baseline Report Final*. November 2, 2012. Prepared for the Indiana Demand Side Management Coordination Committee Core Programs

[156] Ibid.

[157] This value reflects the minimum federal standard.

$$\Delta kW \text{ for remaining measure life (next 13 years)} = Btuh * \frac{\frac{1}{EER_{BASE}} - \frac{1}{EER_{EE}}}{1{,}000} * CF$$

Where:

EER_{EXIST} = EER efficiency of existing unit (= actual; otherwise calculate as SEER * 0.9)

EER_{BASE} = EER efficiency of baseline unit (= 11)[158]

EER_{EE} = EER efficiency of ENERGY STAR unit (= actual)

CF = Summer peak coincidence factor (= 0.88)[159]

For example, the demand reduction from replacing a 3-ton, SEER 10 unit (EER 9) with a new SEER 14.5, EER 12 unit in Indianapolis would be:

$$\Delta kW \text{ for remaining life of existing unit (first 5 years)} = 36{,}000 * \frac{\frac{1}{9} - \frac{1}{12}}{1{,}000} * 0.88 = 0.88 \text{ kW}$$

$$\Delta kW \text{ for remaining measure life (next 13 years)} = 36{,}000 * \frac{\frac{1}{11} - \frac{1}{12}}{1{,}000} * 0.88 = 0.24 \text{ kW}$$

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.

---

[158] Ibid.

[159] Duke Energy load shape data for residential AC loads from: Integral Analytics, Inc. DSMore cost-effectiveness tool. Available online: www.integralanalytics.com

Central Air Conditioning (Time of Sale)

	Measure Details
Official Measure Code	Res-HVAC-AC-1
Measure Unit	Per unit
Measure Category	HVAC
Sector(s)	Residential
Annual Energy Savings (kWh)	Varies by location
Peak Demand Reduction (kW)	Varies by location
Annual Fossil Fuel Savings (MMBtu)	Varies by location
Lifetime Energy Savings (kWh)	Varies by location
Lifetime Fossil Fuel Savings (MMBtu)	Varies by location
Water Savings (gal/yr)	0
Effective Useful Life (years)	18
Incremental Cost	Varies by location
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is replacing a central air conditioning unit with a new ENERGY STAR-qualifying unit. Savings are calculated between a new baseline unit and an efficient unit.

Definition of Efficient Equipment

The efficient equipment is a ducted, split central air conditioning unit meeting the minimum ENERGY STAR efficiency level standards of 14.5 SEER and 12 EER.

Definition of Baseline Equipment

The baseline condition is a new replacement unit meeting the minimum federal efficiency standard of 13 SEER and 11 EER.

Deemed Lifetime of Efficient Equipment

The expected measure life is 18 years.[160]

Deemed Measure Cost

The incremental measure cost between a new baseline unit and the efficient unit should be used; see table below.

---

[160] GDS Associates. *Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures*. June 2007. Available online: http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf

Deemed Incremental Measure Cost per Ton by SEER

Efficiency Level	Incremental Cost per Ton
SEER 14	$119
SEER 15	$238
SEER 16	$357
SEER 17	$476
SEER 18	$596
SEER 19	$715
SEER 20	$834
SEER 21	$908

Savings Algorithm

Energy Savings

$$\Delta \text{kWh} = EFLH_{COOL} * Btuh * \frac{\frac{1}{SEER_{BASE}} - \frac{1}{SEER_{EE}}}{1{,}000}$$

Where:

$EFLH_{COOL}$ = Equivalent full load cooling hours (= dependent on location; see table below)

Equivalent Full Load Cooling Hours by City

Location	$EFLH_{COOL}$*
Indianapolis	487
South Bend	431
Evansville	600
Ft. Wayne	373
Terre Haute	569

* Based on prototypical building simulations. See Appendix A.

Btuh = Size of equipment in Btuh (= actual; otherwise assume 28,994;[161] note: 1 ton = 12,000 Btuh)

$SEER_{EE}$ = SEER efficiency of ENERGY STAR unit (= actual)

$SEER_{BASE}$ = SEER efficiency of baseline unit (= 13)[162]

---

[161] TecMarket Works, et al. *Residential Baseline Report Final*. November 2, 2012. Prepared for the Indiana Demand Side Management Coordination Committee Core Programs

[162] This value reflects the minimum federal standard.

For example, the energy savings from installing a new 3-ton, SEER 14.5 unit in Indianapolis would be:

$$\Delta\text{kWh} = 487 * 36{,}000 * \frac{\frac{1}{13} - \frac{1}{14.5}}{1{,}000} = 140\text{ kWh}$$

Summer Peak Coincident Demand Reduction

$$\Delta\text{kW} = BtuH * \frac{\frac{1}{EER_{BASE}} - \frac{1}{EER_{EE}}}{1{,}000} * CF$$

Where:

EER_{BASE} = EER efficiency of baseline unit (= 11)[163]

EER_{EE} = EER efficiency of ENERGY STAR unit (= actual)

CF = Summer peak coincidence factor (= 0.88)[164]

For example, the demand reduction from installing a new 3-ton, SEER 14.5, EER 12 unit in Indianapolis would be:

$$\Delta\text{kW} = 36{,}000 * \frac{\frac{1}{11} - \frac{1}{12}}{1{,}000} * 0.88 = 0.220\text{ kW}$$

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.

---

[163] Ibid.

[164] Duke Energy load shape data for residential AC loads from: Integral Analytics, Inc. DSMore cost-effectiveness tool. Available online: www.integralanalytics.com

Central Air Source Heat Pump (Early Replacement)

	Measure Details
Official Measure Code	Res-HVAC-ASHP-ER-1
Measure Unit	Per unit
Measure Category	HVAC
Sector(s)	Residential
Annual Energy Savings (kWh)	Varies by location
Peak Demand Reduction (kW)	Varies by location
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	Varies by location
Lifetime Fossil Fuel Savings (MMBtu)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	18
Incremental Cost	Varies by location
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is the early removal of an existing inefficient central heat pump unit from service, prior to its natural end of life, and replacing with a new ENERGY STAR-qualifying unit. Savings are calculated between the existing unit and efficient unit consumption during the remaining life of the existing unit, and between the new baseline unit and efficient unit consumption for the remainder of the measure life.

Definition of Efficient Equipment

The efficient equipment is a ducted, split central heat pump unit meeting the minimum ENERGY STAR efficiency level standards of 14.5 SEER, 12 EER, and 8.2 HSPF.

Definition of Baseline Equipment

The baseline condition is the existing inefficient central heat pump unit for the remaining assumed useful life of the unit, then for the remainder of the measure life the baseline becomes a new replacement unit meeting the minimum federal efficiency standard of 13 SEER, 11 EER, and 7.7 HSPF).

Deemed Lifetime of Efficient Equipment

The expected measure life is 18 years.[165]

---

[165] GDS Associates. *Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures*. June 2007. Available online: http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf

The assumed remaining useful life of the existing central heat pump unit being replaced is 5 years.[166]

Deemed Measure Cost

The actual measure cost for removing the existing unit and installing the new should be used.

Deemed O&M Cost Adjustments

The net present value of the deferred replacement cost (the cost associated with replacing the existing unit with a standard unit that would have occurred after 5 years, had the existing unit not been replaced) should be calculated as: Actual Cost of ENERGY STAR unit - incremental cost of ENERGY STAR unit over baseline unit (based on efficiency level; see table below)[167] * 63%.[168]

Deemed O&M Cost Adjustment per Ton by SEER Level

Efficiency Level	Cost per Ton
SEER 14	\$137
SEER 15	\$274
SEER 16	\$411
SEER 17	\$548
SEER 18	\$685

Savings Algorithm

Energy Savings

$$\Delta\text{kWh for remaining life of existing unit (first 5 years)} = EFLH_{COOL} * Btuh_{COOL} * \frac{\frac{1}{SEER_{EXIST}} - \frac{1}{SEER_{EE}}}{1{,}000} + EFLH_{HEAT} * Btuh_{HEAT} * \frac{\frac{1}{HSPF_{EXIST}} - \frac{1}{HSPF_{EE}}}{1000}$$

$$\Delta\text{kWh for remaining measure life (next 13 years)} = FLH_{COOL} * Btuh_{COOL} * \frac{\frac{1}{SEER_{BASE}} - \frac{1}{SEER_{EE}}}{1{,}000} + EFLH_{HEAT} * Btuh_{HEAT} * \frac{\frac{1}{HSPF_{BASE}} - \frac{1}{HSPF_{EE}}}{1{,}000}$$

---

[166] Ohio Technical Reference Manual.

[167] California Public Utilities Commission. *Database for Energy Efficient Resources.* 2008. Available online: www.deeresources.com.

[168] This 63% is the ratio of the net present value (with a 5% discount rate) of the annuity payments from years 6 to 18 of a deferred replacement of a standard efficiency unit costing \$2,857.00, divided by the standard efficiency unit cost (\$2,857.00). This way of calculating savings allows for using the known ENERGY STAR replacement cost to calculate an appropriate baseline replacement cost. The standard unit cost based on: ENERGY STAR. “Central Air Conditioning Calculator."

Where:

$EFLH_{COOL}$ = Equivalent full load cooling hours (= dependent on location; see table below)

Equivalent Full Load Cooling Hours by City

Location	$EFLH_{COOL}$*
Indianapolis	487
South Bend	431
Evansville	600
Ft. Wayne	373
Terre Haute	569

* Based on prototypical building simulations. See Appendix A.

$EFLH_{HEAT}$ = Equivalent full load heating hours (= dependent on location; see table below)

Equivalent Full Load Heating Hours by City

Location	$EFLH_{HEAT}$*
Indianapolis	1,341
South Bend	1,427
Evansville	982
Ft. Wayne	1,356
Terre Haute	804

* Heating EFLH extracted from simulations. See Appendix A.

$Btuh_{COOL}$ = Cooling capacity of equipment in Btu/hr (= actual; note: 1 ton = 12,000 Btuh)

$Btuh_{HEAT}$ = Heating capacity of equipment in Btu/hr (= actual)

$SEER_{EXIST}$ = Seasonal average efficiency of existing unit in SEER (= actual; otherwise assume 11.15)[169]

$SEER_{EE}$ = SEER efficiency of ENERGY STAR unit (= actual)

$SEER_{BASE}$ = SEER efficiency of baseline unit (= 13)[170]

$HSPF_{EXIST}$ = Heating seasonal performance factor of existing air-source heat pump (= actual)

---

[169] TecMarket Works, et al. *Residential Baseline Report Final*. November 2, 2012. Prepared for the Indiana Demand Side Management Coordination Committee Core Programs

[170] This value reflects the minimum federal standard.

$HSPF_{EE}$ = Heating seasonal performance factor of efficient air-source heat pump (= actual installed)

$HSPF_{BASE}$ = Heating seasonal performance factor of baseline air-source heat pump (= 7.7)[171]

1,000 = Conversion from Wh to kWh

For example, the energy savings from replacing a 3-ton SEER 10, HSPF 7.2 unit with a new SEER 14.5, HSPF 8.7 unit in Indianapolis would be:

$$\Delta\text{kWh for remaining life of existing unit (first 5 years)} = 487 * 36{,}000 * \frac{\frac{1}{10}-\frac{1}{14.5}}{1{,}000} + 1{,}341 * \frac{36{,}000}{1{,}000} * \left(\frac{1}{7.2}-\frac{1}{8.7}\right) = 1{,}700\ \text{kWh}$$

$$\Delta\text{kWh for remaining measure life (next 13 years)} = 487 * 36{,}000 * \frac{\frac{1}{13}-\frac{1}{14.5}}{1{,}000} + 1{,}341 * \frac{36{,}000}{1{,}000} * \left(\frac{1}{7.7}-\frac{1}{8.7}\right) = 860\ \text{kWh}$$

Summer Peak Coincident Demand Reduction

$$\Delta\text{kW for remaining life of existing unit (first 5 years)} = Btuh_{COOL} * \frac{\frac{1}{EER_{EXIST}}-\frac{1}{EER_{EE}}}{1{,}000} * CF$$

$$\Delta\text{kW for remaining measure life (next 13 years)} = Btuh_{COOL} * \frac{\frac{1}{EER_{BASE}}-\frac{1}{EER_{EE}}}{1{,}000} * CF$$

Where:

EER_{EXIST} = EER efficiency of existing unit (= actual; = SEER * 0.9)[172]

EER_{BASE} = EER efficiency of baseline unit (= 11)[173]

EER_{EE} = EER efficiency of ENERGY STAR unit (= actual)

CF = Summer peak coincidence factor (= 0.88)[174]

---

[171] Ibid.

[172] If SEER is unknown, use the default EER of (10 * 0.9) = 9.0. This calculation is based on a prior assessment of industry equipment efficiency ratings.

[173] This value reflects the minimum federal standard.

[174] Duke Energy load shape data for residential AC loads from: Integral Analytics, Inc. DSMore cost-effectiveness tool. Available online: www.integralanalytics.com

For example, the demand reduction from replacing a 3-ton, SEER 10 (EER 9) unit with a new SEER 14.5 (EER 12) unit in Indianapolis would be:

$$\Delta\text{kW for remaining life of existing unit (first 5 years)} = 36{,}000 * \frac{\frac{1}{9}-\frac{1}{12}}{1{,}000} * 0.88 = 0.88\ \text{kW}$$

$$\Delta\text{kW for remaining measure life (next 13 years)} = 36{,}000 * \frac{\frac{1}{11}-\frac{1}{12}}{1{,}000} * 0.88 = 0.24\ \text{kW}$$

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.

Central Air Source Heat Pump (Time of Sale)

	Measure Details
Official Measure Code	Res-HVAC-ASHP-1
Measure Unit	Per unit
Measure Category	HVAC
Sector(s)	Residential
Annual Energy Savings (kWh)	Varies by location
Peak Demand Reduction (kW)	Varies by location
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	Varies by location
Lifetime Fossil Fuel Savings (MMBtu)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	18
Incremental Cost	Varies by location
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is the installation a new ENERGY STAR-qualifying unit. Savings are calculated between a new baseline unit and the efficient unit.

Definition of Efficient Equipment

The efficient equipment is a ducted, split central heat pump unit meeting the minimum ENERGY STAR efficiency level standards of 14.5 SEER, 12 EER, and 8.2 HSPF.

Definition of Baseline Equipment

The baseline condition is a new replacement unit meeting the minimum federal efficiency standard of 13 SEER, 11 EER, and 7.7 HSPF.

Deemed Lifetime of Efficient Equipment

The expected measure life is 18 years.[175]

Deemed Measure Cost

The incremental measure cost of installing the new unit over the baseline unit should be used; see table below.

---

[175] GDS Associates. *Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures*. June 2007. Available online: http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf

Deemed Incremental Measure Cost by SEER

Efficiency Level	Incremental Cost per Ton
SEER 14	\$137
SEER 15	\$274
SEER 16	\$411
SEER 17	\$548
SEER 18	\$685

Savings Algorithm

Energy Savings

$$\Delta \text{kWh} = \left(\frac{EFLH_{COOL} * Btuh_{COOL}}{1{,}000}\right) * \left(\frac{1}{SEER_{BASE}} - \frac{1}{SEER_{EE}}\right) + \left(\frac{EFLH_{HEAT} * Btuh_{HEAT}}{1{,}000}\right) * \left(\frac{1}{HSPF_{BASE}} - \frac{1}{HSPF_{EE}}\right)$$

Where:

$EFLH_{COOL}$ = Equivalent full load cooling hours (= dependent on location; see table below)

Equivalent Full Load Cooling Hours by City

Location	$EFLH_{COOL}$*
Indianapolis	487
South Bend	431
Evansville	600
Ft. Wayne	373
Terre Haute	569

* Based on prototypical building simulations. See Appendix A.

$EFLH_{HEAT}$ = Equivalent full load heating hours (= actual; dependent on location, see table below)

Equivalent Full Load Heating Hours by City

Location	$EFLH_{HEAT}$*
Indianapolis	1,341
South Bend	1,427
Evansville	982
Ft. Wayne	1,356
Terre Haute	804

* Heating EFLH extracted from simulations. See Appendix A.

$Btuh_{COOL}$ = Cooling capacity of equipment in Btuh (= actual; note: 1 ton = 12,000 Btuh)

$Btuh_{HEAT}$ = Heating capacity of equipment in Btuh (= actual)

SEER_{EE} = SEER efficiency of ENERGY STAR unit (= actual)

$\text{SEER}_{\text{BASE}}$ = SEER efficiency of baseline unit (= 13)[176]

HSPF_{EE} = Heating seasonal performance factor of efficient air-source heat pump (= actual)

$\text{HSPF}_{\text{BASE}}$ = Heating sseasonal performance factor of baseline air-source heat pump (= 7.7)[177]

For example, the energy savings from installing a new SEER 14.5, HSPF 8.7, 3-ton unit in Indianapolis would be:

$$\Delta\text{kWh} = 487 * 36{,}000 * \frac{\frac{1}{13}-\frac{1}{14.5}}{1{,}000} + 1{,}341 * \frac{36{,}000}{1{,}000} * \left(\frac{1}{7.7}-\frac{1}{8.7}\right) = 860\ \text{kWh}$$

Summer Peak Coincident Demand Reduction

$$\Delta\text{kW} = Btuh_{COOL} * \frac{\frac{1}{EER_{BASE}}-\frac{1}{EER_{EE}}}{1{,}000} * CF$$

Where:

EER_{BASE} = EER efficiency of baseline unit (= 11)[178]

EER_{EE} = EER efficiency of ENERGY STAR unit (= actual)

CF = Summer peak coincidence factor (= 0.88)[179]

For example, the demand reduction from installing a new SEER 14.5, EER 12 unit in Indianapolis would be:

$$\Delta\text{kW} = 36{,}000 * \frac{\frac{1}{11}-\frac{1}{12}}{1{,}000} * 0.88 = 0.24\ \text{kW}$$

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.

---

[176] This value reflect the minimum federal standard.

[177] Ibid.

[178] Ibid.

[179] Roberts and Salcido, Architectural Energy Corporation. *Peak Electric Demand Calculations in the REM/Rate Home Energy Rating Software and REM/Design Home Energy Analysis Software*. February 2008. “This formulaic relationship was derived from 1,861 unique combinations of data, from nearly 200,000 ARI-rated residential central air conditioners.

Ground Source Heat Pumps (Time of Sale)

	Measure Details
Official Measure Code	Res-HVAC-GSHP-1
Measure Unit	Per unit
Measure Category	HVAC
Sector(s)	Residential
Annual Energy Savings (kWh)	Varies by location
Peak Demand Reduction (kW)	Varies by location
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	Varies by location
Lifetime Fossil Fuel Savings (MMBtu)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	18
Incremental Cost	$3,609.00
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure in installing a new GSHP system meeting the ENERGY STAR efficiency standards presented in the table below. This measure relates to installing a new system in an existing home (i.e., time of sale).

ENERGY STAR Efficiency Standards for Ground-Source Heat Pumps

Product Type	EER	COP
Water-to-Air		
Closed Loop	17.1	3.6
Open Loop	21.1	4.1
Water-to-Water		
Closed Loop	16.1	3.1
Open Loop	20.1	3.5
DGX	16	3.6

Definition of Efficient Equipment

The efficient equipment is a GSHP meeting the minimum ENERGY STAR efficiency level standards effective at the time of installation, as detailed in the table above.

Definition of Baseline Equipment

The baseline equipment is an ASHP meeting the federal standard efficiency level of 13 SEER and 11 EER.

Deemed Lifetime of Efficient Equipment

The expected measure life is 18 years.[180]

Deemed Measure Cost

The actual installed cost of the GSHP should be used, minus the assumed installation cost of a 3-ton, standard baseline ASHP of $3,609.00.[181]

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\Delta kWh = \left(EFLH_{COOL} * Btuh_{COOL} * \frac{\frac{1}{SEER_{BASE}} - \frac{1}{EER_{EE} * 1.02}}{1{,}000} \right) + \left(EFLH_{HEAT} * Btuh_{HEAT} * \frac{\frac{1}{HSPF_{BASE}} - \frac{1}{COP_{EE} * 3.412}}{1{,}000} \right)$$

Where:

$EFLH_{COOL}$ = Equivalent full load cooling hours (= dependent on location; see table below)

Equivalent Full Load Cooling Hours by City

Location	$EFLH_{COOL}$*
Indianapolis	487
South Bend	431
Evansville	600
Ft. Wayne	373
Terre Haute	569

* Based on prototypical building simulations. See Appendix A.

---

[180] GDS Associates. *Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures*. June 2007. Available online: http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf

[181] California Public Utilities Commission. *Database for Energy Efficient Resources.* 2008. Available online: www.deeresources.com. The material cost of a 13 SEER air conditioner is $796.00 per ton, with a labor cost of $407.00 per ton. The cost for a 3-ton unit would be: (796 + 407) * 3 = $3,609.00.

$Btuh_{COOL}$ = Cooling capacity of equipment in Btuh (= actual; note: 1 ton = 12,000 Btuh)

$Btuh_{HEAT}$ = Heating capacity of equipment in Btuh (= actual)

$SEER_{BASE}$ = SEER efficiency of baseline unit (= 13)[182]

EER_{EE} = EER efficiency of efficient unit (= actual)

1.02 = Constant used to estimate the SEER based on the efficient unit EER[183]

$EFLH_{HEAT}$ = Equivalent full load heating hours (= actual; dependent on location, see table below)

Equivalent Full Load Heating Hours by City

Location	$EFLH_{HEAT}$*
Indianapolis	1,341
South Bend	1,427
Evansville	982
Ft. Wayne	1,356
Terre Haute	804

* Heating EFLH extracted from simulations. See Appendix A.

$HSPF_{BASE}$ = Heating season performance factor for baseline unit (= 7.7)[184]

COP_{ee} = Coefficient of Performance of efficient unit (= actual)

3.412 = Constant to convert the COP of the unit to the heating season performance factor

For example, the energy savings from installing a 3-ton heating and cooling unit with EER rating of 16 and COP of 3.5 in Indianapolis would be:

$$\Delta kWh = \left(487 * 36{,}000 * \frac{\frac{1}{13} - \frac{1}{16 \, * \, 1.02}}{1{,}000}\right) + \left(1{,}341 * 36{,}000 * \frac{\frac{1}{7.7} - \frac{1}{3.5 \, * \, 3.412}}{1{,}000}\right) = 2{,}501$$

---

[182] This is the minimum federal standard from: Federal Register, Vol. 66, No. 14, Monday, January 22, 2001/Rules and Regulations. p. 7,170-7,200.

[183] Note that the EERs of GSHPs are measured differently than EERs of ASHP, as they are focused on entering water temperatures rather than ambient air temperatures. The equivalent SEER of a GSHP can be estimated by multiplying the EER by 1.02 (based on extrapolating manufacturer data).

[184] This is the minimum federal standard from: Federal Register, Vol. 66, No. 14, Monday, January 22, 2001/Rules and Regulations. p. 7,170-7,200.

Summer Peak Coincident Demand Reduction

$$\Delta kW = Btuh_{COOL} * \frac{\left(\frac{1}{EER_{BASE}} - \frac{1}{EER_{EE} \ * \ 1.02 \ * \ 0.37 \ + \ 6.43}\right)}{1,000} * CF$$

Where:

EER_{BASE} = EER efficiency of baseline unit (= 11)[185]

EER_{EE} = EER efficiency of ENERGY STAR unit (= actual)

1.02 = Constant used to estimate the unit's equivalent air conditioning SEER based on GSHP unit's EER.[186] This is then converted to the unit's equivalent air conditioning EER to enable comparisons to the baseline unit using the following algorithm: EER_{AC} = $(SEER \ * \ 0.37) \ + \ 6.43$[187]

CF = Summer peak coincidence factor (= 0.88)[188]

For example, a 3 ton unit with EER rating of 16:

$$\Delta kW = 36,000 * \frac{\frac{1}{11} - \frac{1}{16 * 1.02 * 0.37 + 6.43}}{1000} * 0.88 = 0.34 \text{ kW}$$

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.

---

[185] Ibid.

[186] Note that the EERs of GSHPs are measured differently than EERs of ASHP, as they are focused on entering water temperatures rather than ambient air temperatures. The equivalent SEER of a GSHP can be estimated by multiplying the EER by 1.02 (based on extrapolating manufacturer data).

[187] Roberts and Salcido, Architectural Energy Corporation. *Peak Electric Demand Calculations in the REM/Rate Home Energy Rating Software and REM/Design Home Energy Analysis Software*. February 2008. "This formulaic relationship was derived from 1,861 unique combinations of data, from nearly 200,000 ARI-rated residential central air conditioners.

[188] Duke Energy load shape data for residential AC loads from: Integral Analytics, Inc. DSMore cost-effectiveness tool. Available online: www.integralanalytics.com

Residential Electronically Commutated Motors

	Measure Details
Official Measure Code	Res-HVAC-ECMotor-1
Measure Unit	Per motor
Measure Category	HVAC
Sector(s)	Residential
Annual Energy Savings (kWh)	415
Peak Demand Reduction (kW)	0
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	
Lifetime Fossil Fuel Savings (MMBtu)	
Water Savings (gal/yr)	0
Effective Useful Life (years)	10
Incremental Cost	$250.00
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is installing an electronically commutated motors on a natural gas furnace or heat pump supply fans. Energy savings and demand reduction are realized through reductions in fan power due to improved motor efficiency and variable flow operation.

Definition of Efficient Equipment

The efficient condition is installing an electronically commutated motor on a furnace or heat pump air handler fan.

Definition of Baseline Equipment

The baseline condition is a standard furnace or heat pump supply fan motor.

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 10 years.

Deemed Measure Cost

The incremental cost for this measure is $250.00.

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\Delta kWh = 415 \text{ per furnace or air handler}$$

The deemed energy savings per electronically commutated motor furnace or air handler were originally based on a 2009 impact evaluation of these furnaces in Wisconsin.[189] The study findings were based on field measurements of furnaces with and without electronically commutated motors as well as on surveys with homeowners and contractors to determine homeowner behavior with respect to fan control strategies for electronically commutated motor furnaces. The study included details of cycling versus continuous fan operation in furnaces before and after installing a furnace with an electronically commutated motor. The 2015 publication of the Wisconsin Focus on Energy Technical Reference Manual[190] revised the deemed savings from this study to 415 kWh per year.

Summer Peak Coincident Demand Reduction

There is no summer peak coincident demand reduction from this measure.

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.[191]

---

[189] PA Consulting Group. *ECM Furnace Impact Assessment Report.* January 12, 2009. https://focusonenergy.com/sites/default/files/emcfurnaceimpactassessment_evaluationreport.pdf

[190] The Cadmus Group, Inc. *Wisconsin Focus on Energy Technical Reference Manual.* January 2015. p. 338.

[191] Fossil fuel interactions are expected for this technology, but were not evaluated.

Programmable Thermostats (Time of Sale, Direct Install)

	Measure Details
Official Measure Code	Res-HVAC-Tstat-1
Measure Unit	Per unit
Measure Category	HVAC
Sector(s)	Residential
Annual Energy Savings (kWh)	Varies by location
Peak Demand Reduction (kW)	0
Annual Fossil Fuel Savings (MMBtu)	Varies by location
Lifetime Energy Savings (kWh)	Varies by location
Lifetime Fossil Fuel Savings (MMBtu)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15
Incremental Cost	$35.00
Important Comments	Assumes standard manual thermostat as baseline
Effective Date	January 10, 2013
End Date	TBD

Description

Programmable thermostats can save energy through the advanced scheduling of time-of-day and/or day-of-week setbacks to control heating and cooling setpoints. Typical usage reduces the heating setpoint during times of the day when occupants are usually not at home (work hours), keeping the home at a cooler temperature in the winter; or increases the cooling setpoint during times of the day when occupants are usually not at home (work hours), keeping the home at a warmer temperature in the summer.

Definition of Efficient Equipment

The efficient condition is a standard programmable thermostat.

Definition of Baseline Equipment

The baseline condition is a standard, non-programmable thermostat for the central cooling and/or heating system (baseboard electric is excluded).

Deemed Lifetime of Efficient Equipment

The lifetime of this measure is 15 years.

Deemed Measure Cost

The incremental cost for purchasing a programmable thermostat has significant variation, but is typically around $35.00 (based on current retail market prices). Measures directly installed through retrofit programs should use the actual material and labor costs.

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Savings from programmable thermostats can be difficult to estimate from analytical methods due to the significant behavioral interactions in both the initial programming and the year-over year operation. Studies that evaluate the savings impacts of programmable thermostats vary, but there is considerable and credible regard for the findings of a 2007 study[192] that incorporated large sample sizes of survey response and billing analyses.

Energy Savings

The cooling energy savings for homes with a central air conditioner would be:

$$\Delta\text{kWh} = \frac{1}{SEER} * EFLH_{COOL} * \frac{Btuh_{COOL}}{1{,}000} * ESF_{COOL}$$

Where:

SEER = Seasonal average energy efficiency ratio (Btu/watt-hour; = actual, otherwise based on year from table below)

SEER by Equipment Age

Age of Equipment	SEER Estimate
Before 2006	10
After 2006	11.15[193]

$EFLH_{COOL}$ = Equivalent full load cooling hours (= dependent on location; see table below)

Equivalent Full Load Cooling Hours by City

Location	$EFLH_{COOL}$*
Indianapolis	487
South Bend	431
Evansville	600
Ft. Wayne	373
Terre Haute	569

* Based on prototypical building simulations. See Appendix A.

---

[192] 2007, RLW Analytics, “Validating the Impact of Programmable Thermostats”

[193] TecMarket Works, et al. *Residential Baseline Report Final*. Prepared for the Indiana Demand Side Management Coordination Committee Core Programs. November 2, 2012.

$Btuh_{COOL}$= Cooling system capacity in Btu/hr (= actual; otherwise assume 28,994 Btuh)[194]

1,000 = Conversion from Wh to kWh

ESF_{COOL} = Cooling energy savings fraction (= 0.09)[195]

For example, the cooling savings in a home in Indianapolis with a 3-ton, 10 SEER heat pump would be:

$$\Delta\text{kWh} = \frac{1}{10} * 487 * \frac{36{,}000}{1{,}000} * 0.09 = 158\text{ kWh}$$

The heating savings from that same home (which has a heat pump or electric furnace) would be:

$$\Delta\text{kWh} = EFLH_{HEAT} * \frac{Btuh_{HEAT}}{\eta_{HEAT} * 3{,}412} * ESF_{HEAT}$$

Where:

$EFLH_{HEAT}$ = Equivalent full load heating hours (= actual; dependent on location, see table below)

Equivalent Full Load Heating Hours by City

Location	$EFLH_{HEAT}$*
Indianapolis	1,341
South Bend	1,427
Evansville	982
Ft. Wayne	1,356
Terre Haute	804

* Heating EFLH extracted from simulations. See Appendix B.

$Btuh_{HEAT}$ = Heating capacity (output) of equipment in Btuh (= actual)[196]

η_{HEAT} = Efficiency in COP of heating equipment (= actual; otherwise depending on equipment age, see table below)

COP Estimates by System Type

System Type	Age of Equipment	HSPF Estimate	COP Estimate
Heat Pump	Before 2006	6.8	2.00
	After 2006	7.7	2.26
Resistance	N/A	N/A	1.00

---

[194] Ibid.

[195] 2007, RLW Analytics, "Validating the Impact of Programmable Thermostats"

[196] TecMarket Works, et al. *Residential Baseline Report Final*. Prepared for the Indiana Demand Side Management Coordination Committee Core Programs. November 2, 2012.

3,412 = Conversion from Btuh to kW

ESF_{HEAT} = Heating energy savings fraction (= 0.068)[197]

For example, the energy heating savings in a home in Indianapolis with 6.8 HSPF heat pump with 100,000 Btu/hr of heating capacity would be:

$$\Delta kWh = 1{,}341 * \frac{100{,}000}{2.0 * 3{,}412} * 0.068 = 1{,}336\ kWh$$

Summer Peak Coincident Demand Reduction

There is no expected peak demand reduction associated with this measure.

Fossil Fuel Impact Descriptions and Calculation

$$\Delta MMBtu = FLH_{HEAT} * \frac{Btuh_{FF}}{1{,}000{,}000} * ESF_{HEAT}$$

Where:

$Btuh_{FF}$ = Heating capacity of fossil fuel equipment in Btuh (= actual; otherwise assume 77,386 Btuh)[198]

1,000,000 = Conversion from Btu to MMBtu

For example, the fossil fuel savings from a home in Indianapolis with a 100,000 Btu/hr, 84 AFUE natural gas furnace would be:

$$\Delta MMBtu = 1{,}341 * \frac{100{,}000}{1{,}000{,}000} * 0.068 = 9.119\ MMBtu$$

---

[197] RLW Analytics. *Validating the Impact of Programmable Thermostats.* 2007.

[198] TecMarket Works, et al. *Residential Baseline Report Final*. Prepared for the Indiana Demand Side Management Coordination Committee Core Programs. November 2, 2012.

Wi-Fi Connected Smart Thermostats (Time of Sale, Direct Install)

	Measure Details
Official Measure Code	Res-HVAC-Tstat-2
Measure Unit	Per unit
Measure Category	HVAC
Sector(s)	Residential
Annual Energy Savings (kWh)	Varies by location
Peak Demand Reduction (kW)	0
Annual Fossil Fuel Savings (MMBtu)	Varies by location
Lifetime Energy Savings (kWh)	Varies by location
Lifetime Fossil Fuel Savings (MMBtu)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15
Incremental Cost	$250.00
Important Comments	Assumes standard non-programmable thermostat as baseline
Effective Date	July 15, 2015
End Date	TBD

Description

Programmable thermostats can save energy through the advanced scheduling of time-of-day and/or day-of-week setbacks to control heating and cooling setpoints. In addition to these capabilities, Wi-Fi connected smart thermostats provide remote control and monitoring via a smartphone application or web portal. Smart thermostats also have the capacity to detect when the house is unoccupied, and can be set to automatically lower energy use without requiring active programming from the user. When the house in unoccupied, the smart thermostat will reduce the heating setpoint in the winter, and increase the cooling setpoint in the summer. As a result, smart thermostats optimize energy without the need for interaction from the user.

Definition of Efficient Equipment

The efficient condition is a Wi-Fi connected smart thermostat.

Definition of Baseline Equipment

The baseline condition is a standard, non-programmable thermostat for the central cooling and/or heating system (baseboard electric is excluded).

Deemed Lifetime of Efficient Equipment

The lifetime of this measure is 15 years.

Deemed Measure Cost

The incremental cost for purchasing a programmable thermostat has significant variation, but is typically around $250.00 (based on current retail market prices). Measures directly installed through retrofit programs should use the actual material and labor costs.

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

The measure savings are based on a 2015 evaluation study[199] in Indiana that revealed the heating and cooling energy saving impacts of Wi-Fi connected smart thermostats on users with a manual thermostat as baseline, using large sample sizes and billing analyses.

Energy Savings

The cooling energy savings for homes with a central air conditioner would be:

$$\Delta \text{kWh} = \frac{1}{SEER} * EFLH_{COOL} * \frac{Btuh_{COOL}}{1{,}000} * ESF_{COOL}$$

Where:

SEER = Seasonal average energy efficiency ratio (Btu/watt-hour; = actual, otherwise based on year from table below)

SEER by Equipment Age

Age of Equipment	SEER Estimate
Before 2006	10
After 2006	11.15[200]

$EFLH_{COOL}$ = Equivalent full load cooling hours (= dependent on location; see table below)

Equivalent Full Load Cooling Hours by City

Location	$EFLH_{COOL}$*
Indianapolis	487
South Bend	431
Evansville	600
Ft. Wayne	373
Terre Haute	569

* Based on prototypical building simulations. See Appendix A.

---

[199] Cadmus (Aarish, C., M. Perussi, A. Rietz, and D. Korn). *Evaluation of the 2013–2014 Programmable and Smart Thermostat Program.* Prepared for Northern Indiana Public Service Company and Vectren Corporation. 2015.

[200] TecMarket Works, et al. *Residential Baseline Report Final*. Prepared for the Indiana Demand Side Management Coordination Committee Core Programs. November 2, 2012.

$Btuh_{COOL}$= Cooling system capacity in Btu/hr (= actual; otherwise assume 28,994 Btuh)[201]

1,000 = Conversion from Wh to kWh

ESF_{COOL} = Cooling energy savings fraction (= 0.139)[202]

For example, the cooling savings in a home in Indianapolis with a 3-ton, 10 SEER heat pump would be:

$$\Delta kWh = \frac{1}{10} * 487 * \frac{36{,}000}{1{,}000} * 0.139 = 244\ kWh$$

The heating savings from that same home (which has a heat pump or electric furnace) would be:

$$\Delta kWh = EFLH_{HEAT} * \frac{Btuh_{HEAT}}{\eta_{HEAT} * 3{,}412} * ESF_{HEAT}$$

Where:

$EFLH_{HEAT}$ = Equivalent full load heating hours (= actual; dependent on location, see table below)

Equivalent Full Load Heating Hours by City

Location	$EFLH_{HEAT}$*
Indianapolis	1,341
South Bend	1,427
Evansville	982
Ft. Wayne	1,356
Terre Haute	804

* Heating EFLH extracted from simulations. See Appendix B.

$Btuh_{HEAT}$ = Heating capacity (output) of equipment in Btuh (= actual)[203]

η_{HEAT} = Efficiency in COP of heating equipment (= actual; otherwise depending on equipment age, see table below)

COP Estimates by System Type

System Type	Age of Equipment	HSPF Estimate	COP Estimate
Heat Pump	Before 2006	6.8	2.00
	After 2006	7.7	2.26

---

[201] Ibid.

[202] Cadmus (Aarish, C., M. Perussi, A. Rietz, and D. Korn). *Evaluation of the 2013–2014 Programmable and Smart Thermostat Program.* Prepared for Northern Indiana Public Service Company and Vectren Corporation. 2015.

[203] TecMarket Works, et al. *Residential Baseline Report Final*. Prepared for the Indiana Demand Side Management Coordination Committee Core Programs. November 2, 2012.

Resistance	N/A	N/A	1.00

3,412 = Conversion from Btuh to kW

ESF_{HEAT} = Heating energy savings fraction (= 0.125)[204]

For example, the energy heating savings in a home in Indianapolis with 6.8 HSPF heat pump with 100,000 Btu/hr of heating capacity would be:

$$\Delta\text{kWh} = 1{,}341 * \frac{100{,}000}{2.0 * 3{,}412} * 0.125 = 2{,}456\ \text{kWh}$$

Summer Peak Coincident Demand Reduction

There is no expected peak demand reduction associated with this measure.

Fossil Fuel Impact Descriptions and Calculation

$$\Delta\text{MMBtu} = FLH_{HEAT} * \frac{Btuh_{FF}}{1{,}000{,}000} * ESF_{HEAT}$$

Where:

$Btuh_{FF}$ = Heating capacity of fossil fuel equipment in Btuh (= actual; otherwise assume 77,386 Btuh)[205]

1,000,000 = Conversion from Btu to MMBtu

For example, the fossil fuel savings from a home in Indianapolis with a 100,000 Btu/hr, 84 AFUE natural gas furnace would be:

$$\Delta\text{MMBtu} = 1{,}341 * \frac{100{,}000}{1{,}000{,}000} * 0.125 = 16.763\ \text{MMBtu}$$

---

[204] Cadmus (Aarish, C., M. Perussi, A. Rietz, and D. Korn). *Evaluation of the 2013–2014 Programmable and Smart Thermostat Program.* Prepared for Northern Indiana Public Service Company and Vectren Corporation. 2015.

[205] TecMarket Works, et al. *Residential Baseline Report Final*. Prepared for the Indiana Demand Side Management Coordination Committee Core Programs. November 2, 2012.

Condensing Furnaces-Residential (Time of Sale)

	Measure Details
Official Measure Code	Res-HVAC-Furn-1
Measure Unit	Per furnace
Measure Category	HVAC
Sector(s)	Residential
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Fossil Fuel Savings (MMBtu)	Varies by location
Lifetime Energy Savings (kWh)	0
Lifetime Fossil Fuel Savings (MMBtu)	Varies by location
Water Savings (gal/yr)	0
Effective Useful Life (years)	15
Incremental Cost	Varies by project
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is a new, ENERGY STAR-qualified, high-efficiency natural gas-fired condensing furnace for residential space heating. High-efficiency features may include improved heat exchangers and modulating multi-stage burners.

Definition of Efficient Equipment

The efficient condition is a furnace with an AFUE rating ≥ 90% and with < 225,000 Btuh input energy.

Definition of Baseline Equipment

The baseline condition is a non-condensing furnace with the federal AFUE baseline of 78%.[206] A review of GAMA shipment data indicates that a more suitable market baseline is 80% AFUE.

Deemed Lifetime of Efficient Equipment

The lifetime of this measure is 15 years.[207]

---

[206] Starting on November 19, 2015, savings should be based on using an 80% AFUE for residential furnaces (as indicated in the Electronic Code of Federal Regulations, Title 10, Chapter II, Subchapter D, Part 430, Subpart C, Section 430.32).

[207] http://www.cee1.org/resrc/facts/gs-ht-fx.pdf

Deemed Measure Cost

The incremental measure cost is based on the material cost alone, because the labor of the efficient measure is comparable to the labor cost of the baseline measure, and is dependent on the unit AFUE as outlined in the table below.[208]

Incremental Cost for Measure by AFUE

AFUE	Incremental Cost
90%	$325.68
92%	$379.96
94%	$856.59
96%	$910.87

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Savings are calculated using the difference in the amount of natural gas required based on the efficiency of the furnace and the average annual heating load. There is no change in the distribution system efficiency when the inclusion of a fan motor is assumed.

Energy Savings

There are no energy savings associated with this measure.

Summer Peak Coincident Demand Reduction

There is no expected peak demand reduction associated with this measure.

Fossil Fuel Impact Descriptions and Calculation

$$\Delta\text{MMBtu} = EFLH_{HEAT} * Btuh * \left(\frac{AFUE_{EFF}}{AFUE_{BASE}} - 1\right) * 10^{-6}$$

Where:

$EFLH_{HEAT}$ = Equivalent full load heating hours (= actual; dependent on location, see table below)

---

[208] Itron, Inc. *2010-2012 WO017 Ex Ante Measure Cost Study Final Report*. Submitted to the California Public Utilities Commission. May 27, 2014.

Equivalent Full Load Heating Hours by City

Location	$EFLH_{HEAT}$*
Indianapolis	1,341
South Bend	1,427
Evansville	982
Ft. Wayne	1,356
Terre Haute	804

* Heating EFLH extracted from simulations. See Appendix B.

Btuh = Size of equipment in Btuh input capacity (= actual)

$AFUE_{BASE}$ = Annual fuel utilization efficiency percentage of baseline equipment (= 0.80)

$AFUE_{EFF}$ = Annual fuel utilization efficiency percentage of efficient equipment (= actual)

10^{-6} = Conversion from Btu to MMBtu

For example, the fossil fuel savings from installing a 100,000 Btuh (input) furnace rated at 96 AFUE in Indianapolis would be:

$$\Delta MMBtu = 1{,}341 * 100{,}000 * \left(\frac{0.96}{0.80} - 1\right) * 10^{-6} = 26.820\ \mathrm{MMBtu}$$

Boilers (Time of Sale)

	Measure Details
Official Measure Code	Res-HVAC-Boiler-1
Measure Unit	Per unit
Measure Category	HVAC
Sector(s)	Residential
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Fossil Fuel Savings (MMBtu)	Varies by location
Lifetime Energy Savings (kWh)	0
Lifetime Fossil Fuel Savings (MMBtu)	Varies by location
Water Savings (gal/yr)	0
Effective Useful Life (years)	18
Incremental Cost	Varies by location
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is a new, ENERGY STAR-qualified, high-efficiency natural gas-fired boiler installed for residential space heating.

Definition of Efficient Equipment

The efficient condition is a boiler with an AFUE rating ≥ 85% and with <300,000 Btuh energy input.

Definition of Baseline Equipment

The baseline condition is the federal standard AFUE for boilers of 80%.

Deemed Lifetime of Efficient Equipment

The lifetime of this measure is 18 years.[209]

Deemed Measure Cost

The incremental measure cost, based on materials and installation costs, are a function of the unit AFUE as outlined in the table below.[210]

---

[209] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. "Appliance and Equipment Standards Program." http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/fb_fr_tsd/appendix_e.pdf

[210] Ibid.

Incremental Cost for Measure by AFUE

AFUE	Incremental Cost
85-90	$216.00
≥91	$422.00

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Savings are calculated as the difference in required natural gas, based on the efficiency of the boiler and the average annual heating load. No changes in the distribution system efficiency (including circulator motor) are assumed.

Energy Savings

There are no energy savings associated with this measure.

Summer Peak Coincident Demand Reduction

There is no expected peak demand reduction associated with this measure.

Fossil Fuel Impact Descriptions and Calculation

$$\Delta \text{MMBtu} = EFLH_{HEAT} * Btuh * \left(\frac{AFUE_{EFF}}{AFUE_{BASE}} - 1\right) * 10^{-6}$$

Where:

$EFLH_{HEAT}$ = Equivalent full load heating hours (= actual; dependent on location, see table below)

Equivalent Full Load Heating Hours by City

Location	$EFLH_{HEAT}$*
Indianapolis	1,341
South Bend	1,427
Evansville	982
Ft. Wayne	1,356
Terre Haute	804

* Heating EFLH extracted from simulations. See Appendix A.

Btuh = Size of new equipment in Btuh input capacity (= actual)

$AFUE_{BASE}$= Annual fuel utilization efficiency percentage of baseline equipment (= 0.80)

$AFUE_{EFF}$ = Annual fuel utilization efficiency percentage of efficient equipment (= actual)

For example: the fossil fuel savings from installing a 100,000 Btuh boiler rated at AFUE 85% in Indianapolis would be:

$$\Delta MMBtu = 1{,}341 * 100{,}000 * \left(\frac{0.85}{0.80} - 1\right) * 10^{-6} = 8.381\ MMBtu$$

Lighting

Residential ENERGY STAR Lighting (CFL and LED)

	Measure Details
Official Measure Code	Res-Ltg-CFL-TOS-1
Measure Unit	Per lamp
Measure Category	Lighting
Sector(s)	Residential
Annual Energy Savings (kWh)	Varies by program
Peak Demand Reduction (kW)	Varies by program
Annual Fossil Fuel Savings (MMBtu)	Varies by program
Lifetime Energy Savings (kWh)	Varies by program
Lifetime Fossil Fuel Savings (MMBtu)	Varies by program
Water Savings (gal/yr)	0
Effective Useful Life (years)	Varies by program
Incremental Cost	Varies by program
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

Compact Fluorescent Lamps Time-of-Sale

This measure is a low-wattage, ENERGY STAR-qualified CFL being purchased through a retail outlet in place of an incandescent screw-in bulb. The incremental cost of the CFL compared to the incandescent light bulb is offset via either a rebate or upstream markdowns. Assumptions are based on a time-of-sale purchase, not as retrofit or direct install.

The measure savings are based on the CFL being installed in a residential location. Where the implementation strategy does not allow for the installation location to be known, and absent verifiable evaluation data to support an appropriate residential versus commercial split, it is recommended to use this residential characterization for all purchases, leading to appropriately conservative savings assumptions.

Compact Fluorescent Lamps Direct Install (Early Replacement)

This measure is a low-wattage, ENERGY STAR-qualified CFL being installed by an auditor, contractor, or member of utility staff in a residential location in place of an existing incandescent screw-in bulb through a direct install program. The savings are based on protocols being implemented that guide the bulb installation to high-use locations. The CFL is provided at no cost to the end user.

Residential Light-Emitting Diode Lamps

This measure is a low-wattage, ENERGY STAR-qualified LED screw-in lamp being installed in place of an incandescent screw-in lamp. The incremental cost of the LED compared to the incandescent lamp is offset via either a rebate coupon or upstream markdowns.

Definition of Efficient Equipment

The high-efficiency equipment must be a standard ENERGY STAR-qualified CFL or LED.

Definition of Baseline Equipment

The baseline equipment is an incandescent light bulb, making adjustments to the baseline lamp wattage based on the Lifetime of the LED replacement lamp.

Deemed Lifetime of Efficient Equipment

The expected lifetime of CFLs is 5 years.[211] The expected lifetime of screw-in LED lamps is 15 years.

Deemed Measure Cost

Compact Fluorescent Lamps Time-of-Sale

The incremental cost for a time-of-sale CFL measure is $3.41.[212]

Compact Fluorescent Lamps Direct Install (Early Replacement)

The full cost for a direct-install (early replacement) CFL measure equals the actual cost for implementation and installation (i.e., the cost of the product and the labor for installation).

Residential Light-Emitting Diode Lamps

The incremental cost for a time-of-sale LED measure is $30.91.[213]

Deemed O&M Cost Adjustments

In order to account for the shift in baseline due to federal legislation, the levelized baseline replacement cost over the lifetime of the CFL is calculated using the key assumptions documented in the table below.

Replacement Cost and Component Life by Type of Bulb

	Standard Incandescent	Halogen
Replacement Cost	$0.50	$2.00
Component Life (years; based on lamp life / assumed annual run hours)	1	3

The calculated net present value of the baseline replacement costs based on CFL type is $4.52.

---

[211] This value was calculated using the average rated CFL life of 10,000 hours, including a switching adjustment factor of 0.523 (10,000/1,040 * 0.523 = 5 years) from: California Public Utilities Commission. *Database for Energy Efficient Resources.* 2008. Available online: www.deeresources.com.

[212] Itron, Inc. *2010-2012 WO017 Ex Ante Measure Cost Study Final Report*. Submitted to the California Public Utilities Commission. May 27, 2014.

[213] Ibid.

Savings Algorithms for this Measure

Energy Savings

$$\Delta kWh = \left(\frac{\text{watts}_{BASE} - \text{watts}_{EFF}}{1{,}000}\right) * ISR * HOURS * (1 + WHF_E)$$

Where:

$\text{watts}_{\text{BASE}}$ = Wattage of baseline lamp (= actual; if missing, see table below for CFL[214] and LED wattage)[215]

$\text{watts}_{\text{EFF}}$ = Wattage of efficient lamp (= actual; if missing, see table below)

Efficient Technology	$\text{watts}_{\text{EFF}}$	$\text{watts}_{\text{BASE}}$
CFL	15W or less	3.05 * $\text{watts}_{\text{EFF}}$
	16W - 20W	3.00 * $\text{watts}_{\text{EFF}}$
	21W or more	3.06 * $\text{watts}_{\text{EFF}}$
LED	9W or less	3.38* $\text{watts}_{\text{EFF}}$
	10W – 17W	3.41 * $\text{watts}_{\text{EFF}}$
	18W or more	4.04 * $\text{watts}_{\text{EFF}}$

ISR = In-service rate, or percentage of rebated units that get installed (= use table below)

---

[214] Duke Energy. *Ohio Residential Smart Saver CFL Program* June 2010. Average CFL is 15.47 watts, with average replacement incandescent bulb of 65.8 watts, for a ratio of 4.25 to 1. (note: the study only includes data from respondents who reported both the wattage removed and wattage replaced). Federal legislation stemming from EISA required that all general purpose light bulbs between 40 watts and 100 watts be approximately 30% more energy efficient than incandescent bulbs by 2014, in essence beginning the phase out of standard incandescent bulbs. $\text{Watts}_{\text{BASE}}$ was calculated by finding the new baseline after the incandescent bulb wattage was reduced (from 100 watts to 72 watts, 75 watts to 53 watts, 60 watts to 43 watts, and 40 watts to 29 watts). For example, an average CFL size replacing a 60-watt incandescent is 60/ (4.25) = 14.1 watts; so when the 60-watt incandescent is replaced by a 43-watt halogen, the multiplier is 43/14.1 = 3.05.

[215] U.S. Environmental Protection Agency. "ENERGY STAR-Certified Light Bulbs." http://www.energystar.gov/productfinder/product/certified-light-bulbs/results. EISA baseline adjustments made to the watts multiplier (which is based on weighted averages) according to lumen range requirements set by ENERGY STAR (https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Lamps%20V1%201_Specification.pdf). For example, a 100-watt equivalent bulb needs to output between 1,600 lumens and 1,999 lumens. The average LED in this lumen range is 17.8 watts, so the watts multiplier is 72/17.8 = 4.04.

In-Service Rate by Bulb Type

Program Type	ISR
CFL*	0.89
LED**	1.00

* Based on Duke Energy ISR data for direct install programs. Note: the ISR does not account for stored lamps that may be installed later, and assumes that uninstalled direct install lamps have been permanently removed.

** There is currently no research regarding LED ISR; therefore an ISR of 1.0 is assigned.

HOURS = Average hours of use per year (= based on program type; see table below)

Annual Hours of Use by Program Type*

Program Type	Annual Hours
Time of Sale	902
Direct Install	902
School Kit	1,135
Specialty Lighting	1,190
Multifamily Common Areas	5,950

* TecMarket Works, et al. *Indiana Core Lighting Logger Hours of Use (HOU) Study*. July 29, 2013. Annual hours of use for specialty bulbs and multifamily common areas are from: Illinois Technical Reference Manual, Version 4.0. 2015.

WHF_E = Waste heat factor for energy to account for HVAC interactions with efficient lighting (= depending on location; see table below)

Weighted Average Waste Heat Factors by City*

City	WHF_E	WHF_D	WHF_G
Indianapolis	-0.061	0.055	-0.0018
South Bend	-0.070	0.038	-0.0019
Evansville	-0.034	0.092	-0.0017
Ft Wayne	-0.082	0.038	-0.0019
Terre Haute	-0.048	0.061	-0.0018
Statewide	**-0.059**	**0.057**	**-0.0018**

* See Appendix B for supporting calculations.

For example, the energy savings from direct install 20-watt CFL using the statewide average for HVAC interactive effects would be:

$$\Delta kWh = \left(\frac{(3.00 * 20) - 20}{1{,}000}\right) * 0.89 * 902 * (1 - .059) \ = 30\ kWh$$

Summer Peak Coincident Demand Reduction

$$\Delta kW = \left(\frac{\text{watts}_{BASE} - \text{watts}_{EFF}}{1{,}000}\right) * ISR * (1 + WHF_D) * CF$$

Where:

WHF$_D$ = Waste heat factor for demand to account for HVAC interactions with efficient lighting (= depending on location; see table above)

CF = Summer peak coincidence factor (= 0.11)[216]

For example, the demand reduction from a direct install 10-watt LED in Indianapolis would be:

$$\Delta kW = \left(\frac{(3.41 * 10) - 10}{1{,}000}\right) * 1.0 * (1 + 0.055) * 0.11 = 0.003\ kW$$

Fossil Fuel Impact Descriptions and Calculation

$$\Delta MMBtu_{WH} = \left(\frac{\text{watts}_{BASE} - \text{watts}_{EFF}}{1{,}000}\right) * ISR * HOURS * WHF_G$$

Where:

ΔMMBtu$_{WH}$ = Gross customer annual heating MMBtu fuel increased usage from the reduction in lighting heat

WHF$_G$ = Waste heat factor for fossil fuels to account for HVAC interactions with efficient lighting (= depending on location; see table above)

For example, the fossil fuel savings from a 20-watt, time-of-sale CFL in Terre Haute would be:

$$\Delta MMBtu_{WH} = \left(\frac{(3.00*20)-20}{1{,}000}\right) * 0.89 * 902 * -0.0018 = -0.058\ MMBtu$$

---

[216] Nexus Market Research, RLW Analytics, and GDS Associates. *New England Residential Lighting Markdown Impact Evaluation.* January 20, 2009.

LED Night Lights

	Measure Details
Official Measure Code	Res-Ltg-NiteLite-1
Measure Unit	Per night light
Measure Category	Lighting
Sector(s)	Residential
Annual Energy Savings (kWh)	14
Peak Demand Reduction (kW)	0
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	224
Lifetime Fossil Fuel Savings (MMBtu)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	16
Incremental Cost	$3.00
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is a night light with an LED light source replacing an incandescent night light.

Definition of Efficient Equipment

The efficient condition is an LED night light.

Definition of Baseline Equipment

The baseline condition is an incandescent night light.

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 16 years.[217]

Deemed Measure Cost

The first cost for this measure is $3.00.[218]

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

---

[217] Franklin Energy Systems. *FES-L6a LED and Specialty Lighting – Residential*. Duke Energy work papers. July 1, 2010.

[218] Ibid.

Savings Algorithm

Energy Savings

$$\Delta \text{kWh} = \frac{Watt_{BASE} - Watt_{LED}}{1{,}000} * ISR * Hours$$

Where:

$Watt_{BASE}$ = Wattage of incandescent night light (= 5)

$Watt_{LED}$ = Wattage of LED night light (= 0.33)

ISR = In-service rate, or percentage of rebated units that get installed (= 1.0)

HOURS = Average hours of use per year (= 2,920, or 8 hours per day)

LED night light savings are calculated as follows:

$$\Delta \text{kWh} = \frac{5 - 0.33}{1{,}000} * 1.0 * 2{,}920 = 14 \text{ kWh}$$

Summer Peak Coincident Demand Reduction

There is no expected peak demand reduction associated with this measure.

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.

ENERGY STAR Torchiere (Time of Sale)

	Measure Details
Official Measure Code	Res-Ltg-Torchiere-1
Measure Unit	Per unit
Measure Category	Lighting
Sector(s)	Residential
Annual Energy Savings (kWh)	113
Peak Demand Reduction (kW)	0.008
Annual Fossil Fuel Savings (MMBtu)	-0.137
Lifetime Energy Savings (kWh)	791
Lifetime Fossil Fuel Savings (MMBtu)	-0.959
Water Savings (gal/yr)	0
Effective Useful Life (years)	7
Incremental Cost	$5.00
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is a high-efficiency ENERGY STAR fluorescent torchiere being purchased in place of a baseline mix of halogen and incandescent torchieres, then installed in a residential setting. The savings assumptions are based on a time-of-sale purchase, not as a retrofit or direct install installation.

Definition of Efficient Equipment

The efficient condition is a fluorescent torchiere that meets the ENERGY STAR efficiency standards.

Definition of Baseline Equipment

The baseline condition is a mix of halogen and incandescent torchieres.

Deemed Lifetime of Efficient Equipment

The lifetime of the measure is 7 years.[219]

Deemed Measure Cost

The incremental cost for this measure is $5.00.[220]

---

[219] U.S. Environmental Protection Agency. ENERGY STAR value for this measure. Available online: www.energystar.gov.

[220] California Public Utilities Commission. *Database for Energy Efficient Resources.* 2008. Available online: www.deeresources.com; and Efficiency Vermont. *Technical Reference Manual*. August 9, 2013

Deemed O&M Cost Adjustments

The annual O&M cost adjustment savings is $2.52, based on the component costs and lifetimes shown in the table below.

Deemed Cost Adjustments*

	Efficient Measure		Baseline Measures	
Component	Cost	Life (years)	Cost	Life (years)
Lamp	$7.50	8.87**	$6.00	1.83***

* Efficiency Vermont. *Technical Reference Manual*. August 9, 2013.

** Calculated using the assumed 9,710 hour average rated life of ENERGY STAR CFL torchieres (9,710/1,095= 8.87 years; http://downloads.energystar.gov/bi/qplist/fixtures_prod_list.xls.

** Based on assumption of baseline bulb mix of incandescent and halogen having average rated life of 2,000 hours.

Savings Algorithm

Energy Savings

$$\Delta\text{kWh} = \frac{\Delta Watts_{TORCH}}{1{,}000} * ISR * Hours * (1 + WHF_E)$$

Where:

$\Delta Watts_{TORCH}$ = Average delta watts per purchased ENERGY STAR torchiere (= 73)[221]

ISR = In-service rate, or percentage of units rebated that get installed (= 0.95)[222]

HOURS = Average hours of use per year (= 1,095, or 3 hours per day)[223]

WHF_E = Waste heat factor for energy to account for HVAC interactions with efficient lighting (= -0.059, the weighted average value across all HVAC systems and cities; see Appendix B)

---

[221] Nexus Market Research. *Impact Evaluation of the Massachusetts, Rhode Island and Vermont 2003 Residential Lighting Programs*. Final Report. p. 43 (Table 4-9). October 1, 2004. Value adjusted to conform to EISA baseline reduction, and reduced delta watts multipliers to 63% in 2015.

[222] Nexus Market Research and RLW Analytics. *Impact Evaluation of the Massachusetts, Rhode Island, and Vermont 2003 Residential Lighting Programs*. Table 6-3 on page 63 indicates that 86% of torchieres were installed, and 9% more would be installed. Table 6-7 on page 67 indicates that no torchieres are purchased as spares, so savings are based on all bulbs being installed in first year.

[223] Nexus Market Research. *Impact Evaluation of the Massachusetts, Rhode Island and Vermont 2003 Residential Lighting Programs*. Final Report. p. 104 (Table 9-7). October 1, 2004.

For example, the energy savings from installing an ENERGY STAR torchiere using statewide average HVAC interactive effects would be:

$$\Delta \text{kWh} = \frac{73}{1{,}000} * 0.95 * 1{,}095 * (1 - 0.059) = 71 \text{ kWh}$$

Summer Peak Coincident Demand Reduction

$$\Delta \text{kW} = \frac{\Delta Watts_{TORCH}}{1{,}000} * ISR * (1 + WHF_D) * CF$$

Where:

WHF_D = Waste heat factor for demand to account for HVAC interactions with efficient lighting (= 0.057 as weighted average value across all HVAC systems and cities; see Appendix B)

CF = Summer peak coincidence factor (= 0.11)[224]

For example, the demand reduction from installing an ENERGY STAR torchiere using statewide average HVAC interactive effects would be:

$$\Delta \text{kW} = \frac{73}{1{,}000} * 0.95 * (1 + 0.057) * 0.11 = 0.008 \text{ kW}$$

Fossil Fuel Impact Descriptions and Calculation

$$\Delta \text{MMBtu}_{\text{WH}} = \frac{\Delta Watts_{TORCH}}{1{,}000} * ISR * Hours * WHF_G$$

Where:

$\Delta \text{MMBtu}_{\text{WH}}$ = Gross increase in customer annual heating MMBtu fuel usage from the reduction in lighting heat

WHF_G = Waste heat factor for fossil fuels to account for HVAC interactions with efficient lighting (= -0.0018 as weighted average value across all HVAC systems and cities; see Appendix B)

For example, the fossil fuel savings from installing an ENERGY STAR torchiere using statewide average HVAC interactive effects would be:

$$\Delta \text{MMBtu}_{\text{WH}} = \frac{73}{1{,}000} * 0.95 * 1{,}095 * -0.0018 = \text{- 0. 137 MMBtu}$$

---

[224] Nexus Market Research, RLW Analytics, and GDS Associates. *New England Residential Lighting Markdown Impact Evaluation*. January 20, 2009.

Dedicated Pin Based Compact Fluorescent Lamp (CFL) Table Lamp (Time of Sale)

	Measure Details
Official Measure Code	Res-Ltg-CFLTable-1
Measure Unit	Per unit
Measure Category	Lighting
Sector(s)	Residential
Annual Energy Savings (kWh)	24
Peak Demand Reduction (kW)	0.003
Annual Fossil Fuel Savings (MMBtu)	-0.046
Lifetime Energy Savings (kWh)	192
Lifetime Fossil Fuel Savings (MMBtu)	-0.368
Water Savings (gal/yr)	0
Effective Useful Life (years)	8
Incremental Cost	$8.00
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is a dedicated, pin-based, low-wattage CFL table lamp being purchased through a retail outlet in place of an equivalent incandescent lamp. The incremental cost of the CFL lamp compared to an incandescent lamp is offset via either rebate coupons or upstream markdowns. Savings assumptions are based on a time-of-sale purchase, not as a retrofit or direct install installation, and based on the CFL being installed in a residential location.

Definition of Efficient Equipment

The high-efficiency equipment is a dedicated, pin-based, low-wattage CFL table lamp.

Definition of Baseline Equipment

The baseline equipment is an incandescent table lamp.

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 8 years.[225]

Deemed Measure Cost

The incremental cost for this measure is $8.00.

---

[225] GDS Associates. *Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures*. June 2007. Available online: http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf

Deemed O&M Cost Adjustments

In order to account for the shift in baseline due to federal legislation, the levelized baseline replacement cost over the lifetime of the CFL is calculated using the key assumptions outlined in the table below.

Key Assumptions for Deemed Cost Adjustments

	Standard Incandescent	Halogen
Replacement Cost	\$0.50	\$2.00
Component Life (years, based on lamp life / assumed annual run hours)	1*	3

* Assumes a rated life for incandescent bulb of approximately 1,000 hours.

The calculated net present value of the baseline replacement costs based on CFLs is \$4.97.

Savings Algorithm

Energy Savings

$$\Delta\text{kWh} = \frac{\Delta Watts}{1{,}000} * ISR * Hours * (1 + WHF_E)$$

Where:

ΔWatts = Difference in wattage between CFL and incandescent bulb (= 28.8)[226]

ISR = In-service rate, or percentage of units rebated that get installed (= 1.0)

HOURS = Average hours of use per year (= 901)[227]

WHF_E = Waste heat factor for energy to account for HVAC interactions with efficient lighting (=- 0.059 as weighted average value across all HVAC systems and cities; see Appendix B)

For example, the energy savings from installing a CFL table lamp using statewide average HVAC interactive effects would be:

$$\Delta\text{kWh} = \frac{28.8}{1{,}000} * 1.0 * 901 * (1 - 0.059) = 24\text{ kWh}$$

Summer Peak Coincident Demand Reduction

$$\Delta\text{kW} = \frac{\Delta\, Watts}{1{,}000} * ISR * (1 + WHF_D) * CF$$

---

[226] RLW Analytics. *New England Residential Lighting Markdown Impact Evaluation*. January 20, 2009. Value adjusted to conform to the EISA baseline reduction. Delta watts multiplier reduced to 63% in 2015.

[227] Nexus Market Research, RLW Analytics, and GDS Associates. *New England Residential Lighting Markdown Impact Evaluation*. p. 50. January 20, 2009.

Where:

WHF_D = Waste heat factor for demand to account for HVAC interactions with efficient lighting (= 0.057 as weighted average value across all HVAC systems and cities; see Appendix B)

CF = Summer peak coincidence factor (= 0.11)[228]

For example, the demand reduction from installing a CFL table lamp using statewide average HVAC interactive effects would be:

$$\Delta\text{kW} = \frac{28.8}{1{,}000} * 1.0 * (1 + 0.057) * 0.11 = 0.003\ \text{kW}$$

Fossil Fuel Impact Descriptions and Calculation

$$\Delta\text{MMBtu}_{WH} = \frac{\Delta Watts}{1{,}000} * ISR * Hours * WHF_G$$

Where:

ΔMMBtu_{WH} = Gross increase in customer annual heating MMBtu fuel usage from the reduction in lighting heat

WHF_G = Waste heat factor for fossil fuels to account for HVAC interactions with efficient lighting (= -0.0018 as weighted average value across all HVAC systems and cities; see Appendix B)

For example, the fossil fuel savings from installing a CFL table lamp using statewide average HVAC interactive effects would be:

$$\Delta\text{MMBtu}_{WH} = \frac{28.8}{1{,}000} * 1.0 * 901 * -0.0018 = -\ 0.046\ \text{MMBtu}$$

---

[228] Ibid.

Ceiling Fan with ENERGY STAR Light Fixture (Time of Sale)

	Measure Details
Official Measure Code	Res-Appl-CeilFan-1
Measure Unit	Per unit
Measure Category	Lighting/Appliances
Sector(s)	Residential
Annual Energy Savings (kWh)	108
Peak Demand Reduction (kW)	0.013
Annual Fossil Fuel Savings (MMBtu)	-0.194
Lifetime Energy Savings (kWh)	~1,080
Lifetime Fossil Fuel Savings (MMBtu)	~-1.94
Water Savings (gal/yr)	0
Effective Useful Life (years)	10
Incremental Cost	$86.00
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is installing an ENERGY STAR ceiling fan with a high-efficiency motor and CFLs in place of a standard fan with incandescent bulbs.

Definition of Efficient Equipment

The efficient equipment is an ENERGY STAR-certified ceiling fan with CFLs.

Definition of Baseline Equipment

The baseline equipment is a standard fan with incandescent bulbs.

Deemed Lifetime of Efficient Equipment

The measure life is 10 years.[229]

Deemed Measure Cost

The incremental cost for the ENERGY STAR ceiling fan is $86.00.[230]

---

[229] U.S. Environmental Protection Agency. "ENERGY STAR Ceiling Fan Savings Calculator." http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Ceiling_Fan_Savings_Calculator_Consumer.xls

[230] Ibid.

Deemed O&M Cost Adjustments

In order to account for the shift in baseline due to federal legislation, the levelized baseline replacement cost over the lifetime of the CFL is calculated using the key assumptions shown in the table below.

Key Assumptions for Calculating Levelized Baseline Replacement Costs

	Standard Incandescent	Efficient Incandescent
Replacement Cost	\$0.50	\$2.00
Component Life (years, based on lamp life / assumed annual run hours)	1*	3

* Based on a rated life for incandescent bulb of approximately 1,000 hours.

The calculated net present value of the baseline replacement costs minus the CFL replacement cost (i.e., three bulbs) is \$7.45.

Savings Algorithm

Energy Savings

$$\Delta kWh = (\%low * (LowkW_{BASE} - LowkW_{EE}) + \%med * (MedkW_{BASE} - MedkW_{EE}) + \%high * (HighkW_{BASE} - HighkW_{EE})) * Hours_{FAN}) + (InckW - CFLkW) * Hours_{LIGHT} * (1 + WHF_E)$$

Where:[231]

%low = Percentage of time on low speed (= 40%)

%med = Percentage of time on medium speed (= 40%)

%high = Percentage of time on high speed (= 20%)

$LowWatt_{BASE}$ = Low speed baseline ceiling fan wattage (= 0.0152 kW)

$LowWatt_{EE}$ = Low speed ENERGY STAR ceiling fan wattage (= 0.0117 kW)

$MedWatt_{BASE}$ = Medium speed baseline ceiling fan wattage (= 0.0348 kW)

$MedWatt_{EE}$ = Medium speed ENERGY STAR ceiling fan wattage (= 0.0314 kW)

$HighWatt_{BASE}$ = High speed baseline ceiling fan wattage (= 0.0725 kW)

$HighWatt_{EE}$ = High speed ENERGY STAR ceiling fan wattage (= 0.0715 kW)

$HOURS_{FAN}$ = Typical fan operating hours (= 1,022 at 2.8 hours per day)

InckW = Incandescent bulb kilowatts (= 0.129, assumes three 43-watt bulbs)

CFLkW = CFL kilowatts (= 0.042, assumes three 14-watt bulbs)

---

[231] All data points (unless otherwise noted) came from: U.S. Environmental Protection Agency. “ENERGY STAR Ceiling Fan Savings Calculator.” http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Ceiling_Fan_Savings_Calculator_Consumer.xls

$HOURS_{LIGHT}$ = Typical lighting operating hours (= 1,277.5 at 3.5 hours per day)

WHF_E = Waste heat factor for energy to account for HVAC interactions with efficient lighting (= -0.059 as weighted average value across all HVAC systems and cities; see Appendix B)

For example, the energy savings from installing an ENERGY STAR ceiling fan (using statewide average HVAC interactive effects) would be:

$$\Delta kWh = ((0.4 * (0.0152 - 0.0117) + 0.4 * (0.0348 - 0.0314) + 0.2 * (0.0725 - 0.0715)) * 1{,}022) + ((0.129 - 0.042) * 1{,}277.5 * (1 - 0.059)) = 108 \text{ kWh}$$

Summer Peak Coincident Demand Reduction

$$\Delta kW = \%low * (LowkW_{BASE} - LowkW_{EE}) + \%med * (MedkW_{BASE} - MedkW_{EE}) + \%high * (HighkW_{BASE} - HighkW_{EE}) + (InckW - CFLkW) * (1 + WHF_D) * CF$$

Where:

WHF_D = Waste heat factor for demand to account for HVAC interactions with efficient lighting (= 0.057 as weighted average across all HVAC systems and cities; see Appendix B)

CF = Summer peak coincidence factor (= 0.11)[232]

For example, the demand reduction from installing an ENERGY STAR ceiling fan (using statewide average HVAC interactive effects) would be:

$$\Delta kW = ((0.4 * (0.0152 - 0.0117) + 0.4 * (0.0348 - 0.0314) + 0.2 * (0.0725 - 0.0715)) + ((0.129 - 0.042) * (1 + 0.057)) * 0.11 = 0.013 \text{ kW}$$

Fossil Fuel Impact Descriptions and Calculation

$$\Delta MMBtu_{WH} = \Delta kWh * WHF_G$$

Where:

$\Delta MMBtu_{WH}$ = Gross increase in customer annual heating MMBtu fuel usage from the reduction in lighting heat

WHF_G = Waste heat factor for fossil fuels to account for HVAC interactions with efficient lighting (= -0.0018 as weighted average across all HVAC systems and cities; see Appendix B)

---

[232] Nexus Market Research, RLW Analytics, and GDS Associates. *New England Residential Lighting Markdown Impact Evaluation.* January 20, 2009.

Miscellaneous

Residential Two Speed / Variable Speed Pool Pumps (Time of Sale)

	Measure Details
Official Measure Code	Res-Pool-Pump-1
Measure Unit	Per unit
Measure Category	Miscellaneous
Sector(s)	Residential
Annual Energy Savings (kWh)	Varies by speed control type
Peak Demand Reduction (kW)	Varies by speed control type
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	Varies by speed control type
Lifetime Fossil Fuel Savings (MMBtu)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	10
Incremental Cost	Varies by speed control type
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is purchasing and installing an efficient two speed or variable speed residential pool pump motor in place of a standard single speed motor of equivalent horsepower.

Definition of Efficient Equipment

The high efficiency equipment is a two speed or variable speed residential pool pump.

Definition of Baseline Equipment

The baseline equipment is a single speed residential pool pump.

Deemed Lifetime of Efficient Equipment

The estimated useful life for a variable speed pool pump is 10 years.

Deemed Measure Cost

The incremental cost is estimated as $175.00 for a two speed motor and $750.00 for a variable speed motor.[233]

---

[233] Lockheed Martin. Pump retail price data. July 2009.

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\Delta\text{kWh} = \frac{hp*LF*0.746}{\eta_{PUMP}} * \frac{Hrs}{day} * \frac{Days}{yr} * ESF$$

Where:[234]

hp = Horsepower of pump motor (= 1.5)

LF = Load factor of pump motor (= 0.66)

0.746 = Conversion of hp to kW

η_{PUMP} = Efficiency of pump motor (= 0.325)

Hrs/day = Assumed hours of pump operation per day (= 6)[235]

Days/yr = Assumed number of days pool in use (= 100)[236]

ESF = Energy savings factor (= depending on pump type)

$$\text{ESF}_{\text{TWO SPEED}} = 0.322$$

$$\text{ESF}_{\text{VARIABLE SPEED}} = 0.86$$

$$\Delta\text{kWh}_{\text{TWO SPEED}} = \frac{1.5*0.66*0.746}{0.325} * 6 * 100 * 0.32 = 436 \text{ kWh}$$

$$\Delta\text{kWh}_{\text{VARIABLE SPEED}} = \frac{1.5*0.66*0.746}{0.325} * 6 * 100 * 0.86 = 1{,}173 \text{ kWh}$$

Summer Peak Coincident Demand Reduction

$$\Delta\text{kW} = \frac{HP*LF*0.746}{\eta Pump} * CF * DSF$$

---

[234] Unless otherwise stated, all assumptions from: First Energy. *Residential Swimming Pool Pumps memo.*

[235] Consortium for Energy Efficiency. *Pool Pump Exploration Memo*. June 2009.

[236] Assumes pool operation from Memorial Day to Labor Day.

Where:

DSF = Demand savings factor (= dependent on pump type)

$DSF_{TWO\ SPEED} = 0.59$

$DSF_{VARIABLE\ SPEED} = 0.91$

CF = Summer peak coincidence factor (= 0.83)[237]

$$\Delta kW_{TWO\ SPEED} = \frac{1.5 * 0.66 * 0.746}{0.325} * 0.83 * 0.59 = 1.113\ kW$$

$$\Delta kW_{VARIABLE\ SPEED} = \frac{1.5 * 0.66 * 0.746}{0.325} * 0.83 * 0.91 = 1.716\ kW$$

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.

---

[237] Efficiency Vermont. TRM August, 9, 2013. Coincidence factor based on market feedback about the typical run pattern for pool pumps, which revealed that most people run the pump during the day, and set a timer to turn the pump off during the night.

Residential Premium Efficiency Pool Pump Motor (Time of Sale)

	Measure Details
Official Measure Code	Res-Pool-Motor-1
Measure Unit	Per unit
Measure Category	Miscellaneous
Sector(s)	Residential
Annual Energy Savings (kWh)	404
Peak Demand Reduction (kW)	0.559
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	4,040
Lifetime Fossil Fuel Savings (MMBtu)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	10
Incremental Cost	$50.00
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is purchasing and installing a residential, 1.5 HP, premium efficiency, single speed pool pump motor in place of a standard single speed motor of equivalent horsepower.

Definition of Efficient Equipment

The high-efficiency equipment is a residential, 1.5 HP, premium efficiency, single speed pool pump motor.

Definition of Baseline Equipment

The baseline equipment is a residential, 1.5 HP, standard, single speed pool pump motor.

Deemed Lifetime of Efficient Equipment

The estimated useful life for a pump is 10 years.

Deemed Measure Cost

The incremental cost for this measure is $50.00.[238]

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

---

[238] Franklin Energy Services. *M4 – HE Swimming Pool Pumps – Residential*.

Savings Algorithm

Energy Savings

$$\Delta kWh = hp * 0.746 * \frac{Hrs}{Day} * \frac{Days}{Yr} * \left(\frac{LF_{BASE}}{\eta_{BASE}} - \frac{LF_{EFF}}{\eta_{EFF}}\right)$$

Where:[239]

hp = Horsepower of motors (= 1.5)

0.746 = Conversion from horsepower to kilowatts

LF_{BASE} = Load factor of baseline motor (= 0.66)

LF_{EFF} = Load factor of efficient motor (= 0.65)

$\eta Pump_{BASE}$ = Efficiency of baseline motor (= 0.325)

$\eta Pump_{EFF}$ = Efficiency of premium efficiency motor (= 0.455)

Hrs/Day = Assumed hours of pump operation per day (= 6)[240]

Days/Yr = Assumed number of days pool in use (= 100 days)[241]

$$\Delta kWh = 1.5 * 0.746 * 6 * 100 * \left(\frac{0.66}{0.325} - \frac{0.65}{0.455}\right) = 404\ kWh$$

Summer Peak Coincident Demand Reduction

$$\Delta kW = hp * 0.746 * CF * \left(\frac{LF_{BASE}}{\eta_{BASE}} - \frac{LF_{EFF}}{\eta_{EFF}}\right)$$

Where:

CF = Summer peak coincidence factor (= 0.83)[242]

$$\Delta kWh = 1.5 * 0.746 * 0.83 * \left(\frac{0.66}{0.325} - \frac{0.65}{0.455}\right) = 0.559\ kW$$

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.

---

[239] Unless otherwise stated, all assumptions from: First Energy. *Residential Swimming Pool Pumps Memo.*

[240] Consortium for Energy Efficiency. *Pool Pump Exploration Memo*. June 2009.

[241] Assumes pool operation from Memorial Day to Labor Day.

[242] Efficiency Vermont. TRM. August 9, 2013. Coincidence factor based on market feedback about the typical run pattern for pool pumps, which revealed that most people run the pump during the day, and set a timer to turn the pump off during the night.

Residential New Construction

	Measure Details
Official Measure Code	Res-WB-RNC-1
Measure Unit	Per project
Measure Category	Miscellaneous
Sector(s)	Residential
Annual Energy Savings (kWh)	Varies by project
Peak Demand Reduction (kW)	Varies by project
Annual Fossil Fuel Savings (MMBtu)	Varies by project
Lifetime Energy Savings (kWh)	Varies by project
Lifetime Fossil Fuel Savings (MMBtu)	Varies by project
Water Savings (gal/yr)	Varies by project
Effective Useful Life (years)	Varies by project
Incremental Cost	
Important Comments	
Effective Date	
End Date	

Description

This measure is residential new construction for homes built in Indiana. The savings are based on using accredited HERS software that complies with the Mortgage Industry National Home Energy Rating Systems Accreditation Standards developed by RESNET.

Energy savings and demand reduction are estimated per home for heating, cooling, hot water, lighting, ceiling fans, and appliances, including refrigerators and dishwashers. To avoid double-counting savings, this measure savings should not also be included as savings under another program. However, savings for efficient products installed in the home other than those listed above and that are not claimed under the program may be captured through another program.

Definition of Efficient and Baseline Equipment

The following assumptions underlie the measure savings calculation methodology:

1. Program implementers are using REM/Rate™ or another RESNET-approved software to conduct HERS ratings on each efficient new home built. For recommendations on estimating savings using a rating tool other than REM/Rate™, see the Other Software section.
2. Program administrators will employ the User Defined Reference Home (UDRH) feature provided in REM/Rate™ to estimate savings. This allows for comparing the energy consumption of a rated home with a UDRH.

The UDRH is an exact replica of the rated home in size, structure, and climate zone, but the energy characteristics are defined by local code or building practices. Until a formal study characterizing baseline building practices is completed for Indiana, the UDRH shall be defined by the residential energy efficiency section of the prevailing Indiana building code.

Deemed Lifetime of Efficient Equipment

The estimated useful life varies by equipment installed.

Deemed Measure Cost

More program detail is needed to determine incremental costs.

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

Energy savings, including fossil fuel savings, for heating, cooling, hot water, lighting, and appliances are based on the direct output of REM/Rate™ (or other RESNET-approved energy modeling software). Energy savings are determined on a per-home basis with the following calculation:

Energy savings = UDRH energy consumption – Rated home energy consumption

The UDRH shall be defined by the most recent code, with some supplemental clarifications (see the table in the User Defined Reference Home Specifications section below).

For residential new construction projects that participate through a RESNET-approved sampling protocol, energy savings shall be determined based on the savings from the model home, linearly adjusted based on the floor square footage compared to all other homes included in that sample set. Chapter 6 of the RESNET Mortgage Industry National Home Energy Rating Standards provides technical guidelines on the sampling protocol.

Summer Peak Coincident Demand Reduction

Demand reduction for heating, cooling, hot water, lighting, and appliances are based on the direct output of REM/Rate™ (or other RESNET-approved energy modeling software). System peak electric demand reduction is calculated on a per-home basis using the following calculation:

$$\text{Peak coincident demand reduction} = (UDRH\ electric\ demand - Rated\ home\ electric\ demand) * CF$$

The demand reduction from right-sizing mechanical equipment is calculating using the following equation:

$$\text{Peak coincident demand reduction} = (UDRH\ electric\ demand * OFUDRH - Rated\ home\ electric\ demand * OFr) * CF$$

Where:

CF = Coincidence factor; equates the installed HVAC system demand to its demand during system peak

OFUDRH = Over-sizing factor for the HVAC unit in the UDRH home

OF_R = Over-sizing factor for the HVAC unit in the rated home

Rated Home = Rated home electric demand output as determined from REM/Rate™

UDRH = User defined reference home electric demand output (= see table below)

Peak Demand Variable Definitions

Variable	Type	Value	Sources
OFUDRH	Fixed	1.60	Public Service Electric and Gas. *Residential New Construction Baseline Study*. 1997. Long Island Power Authority. *Residential New Construction Technical Baseline Study.* 2004. Reports use over-sizing values of 155% to 172%.
OF_R	Fixed	1.15	Program guideline for rated home.
CF	Fixed	0.50	Energy Center of Wisconsin. *Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research.* p. 32. May 2008.

Fossil Fuel Impact Descriptions and Calculation

The fossil fuel impacts from this measure are outlined as part of the Energy Savings section.

User Defined Reference Home (UDRH) Specifications

The following table provides inputs for a UDRH based on the 2009 IECC, with some supplemental clarifications.

2009 IECC UDRH Specifications

Data Point	Value		Unit	Source	Comment
	Zone 4	Zone 5			
Building Thermal Envelope					
Fenestration	0.40	0.35	U-factor	2009 IECC Table 402.1.3	
Skylight	0.60	0.60	U-factor	2009 IECC Table 402.1.3	
Glazed Fenestration SHGC	0.40	0.40	SHGC	2009 IECC Table 404.5.2(1)	No prescriptive requirement.
Ceiling	0.030	0.030	U-factor	2009 IECC Table 402.1.3	
Wood Frame Wall	0.082	0.057	U-factor	2009 IECC Table 402.1.3	
Rim and Band Joists	0.082	0.060	U-factor		Code requirement for wood frame wall.
Mass Wall	0.141	0.082	U-factor	2009 IECC Table 402.1.3	
Frame Floor	0.047	0.033	U-factor	2009 IECC Table 402.1.3	
Basement Wall	0.059	0.059	U-factor	2009 IECC Table 402.1.3	

Data Point	Value		Unit	Source	Comment
	Zone 4	Zone 5			
Slab, Unheated	10, 2	10, 2	R-value, feet	2009 IECC Table 402.1.1	Feet from top of slab edge below grade.
Slab, Heated	15, 2	15, 2	R-value, feet	2009 IECC Table 402.1.1	Feet from top of slab edge below grade.
Crawlspace Wall	0.065	0.065	U-factor	2009 IECC Table 402.1.3	
Air Infiltration Rate	0.0036	0.0036	SLA	2009 IECC Table 404.5.2(1)	Approximately 7 to 8 ACH50.
Mechanical Systems					
Furnace	80		AFUE	Federal Standard	Standard is 78 AFUE, 80 AFUE is adopted based on typical minimum availability and practice.
Boiler	80		AFUE	Federal Standard	
Heat Pump, Heating	7.7		HSPF	Federal Standard	All heat pumps shall be characterized as an ASHP.
Central Air Conditioning	13		SEER	Federal Standard	
Heat Pump, Cooling	13		SEER	Federal Standard	
Water Heating, Natural Gas	0.58		EF	Federal Standard	Federal requirements vary based on tank size. The UDRH feature does not allow adjustments to efficiency values based on tank size, therefore the UDRH reference efficiency shall be based on minimum federal efficiency requirements for a 50 gallon tank.
Water Heating, Oil	0.50		EF	Federal Standard	See Water Heating, Natural Gas.
Water Heating, Electric	0.90		EF	Federal Standard	See Water Heating, Natural Gas.
Integrated Space/Water Heating, Heating	80		AFUE	Federal Standard, Boiler	Combination space and water heating units shall reference the minimum federal standard boiler efficiency for the heating portion of unit.
Integrated Space/Water Heating, Water	0.58 (natural gas) 0.50 (oil) 0.90 (electric)		EF	Federal Standard, Water Heating	Combination space and water heating units shall reference the minimum federal standard water heating efficiency for the water heating portion of unit.
Thermostat, Type	Manual			2009 IECC Table 404.5.2(1)	

<table>
<tr><th rowspan="2">Data Point</th><th colspan="2">Value</th><th rowspan="2">Unit</th><th rowspan="2">Source</th><th rowspan="2">Comment</th></tr>
<tr><th>Zone 4</th><th>Zone 5</th></tr>
<tr><td>Thermostat, Cooling Set Point</td><td colspan="2">75</td><td>°F</td><td>2009 IECC Table 404.5.2(1)</td><td></td></tr>
<tr><td>Thermostat, Heating Set Point</td><td colspan="2">72</td><td>°F</td><td>2009 IECC Table 404.5.2(1)</td><td></td></tr>
<tr><td>Duct Insulation</td><td colspan="2">8</td><td>R-Value</td><td>2009 IECC 403.2.1</td><td></td></tr>
<tr><td>Duct Insulation, Floor Truss</td><td colspan="2">6</td><td>R-Value</td><td>2009 IECC 403.2.1</td><td></td></tr>
<tr><td>Duct Leakage</td><td colspan="2">0.88</td><td>DSE</td><td>2009 IECC Table 404.5.2(1)</td><td></td></tr>
<tr><td>Mechanical Ventilation</td><td colspan="2">N/A</td><td></td><td></td><td>Ventilation is not required by code. The UDRH shall not reference ventilation. The program home will see no energy savings or energy penalty from ventilation.</td></tr>
<tr><td colspan="6">Lights and Appliances</td></tr>
<tr><td>Efficient Lighting</td><td colspan="2">50</td><td>%</td><td>IECC 2009 Section 404.1</td><td></td></tr>
<tr><td>Refrigerator</td><td colspan="2">585</td><td>kWh/yr</td><td>Vermont Energy Investment Corporation</td><td>Based on weighted average of NAECA baseline kWh/yr installed in Vermont of 5,000 hours/year.</td></tr>
<tr><td>Dishwasher</td><td colspan="2">0.46</td><td>EF</td><td>RESNET Standard</td><td></td></tr>
<tr><td>Ceiling Fan</td><td colspan="2">None</td><td></td><td>RESNET Standard</td><td></td></tr>
</table>

Definitions and Acronyms

HERS Provider - A firm or organization that develops, manages, and operates a home energy rating system and is currently accredited by RESNET.

Home Energy Rater or Rater – The person trained and certified by a HERS provider to inspect and analyze a home to evaluate the minimum rated features and prepare an energy efficiency rating.

IECC - International Energy Conservation Code

Rated Home - The specific home being evaluated using the rating procedures contained in the National Home Energy Rating Technical Guidelines.

Rating Tool - A procedure for calculating a home energy efficiency rating, annual energy consumption, and annual energy costs, and which is listed in the “National Registry of Accredited Rating Software Programs” as posted on the RESNET website.

Reference Home - A hypothetical home configured in accordance with the specifications set forth in the National Home Energy Rating Technical Guidelines for the purpose of calculating rating scores

REM/Rate™ - RESNET-approved residential energy analysis, code compliance, and rating software supported by the Architectural Energy Corporation.

RESNET - Residential Energy Services Network, the national standards-making body for the building energy efficiency rating system, www.resnet.us.

UDRH - User Defined Reference Home*,* a feature of REM/Rate™ that enables HERS providers to create other reference buildings based on local construction practice, local code, etc. to compare to the rated home.

Lighting and Appliances

REM/Rate™ offers two input modes for Lights and Appliances: simplified and detailed. The simplified input mode (Lights & Appliances – HERS) is the default and is used to calculate a HERS Index. The detailed input mode (Lights & Appliances – AUDIT) is used to capture additional lighting and appliance data. Since only the simplified input mode is used when calculating a HERS Index, the simplified mode shall be used when calculating energy savings and demand reduction for new construction programs.

Energy savings and demand reduction shall be estimated per home for heating, cooling, hot water, lighting, ceiling fans, and appliances, including refrigerators and dishwashers. To avoid double-counting of savings, measures included in new construction program savings should not also be included in savings for another program. However, savings for efficient products installed in the home other than those listed above and that are not claimed through the residential new construction program may be captured through another program.

User Defined Reference Home (UDRH) Feature

The UDRH feature in REM/Rate™ provides a home-by-home comparison of energy consumption against a user-defined reference home. REM/Rate™ allows for modifying the thermal and energy performance features of the rated home to the specifications provided by the UDRH, leaving the rated home's building size, structure, and climate zone. This allows for comparing the energy consumption of the rated home to the energy consumption of the same home built to different specifications.

The UDRH shall be defined by the residential energy efficiency section of the prevailing Indiana building code. As of April 2012, the Indiana building code is based on the 2009 International Energy Conservation Code (IECC). Therefore, energy savings and demand reduction in Indiana will be based on the difference in estimated energy consumption of the program home, compared to that same home built to 2009 (or any subsequently-updated) IECC specifications.

For REM/Rate™, the UDRH specifications are contained in an ASCII script file that follows a specific syntax. Details on creating a UDRH file are in the REM/Rate™ Help module. Inputs for a UDRH file based on 2009 IECC (with supplemental clarifications) are in Table 3 of the User Defined Reference Home (UDRH) Specifications section.

A UDRH report may be run singly for each home, or in batch mode for multiple homes. Data from the UDRH report may also be exported from REM/Rate™ to an Access database for additional data manipulation and to calculate savings. Additional information on using the UDRH batch export feature is in the REM/Rate™ Help module.

Indiana Climate Zones

Climate zones from the figure below shall be used to determine the applicable energy requirements for the UDRH.

Indiana Climate Zones Map

Active Solar & Photovoltaics

Solar systems installed for water and/or space heating and photovoltaic systems installed to meet electricity demand are not addressed in the 2006 IECC. However, they need to be addressed in the UDRH.

If savings for the residential new construction program can be claimed from the use of active solar or PV systems, these systems should be eliminated from the UDRH so that their savings can be quantified in comparison to the rated home. If savings for the residential new construction program *cannot* be claimed from the use of active solar or PV systems, these systems should not be included in the UDRH. When a system is not referenced in the UDRH, that system will be the same in both the rated and reference homes. This way, the energy consumption for the rated home and the UDRH will be estimated assuming both configurations have the solar or PV system installed, so no savings will be reported. The specific syntax for this is provided in the REM/Rate™ UDRH Syntax Report.

Whole-House Residential Retrofit

	Measure Details
Official Measure Code	Res-WB-WWRetro-1
Measure Unit	Varies by project
Measure Category	Miscellaneous
Sector(s)	Residential
Annual Energy Savings (kWh)	Varies by project
Peak Demand Reduction (kW)	Varies by project
Annual Fossil Fuel Savings (MMBtu)	Varies by project
Lifetime Energy Savings (kWh)	Varies by project
Lifetime Fossil Fuel Savings (MMBtu)	Varies by project
Water Savings (gal/yr)	Varies by project
Effective Useful Life (years)	20
Incremental Cost	Varies by project
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

Whole-house retrofit programs, such as home performance with ENERGY STAR and low-income weatherization initiatives, may include a variety of treatments, including building shell and HVAC upgrades and the direct installation of energy-efficient products. This protocol describes how building energy modeling of each individual home treated through a program may be used to estimate savings for the building shell (e.g., air sealing, insulation) and HVAC (e.g., duct sealing, central heating and/or cooling system replacements) measures installed in those homes. Savings from other measures such as efficient lighting, appliances, or water heating should be estimated using deemed values or deemed calculations provided for such measures elsewhere in this TRM.

The alternative to using building energy modeling to develop energy savings for the shell and HVAC measures would be to use the deemed measure savings calculations found elsewhere in this TRM for each installed measures (air sealing, insulation, duct sealing, etc.). Deemed savings calculations are easier to administer and implement but may be less precise because they are based on some assumed average characteristics of homes (such as average heating system efficiencies) and do not capture interactive effects between some measures.

Definition of Efficient Equipment

The efficient condition is a house that was treated by installing building shell and HVAC measures. Savings from installed measures outside of these categories should follow the appropriate measure-specific characterizations.

Definition of Baseline Equipment

The baseline condition is a house before being retrofitted with installed measures. The only exception is that the assumed baseline efficiency of a heating system or central air conditioner that is being replaced should be consistent with the current minimum federal efficiency standards for such equipment, unless it is clear that the equipment would not have been replaced at that particular time were it not for program influence (i.e., to claim a baseline efficiency lower than the current federal minimum, there must be program documentation that the old equipment would otherwise not have been replaced).

Deemed Lifetime of Efficient Equipment

The average savings-weighted lifetime for this measure is 20 years, based on an anticipated mixture of building shell and HVAC measures ranging from 15 years to 25 years.[243]

Deemed Measure Cost

The actual costs for procuring and installing the equipment, materials, and/or services should be used as the deemed measure cost.

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

The requirements for a model-based approach to savings claims are delineated in part through adherence with at least one of the following national standards for whole-house savings calculations:

- RESNET-approved rating software (http://resnet.us)
- Software energy simulation performance exceeding the requirements of National Renewable Energy Laboratory's Home Energy Rating System, BESTEST (http://www.nrel.gov/docs/legosti/fy96/7332b.pdf)
- U.S. Department of Energy Weatherization Assistance Program approval (http://www.waptec.org)

Proper savings estimates from modeling software also require that uninsulated wall or ceiling baseline conditions are modeled as no less than R-5. In addition, software tools must be calibrated against actual consumption data for each treated home or from a sample sized for a 90% confidence interval with ±10% margin of statistical precision error. These requirements address concerns that modeling software can overestimate savings, particularly cooling savings.

The software tools must provide outputs that separately account for heating and cooling energy and peak demand reduction so that demand and fuel-related economic savings may be properly addressed.

---

[243] A review of measures installed could be used to assess whether to adjust the savings-weighted average in accordance with a measure distribution that favors longer (insulation) or shorter (air sealing) lifetimes.

Commercial & Industrial Market Sector

Building Shell

Cool Roof (Retrofit – New Equipment)

	Measure Details
Official Measure Code	CI-Shell-CoolRoof-1
Measure Unit	Per unit
Measure Category	Building Shell
Sector(s)	Commercial
Annual Energy Savings (kWh)	Varies by project
Peak Demand Reduction (kW)	Varies by project
Annual Fossil Fuel Savings (MMBtu)	Varies by project
Lifetime Energy Savings (kWh)	Varies by project
Lifetime Fossil Fuel Savings (MMBtu)	Varies by project
Water Savings (gal/yr)	0
Effective Useful Life (years)	15
Incremental Cost	$8,454.67 per 1,000 square feet
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is the installation of cool roof roofing materials in commercial buildings. A cool roof is assumed to have a solar absorbance of 0.3[244] compared to a standard roof with a solar absorbance of 0.8.[245] Energy savings and demand reduction are realized through reductions in the building cooling loads. The approach uses DOE-2.2 simulations on a series of commercial prototypical building models. Energy and demand impacts are normalized per thousand square feet of roof space.

Definition of Efficient Equipment

The efficient condition is a roof with a solar absorbance of 0.30.

Definition of Baseline Equipment

The baseline condition is a roof with a solar absorbance of 0.80.

---

[244] Maximum value to meet cool roof standards under California’s Title 24.

[245] Itron. *2004-2005 Database for Energy Efficiency Resources (DEER) Update Study.* December 2005.

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 15 years.[246]

Deemed Measure Cost

The full installed cost for retrofit applications is $8,454.67 per 1,000 square feet (kSF).[247]

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\Delta\text{kWh} = \frac{SF}{1{,}000} * \Delta\, kWh_{kSF}$$

Where:

SF = Square footage of the roof (= actual; to be collected with the incentive form)

$\Delta\text{kWh}_{\text{kSF}}$ = Unit energy savings per 1,000 square feet of roof (= see table in Reference Tables section)

For example, the energy savings from an assembly building in Indianapolis with 1,000 square feet of roof would be:

$$\Delta\text{kWh} = \frac{1{,}000}{1{,}000} * 197 = 197\text{ kWh}$$

Summer Peak Coincident Demand Reduction

$$\Delta\text{kW} = \frac{SF}{1{,}000} * \Delta kW_{kSF} * CF$$

Where:

$\Delta\text{kW}_{\text{kSF}}$ = Unit demand reduction per 1,000 square foot of roof area (= see table in Reference Tables section)

CF = Summer peak coincident factor (= 0.74)[248]

---

[246] California Public Utilities Commission. *2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05*. “Effective/Remaining Useful Life Values.” December 16, 2008.

[247] California Public Utilities Commission. *2005 Database for Energy-Efficiency Resources (DEER), Version 2005.2.01*. “Technology and Measure Cost Data.” October 26, 2005.

[248] Duke Energy supplied the coincidence factor for the commercial HVAC end uses (pending verification based on information from the utilities).

For example, the demand reduction from an assembly building in Indianapolis with 1,000 square feet of roof would be:

$$\Delta\text{kW} = \frac{1{,}000}{1{,}000} * 0.141 * 0.74 = 0.104\text{ kW}$$

Fossil Fuel Impact Descriptions and Calculation

$$\Delta\text{MMBtu} = \frac{SF}{1{,}000} * \Delta MMBtu_{kSF}$$

Where:

$\Delta\text{MMBtu}_{\text{kSF}}$ = Unit natural gas savings per 1,000 square feet of roof space (= see table in Reference Tables section)

For example, the fossil fuel impacts from an assembly building in Indianapolis with 1,000 square feet of roof would be:

$$\Delta\text{MMBtu} = \frac{1{,}000}{1{,}000} * -1.451 = \text{-1.45 MMBtu}$$

Reference Tables

Energy Savings and Demand Reduction Factors for Small Commercial Applications

Building	City	$\Delta\text{kWh}_{\text{kSF}}$	$\Delta\text{kW}_{\text{kSF}}$	$\Delta\text{MMBtu}_{\text{kSF}}$
Assembly	Evansville	263	0.159	-1.44
	Ft. Wayne	154	0.091	-1.63
	Indianapolis	197	0.141	-1.45
	South Bend	157	0.003	-1.41
	Terre Haute	203	0.156	-1.44
Big Box Retail	Evansville	223	0.126	-0.90
	Ft. Wayne	152	0.080	-1.16
	Indianapolis	183	0.125	-1.09
	South Bend	155	0.078	-1.02
	Terre Haute	215	0.122	-1.02
Fast Food Restaurant	Evansville	253	0.050	-1.90
	Ft. Wayne	140	0.050	-2.10
	Indianapolis	189	0.050	-2.05
	South Bend	146	0.00	-2.05
	Terre Haute	170	0.003	-2.05
Full Service Restaurant	Evansville	233	0.150	-1.55
	Ft. Wayne	152	0.100	-1.80
	Indianapolis	187	0.150	-1.78
	South Bend	152	0.050	-1.83
	Terre Haute	184	0.100	-1.43
Light Industrial	Evansville	197	0.094	-1.57
	Ft. Wayne	104	0.081	-1.63

Building	City	ΔkWh_{kSF}	ΔkW_{kSF}	$\Delta MMBtu_{kSF}$
	Indianapolis	137	0.063	-1.70
	South Bend	108	0.045	-1.66
	Terre Haute	162	0.064	-1.34
Primary School	Evansville	404	0.678	-2.86
	Ft. Wayne	241	0.506	-2.97
	Indianapolis	328	0.698	-3.01
	South Bend	240	0.636	-2.88
	Terre Haute	359	0.492	-2.34
Small Office	Evansville	230	0.060	-0.84
	Ft. Wayne	156	0.020	-1.02
	Indianapolis	187	0.020	-0.98
	South Bend	157	0.060	-0.98
	Terre Haute	189	0.080	-0.90
Small Retail	Evansville	260	0.125	-1.36
	Ft. Wayne	172	0.078	-1.61
	Indianapolis	210	0.125	-1.58
	South Bend	170	0.031	-1.64
	Terre Haute	245	0.094	-1.16
Warehouse	Evansville	688	0.794	-4.88
	Ft. Wayne	104	0.081	-1.63
	Indianapolis	546	0.594	-5.13
	South Bend	471	0.025	-4.49
	Terre Haute	162	0.064	-1.34

Energy Savings and Demand Reduction Factors for Hospitals

HVAC System	City	ΔkWh_{kSF}	ΔkW_{kSF}	$\Delta MMBtu_{kSF}$
Constant Volume Reheat Economizer with Air Cooled Chiller	Evansville	124	0.104	-1.57
	Indianapolis	104	0.158	-1.37
	South Bend	89	0.001	-1.19
	Ft. Wayne	107	0.085	-0.75
	Terre Haute	116	0.162	-0.71
Constant Volume Reheat Economizer with Water Cooled Chiller	Evansville	86	0.046	-1.57
	Indianapolis	78	0.042	-1.38
	South Bend	67	0.001	-1.19
	Ft. Wayne	81	0.047	-0.75
	Terre Haute	74	0.049	-0.71
Constant Volume Reheat No Economizer with Air Cooled Chiller	Evansville	188	0.104	-1.76
	Indianapolis	167	0.158	-1.56
	South Bend	145	0.001	-1.39
	Ft. Wayne	167	0.085	-0.85
	Terre Haute	166	0.162	-0.81

HVAC System	City	ΔkWh_{kSF}	ΔkW_{kSF}	$\Delta MMBtu_{kSF}$
Constant Volume Reheat No Economizer with Water Cooled Chiller	Evansville	130	0.046	-1.76
	Ft. Wayne	123	0.047	-0.85
	Indianapolis	123	0.046	-1.54
	South Bend	108	0.001	-1.36
	Terre Haute	111	0.049	-0.81
Variable Air Volume Reheat Economizer with Air Cooled Chiller	Evansville	200	0.163	-0.66
	Indianapolis	174	0.176	-0.55
	South Bend	146	0.270	-0.95
	Ft. Wayne	152	0.077	-0.80
	Terre Haute	183	0.192	-0.24
Variable Air Volume Reheat Economizer with Water Cooled Chiller	Evansville	151	0.097	-0.66
	Indianapolis	121	0.059	-0.57
	South Bend	106	0.020	-0.90
	Ft. Wayne	120	0.071	-0.83
	Terre Haute	139	0.047	-0.24

Energy Savings and Demand Reduction Factors for Hotels

HVAC System	City	ΔkWh_{kSF}	ΔkW_{kSF}	$\Delta MMBtu_{kSF}$
Constant Volume Reheat Economizer with Air Cooled Chiller	Indianapolis	528	0.177	-0.10
	South Bend	563	0.151	-0.09
	Evansville	771	0.135	-0.16
	Ft. Wayne	453	0.109	-0.17
	Terre Haute	544	0.198	-0.15
Constant Volume Reheat Economizer with Water Cooled Chiller	Indianapolis	526	0.177	-0.10
	South Bend	561	0.151	-0.09
	Evansville	772	0.135	-0.16
	Ft. Wayne	453	0.114	-0.17
	Terre Haute	545	0.198	-0.15
Constant Volume Reheat No Economizer with Air Cooled Chiller	Indianapolis	537	0.177	-0.07
	South Bend	574	0.151	-0.07
	Evansville	782	0.135	-0.15
	Ft. Wayne	464	0.109	-0.17
	Terre Haute	556	0.198	-0.14
Constant Volume Reheat No Economizer with Water Cooled Chiller	Evansville	781	0.135	-0.15
	Ft. Wayne	464	0.114	-0.16
	Indianapolis	531	0.177	-0.07
	South Bend	570	0.151	-0.07
	Terre Haute	556	0.198	-0.14
Variable Air Volume Reheat Economizer	Indianapolis	535	0.177	-0.06
	South Bend	569	0.151	-0.05
	Evansville	789	0.135	-0.07

HVAC System	City	ΔkWh_{kSF}	ΔkW_{kSF}	$\Delta MMBtu_{kSF}$
with Air Cooled Chiller	Ft. Wayne	470	0.114	-0.10
	Terre Haute	559	0.203	-0.07
Variable Air Volume Reheat Economizer with Water Cooled Chiller	Indianapolis	533	0.177	-0.06
	South Bend	567	0.146	-0.05
	Evansville	787	0.135	-0.07
	Ft. Wayne	467	0.114	-0.10
	Terre Haute	557	0.203	-0.07

Energy Saving and Demand Reduction Factors for Large Offices

HVAC System	City	ΔkWh_{kSF}	ΔkW_{kSF}	$\Delta MMBtu_{kSF}$
Constant Volume Reheat Economizer with Air Cooled Chiller	Evansville	149	0.120	-1.63
	Ft. Wayne	95	0.00	-1.99
	Indianapolis	153	0.00	-2.06
	South Bend	120	0.143	-2.59
	Terre Haute	136	0.103	-1.40
Constant Volume Reheat Economizer with Water Cooled Chiller	Evansville	101	0.00	-1.64
	Ft. Wayne	57	0.00	-1.99
	Indianapolis	120	0.00	-2.20
	South Bend	110	0.00	-2.61
	Terre Haute	95	0.00	-1.43
Constant Volume Reheat No Economizer with Air Cooled Chiller	Evansville	249	0.109	-1.47
	Ft. Wayne	167	0.103	-1.93
	Indianapolis	250	0.057	-1.77
	South Bend	188	0.149	-1.85
	Terre Haute	266	0.103	-1.56
Constant Volume Reheat No Economizer with Water Cooled Chiller	Evansville	184	0.051	-1.46
	Ft. Wayne	143	0.046	-1.93
	Indianapolis	205	0.034	-1.78
	South Bend	152	0.086	-1.85
	Terre Haute	153	0.034	-1.56
Variable Air Volume Reheat Economizer with Air Cooled Chiller	Evansville	297	0.154	-0.27
	Ft. Wayne	190	0.120	-0.87
	Indianapolis	405	0.006	0.58
	South Bend	347	0.126	-0.01
	Terre Haute	422	0.291	0.37
Variable Air Volume Reheat Economizer with Water Cooled Chiller	Evansville	220	0.029	-0.27
	Ft. Wayne	183	0.023	-0.74
	Indianapolis	350	0.00	0.58
	South Bend	252	0.069	-0.18
	Terre Haute	334	0.017	0.37

Commercial Window Film (Retrofit – New Equipment)

	Measure Details
Official Measure Code	CI-Shell-WinFilm-1
Measure Unit	Per square foot
Measure Category	Building Shell
Sector(s)	Commercial
Annual Energy Savings (kWh)	Varies by project
Peak Demand Reduction (kW)	Varies by project
Annual Fossil Fuel Savings (MMBtu)	Varies by project
Lifetime Energy Savings (kWh)	Varies by project
Lifetime Fossil Fuel Savings (MMBtu)	Varies by project
Water Savings (gal/yr)	0
Effective Useful Life (years)	10
Incremental Cost	$267.00 per 100 square feet of window
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is the installation of reflective window film in commercial buildings. The baseline condition is double-pane clear glass with a solar heat gain coefficient (SHGC) of 0.73 and a U-value of 0.72 Btu/hr-SF-°F. The window film is assumed to provide a SHGC of 0.40 or less. Energy savings and demand reduction are realized through reductions in the building cooling loads. The approach uses DOE-2.2 simulations on a series of commercial prototypical building models. The commercial simulation models are adapted from the California DEER, with changes to reflect Indiana climate and building practices. Energy and demand impacts are normalized per 100 square feet of window.

Definition of Efficient Equipment

The efficient condition is double-pane clear glass windows with standard window film. The standard window film will lower the SHGC to 0.40.

Definition of Baseline Equipment

The baseline condition is double-pane clear glass windows without any window film, with a U-value of 0.72, and a SHGC of 0.73.

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 10 years.[249]

Deemed Measure Cost

This is a retrofit-only measure. The actual installed cost should be used, but for analysis purposes, the full installed cost including labor is $267.00 per 100 square feet of window.[250]

Deemed O&M Cost Adjustments

There are no expected O&M savings associated with this measure.

Savings Algorithm

Energy Savings

$$\Delta \text{kWh} = \frac{SF}{100} * \ \Delta\, kWh_{100SF}$$

Where:

SF = Glazing surface area of installed window film in square feet, not including frame

ΔkWh_{100SF} = Unit energy savings per 100 square feet of window film (= see table in Reference Table section)

Summer Peak Coincident Demand Reduction

$$\Delta \text{kW} = \frac{SF}{100} * \Delta kW_{100SF} * \text{CF}$$

Where:

ΔkW_{100SF} = Unit demand reduction per 100 square feet of window film (= see table in Reference Table section)

CF = Summer peak coincident factor (= 0.74)[251]

Since this is a retrofit measure that only applies to existing buildings with clear, double-pane windows, future code adjustments should not affect projected savings.

---

[249] California Public Utilities Commission. *2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05*. "Effective/Remaining Useful Life Values." December 16, 2008.

[250] California Public Utilities Commission. *2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05*. "Cost Values and Summary Documentation." December 16, 2008.

[251] Duke Energy provided the coincidence factor for the commercial HVAC end-use (pending verification based on information from the utilities).

Fossil Fuel Impact Descriptions and Calculation

$$\Delta\text{MMBtu} = \frac{SF}{100} * \Delta MMBtu_{100SF}$$

Where:

$\Delta\text{MMBtu}_{100SF}$ = Unit heating fossil fuel savings per 100 square feet of window film (= see table in Reference Table section)

Reference Table

Energy Saving and Demand Reduction Factors for Window Film

Building Type	ΔkWh$_{100SF}$*	ΔkW$_{100SF}$*	ΔMMBtu$_{100SF}$*
Indianapolis			
Assembly	426	0.15	-3.96
Big Box Retail	350	0.12	-3.39
Fast Food Restaurant	317	0.14	-5.06
Full Service Restaurant	304	0.17	-7.07
Light Industrial	285	0.14	-4.00
Primary School	498	0.22	-7.40
Small Office	309	0.13	-2.70
Small Retail	323	0.15	-4.48
Warehouse	285	0.14	-4.00
Other	344	0.00	-4.67
South Bend			
Assembly	352	0.01	-3.68
Big Box Retail	319	0.08	-2.91
Fast Food Restaurant	260	0.02	-5.21
Full Service Restaurant	260	0.08	-7.02
Light Industrial	231	0.14	-4.25
Primary School	421	0.26	-6.62
Small Office	280	0.12	-2.62
Small Retail	289	0.12	-4.63
Warehouse	231	0.14	-4.25
Other	294	0.00	-4.58
Evansville			
Assembly	586	0.15	-3.12
Big Box Retail	457	0.16	-2.43
Fast Food Restaurant	391	0.14	-4.20
Full Service Restaurant	376	0.17	-5.64
Light Industrial	329	0.14	-3.59
Primary School	537	0.18	-6.76
Small Office	369	0.13	-1.92
Small Retail	416	0.16	-3.38
Warehouse	329	0.14	-3.59

Building Type	**ΔkWh_{100SF}***	**ΔkW_{100SF}***	**$\Delta MMBtu_{100SF}$***
Other	421	0.00	-3.85
Ft. Wayne			
Assembly	335	0.15	-4.12
Big Box Retail	305	0.16	-3.35
Fast Food Restaurant	258	0.14	-5.11
Full Service Restaurant	254	0.19	-7.43
Light Industrial	199	0.16	-4.34
Primary School	442	0.39	-6.83
Small Office	265	0.14	-2.91
Small Retail	273	0.16	-4.79
Warehouse	199	0.16	-4.34
Other	281	0.00	-4.80
Terre Haute			
Assembly	417	0.13	-4.20
Big Box Retail	382	0.09	-2.13
Fast Food Restaurant	306	0.14	-4.20
Full Service Restaurant	310	0.17	-5.47
Light Industrial	273	0.09	-3.41
Primary School	505	0.20	-5.53
Small Office	304	0.11	-1.91
Small Retail	352	0.11	-3.07
Warehouse	273	0.09	-3.41
Other	347	0.00	-3.70

* Unit energy savings, demand reductions, and natural gas savings data are based on a series of prototypical small commercial building simulation runs. The prototypes are based on the California DEER study prototypes, modified for local construction practices. Simulations were run using TMY3 weather data for each of the cities listed. Building prototypes used in the energy modeling are described in Appendix A - Prototypical Building Energy Simulation Model Development.

Roof Insulation (Retrofit – New Equipment)

	Measure Details
Official Measure Code	CI-Shell-RoofInsul-1
Measure Unit	Per square foot
Measure Category	Building Shell
Sector(s)	Commercial
Annual Energy Savings (kWh)	Varies by project
Peak Demand Reduction (kW)	Varies by project
Annual Fossil Fuel Savings (MMBtu)	Varies by project
Lifetime Energy Savings (kWh)	Varies by project
Lifetime Fossil Fuel Savings (MMBtu)	Varies by project
Water Savings (gal/yr)	0
Effective Useful Life (years)	20
Incremental Cost	$1.36 per square foot
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is improvements to the roof insulation in commercial buildings. The roof insulation R-value is assumed to increase to R-18 from the baseline level for each building type. Energy savings and demand reduction are realized through reductions in the building heating and cooling loads. The approach uses DOE-2.2 simulations on a series of commercial prototypical building models. The commercial simulation models are adapted from the California DEER study, with changes to reflect Indiana climate and building practices. Energy and demand impacts are normalized per 1,000 square feet of installed insulation.

Definition of Efficient Equipment

The efficient condition is R-18 insulation on the roof.

Definition of Baseline Equipment

The baseline condition by building type is shown in the table below.

Baseline Condition by Building Type

Building Type	Baseline R-Value
Assembly	R-12
Big Box Retail	R-13.5
Fast Food	R-13.5
Full Service Restaurant	R-13.5
Light Industrial	R-12
School	R-13.5
Small Office	R-13.5
Small Retail	R-13.5

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 20 years.[252]

Deemed Measure Cost

The full installed cost for retrofit applications is $1.36 per square foot.[253]

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\Delta \text{kWh} = \frac{SF}{1{,}000} * \Delta kWh_{kSF}$$

Where:

SF = Square footage of the roof (to be collected with the incentive form)

ΔkWh_{kSF} = Energy savings per 1,000 square feet of roof area (= dependent on building type and region; see table in Reference Table section)

Summer Peak Coincident Demand Reduction

$$\Delta \text{kW} = \frac{SF}{1{,}000} * \Delta kW_{kSF} * CF$$

---

[252] California Public Utilities Commission. *2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05*. “Effective/Remaining Useful Life Values.” December 16, 2008.

[253] Ibid. “Cost Values and Summary Documentation.”

Where:

ΔkW_{kSF} = Demand reduction per 1,000 square feet of roof area (= dependent on building type and region; see table in Reference Table section)

CF = Summer peak coincident factor (= 0.74)[254]

There are no expected future code changes to affect this measure.

Fossil Fuel Impact Descriptions and Calculation

$$\Delta \text{MMBtu} = \frac{SF}{1{,}000} * \Delta MMBtu_{kSF}$$

Where:

$\Delta MMBtu_{kSF}$ = Unit natural gas savings per 1,000 square feet of roof space (= dependent on building type and region; see table in Reference Table section)

Reference Table

Energy Saving and Demand Reduction Factors for Roof Insulation*

Building	City	ΔkWh_{kSF}*	ΔkW_{kSF}*	$\Delta MMBtu_{kSF}$*
Assembly	Evansville	40	0.074	2.07
	Ft. Wayne	39	0.050	4.17
	Indianapolis	48	0.074	3.36
	South Bend	31	0.00	3.26
	Terre Haute	53	0.082	3.60
Big Box Retail	Evansville	6	0.045	1.90
	Ft. Wayne	4	0.025	3.12
	Indianapolis	5	0.041	2.55
	South Bend	1	0.022	2.52
	Terre Haute	1	0.022	2.67
Fast Food Restaurant	Evansville	80	0.00	3.40
	Ft. Wayne	39	0.050	3.80
	Indianapolis	60	0.050	3.75
	South Bend	38	0.00	3.40
	Terre Haute	77	0.050	4.3
Full Service Restaurant	Evansville	72	0.050	3.20
	Ft. Wayne	75	0.025	5.15
	Indianapolis	84	0.050	4.95
	South Bend	72	0.025	5.08

---

[254] Duke Energy provided the coincidence factor for the commercial HVAC end-use (pending verification based on information from the utilities).

Building	City	ΔkWh_{kSF}*	ΔkW_{kSF}*	$\Delta MMBtu_{kSF}$*
	Terre Haute	66	0.025	3.58
Light Industrial	Evansville	73	0.022	2.87
	Ft. Wayne	53	0.014	4.41
	Indianapolis	65	0.019	3.96
	South Bend	58	0.019	4.16
	Terre Haute	65	0.019	3.30
Primary School	Evansville	196	0.298	4.52
	Ft. Wayne	106	0.232	4.48
	Indianapolis	135	0.116	4.23
	South Bend	110	0.108	4.33
	Terre Haute	181	0.110	5.05
Small Office	Evansville	57	0.040	2.02
	Ft. Wayne	38	0.06	3.12
	Indianapolis	50	0.04	2.76
	South Bend	39	0.04	2.84
	Terre Haute	50	0.040	2.48
Small Retail	Evansville	84	0.062	3.20
	Ft. Wayne	68	0.05	4.66
	Indianapolis	84	0.08	4.20
	South Bend	72	0.05	4.50
	Terre Haute	81	0.047	3.77
Warehouse	Evansville	73	0.022	2.87
	Ft. Wayne	54	0.02	4.34
	Indianapolis	60	0.121	7.53
	South Bend	23	0.011	7.32
	Terre Haute	65	0.019	3.30

* Unit energy savings, demand reductions, and natural gas savings data are based on a series of prototypical small commercial building simulation runs. The prototypes are based on the California DEER study prototypes, modified for local construction practices. Simulations were run using TMY3 weather data for each of the cities listed. Building prototypes used in the energy modeling are described in Appendix A - Prototypical Building Energy Simulation Model Development.

High Performance Glazing (Retrofit – Early Replacement)

	Measure Details
Official Measure Code	CI-Shell-HPGlaz-1
Measure Unit	Per square foot
Measure Category	Building Shell
Sector(s)	Commercial
Annual Energy Savings (kWh)	Varies by project
Peak Demand Reduction (kW)	Varies by project
Annual Fossil Fuel Savings (MMBtu)	Varies by project
Lifetime Energy Savings (kWh)	Varies by project
Lifetime Fossil Fuel Savings (MMBtu)	Varies by project
Water Savings (gal/yr)	0
Effective Useful Life (years)	20
Incremental Cost	$54.82 per square foot of window
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is the installation of high performance glazing in commercial buildings. The baseline condition is double-pane clear glass with a solar heat gain coefficient (SHGC) of 0.73 and U-value of 0.72 Btu/hr-SF-°F. The efficient glazing must have a SHGC of 0.40 or less and U-value of 0.57 Btu/hr-SF-°F or less. Energy savings and demand reduction are realized through reductions in the building heating and cooling loads. The approach uses DOE-2.2 simulations on a series of commercial prototypical building models. The commercial simulation models are adapted from the California DEER study, with changes to reflect Indiana climate and building practices. Energy and demand impacts are normalized per 100 square feet of window.

Definition of Efficient Equipment

The efficient condition is a window with a U-value of 0.57 and a SHGC of 0.4.

Definition of Baseline Equipment

The baseline condition is a window with a U-value of 0.72 and a SHGC of 0.73.

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 20 years.[255]

---

[255] California Public Utilities Commission. *2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05*. "Effective/Remaining Useful Life Values." December 16, 2008.

Deemed Measure Cost

The full installed cost for retrofit applications is $54.82 per square foot of window.[256]

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\Delta\text{kWh} = \frac{SF}{100} * \Delta kWh_{100SF}$$

Where:

SF = Glazing surface area of installed window in square feet, not including frame (= actual)

$\Delta\text{kWh}_{100\text{SF}}$ = Energy savings per 100 square feet of window space (= see table in Table Reference section)

Summer Peak Coincident Demand Reduction

$$\Delta\text{kW} = \frac{SF}{100} * \Delta kW_{100SF} * CF$$

Where:

$\Delta\text{kW}_{100\text{SF}}$ = Demand reduction per 100 square feet of window space (= see table in Table Reference section)

CF = Summer peak coincident factor (= 0.74)[257]

Baseline Adjustment

There are no expected future code changes to affect this measure.

Fossil Fuel Impact Descriptions and Calculation

$$\Delta\text{MMBtu} = \frac{SF}{100} * \Delta MMBtu_{100SF}$$

---

[256] Efficiency Vermont. *Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions*. February, 19, 2010. Value derived from Efficiency Vermont project experience and conversations with suppliers.

[257] Duke Energy supplied the coincidence factor for the commercial HVAC end-use (pending verification based on information from the utilities).

Where:

$\Delta MMBtu_{100SF}$ = Unit natural gas savings per 100 square feet of window space (= see table in Table Reference section)

Reference Table

Energy Saving and Demand Reduction Factors for High Performance Windows

Building Type	ΔkWh_{100SF}*	ΔkW_{100SF}*	$\Delta MMBtu_{100SF}$*
Indianapolis			
Assembly	376	0.15	-0.67
Big Box Retail	317	0.12	-0.81
Fast Food Restaurant	316	0.14	-0.84
Full Service Restaurant	331	0.17	-0.99
Light Industrial	272	0.14	-1.69
Primary School	535	0.23	-2.97
Religious Worship	210	0.19	-0.25
Small Office	300	0.14	-0.57
Small Retail	326	0.16	-1.13
Warehouse	272	0.14	-1.69
Other	326	0.00	-1.16
South Bend			
Assembly	301	0.01	-0.96
Big Box Retail	291	0.09	-0.81
Fast Food Restaurant	266	0.03	-0.43
Full Service Restaurant	289	0.08	-0.52
Light Industrial	212	0.14	-1.83
Primary School	450	0.26	-2.44
Small Office	273	0.13	-0.42
Small Retail	298	0.13	-0.88
Warehouse	212	0.14	-1.83
Other	288	0.00	-1.03
Evansville			
Assembly	510	0.15	-1.00
Big Box Retail	406	0.17	-0.78
Fast Food Restaurant	378	0.15	-0.91
Full Service Restaurant	389	0.17	-1.08
Light Industrial	320	0.14	-1.85
Primary School	574	0.19	-3.09
Small Office	351	0.13	-0.46
Small Retail	404	0.16	-1.04
Warehouse	320	0.14	-1.85
Other	406	0.00	-1.34

Building Type	ΔkWh_{100SF}*	ΔkW_{100SF}*	$\Delta MMBtu_{100SF}$*
Ft. Wayne			
Assembly	287	0.16	-0.74
Big Box Retail	280	0.17	-0.11
Fast Food Restaurant	263	0.14	-0.40
Full Service Restaurant	289	0.19	-0.72
Light Industrial	215	0.16	-1.26
Primary School	470	0.20	-2.35
Small Office	261	0.14	-0.47
Small Retail	285	0.17	-0.79
Warehouse	215	0.16	-1.26
Other	285	0.00	-0.90
Terre Haute			
Assembly	362	0.14	-0.52
Big Box Retail	338	0.10	-0.20
Fast Food Restaurant	306	0.14	-0.22
Full Service Restaurant	327	0.17	-0.17
Light Industrial	283	0.11	-0.90
Primary School	539	0.21	-1.81
Small Office	292	0.11	-0.14
Small Retail	344	0.11	-0.43
Warehouse	283	0.11	-0.90
Other	342	0.00	-0.47

* Unit energy savings, demand reduction, and natural gas savings data are based on a series of prototypical small commercial building simulation runs. The prototypes are based on the California DEER study prototypes, modified for local construction practices. Simulations were run using TMY3 weather data for each of the cities listed. Building prototypes used in the energy modeling are described in Appendix A - Prototypical Building Energy Simulation Model Development.

Domestic Hot Water

Heat Pump Water Heaters (New Construction, Retrofit)

	Measure Details
Official Measure Code	CI-SHW-HPWH-1
Measure Unit	Per water heater
Measure Category	Domestic Hot Water
Sector(s)	Commercial
Annual Energy Savings (kWh)	Varies by location
Peak Demand Reduction (kW)	Varies by location
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	Varies by location
Lifetime Fossil Fuel Savings (MMBtu)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	10
Incremental Cost	Varies by project
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is installing a HPWH in place of a standard electric water heater. HPWHs can be added to existing DHW systems to improve the overall efficiency. HPWHs use refrigerants (like an ASHP) and have much higher energy factors than standard electric water heaters. HPWHs remove waste heat from surrounding air sources and preheat the DHW supply system. HPWHs come in a variety of sizes and the choice will depend on the desired temperature output and amount of hot water needed by application. The savings from HPWH will depend on the design, size (capacity), water heating requirements, building application, and climate. This measure could relate to either a retrofit or a new installation.

Definition of Efficient Equipment

The efficient equipment is a HPWH with or without an auxiliary water heating system.

Definition of Baseline Equipment

The baseline equipment is a standard electric storage tank-type water heater. This measure does *not* apply to natural gas-fired water heaters.

Deemed Lifetime of Efficient Equipment

The expected measure life is 10 years.[258]

Deemed Measure Cost

Due to the complexity of HPWH systems, incremental capital costs should be determined on a case-by-case basis. High capacity HPWHs typically have a supplemental heating source, such as an electric resistance heater. For new construction applications, the incremental capital cost for this measure should be calculated as the difference between the installed cost of the entire HPWH system (including any auxiliary heating systems) and the installed cost of a standard electric storage tank water heater of comparable capacity. For retrofit applications, the total installed cost of HPWH should be used.

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\Delta kWh = \frac{GPD * 365 * 8.3 * (T_{OUT} - T_{IN})}{3,412} * \left(\frac{1}{EF_{BASE}} - \frac{1}{EF_{EE}}\right)$$

Where:

GDP = Average daily gallons of hot water consumption (= determined from site-specific data)

365 = Days of operation per year

8.3 = Specific weight of water (8.3 lbs/gal) multiplied by the specify heat of water $(1.0 \frac{Btu}{lb*°F})$

T_{OUT} = Water heater set point (= actual; otherwise assume 130°F)[259]

T_{In} = Cold water temperature entering the DWH system (= depending on climate; see table below)

---

[258] Estimates of measure life from utilities in the Northeast and the U.S. Department of Energy vary from 10 to 15 years. Assume 10 years as a conservative estimate. http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf

[259] National Association of Home Builders Research Center. *Performance Comparison of Residential Hot Water Systems.* Prepared for the National Renewable Energy Laboratory. 2002.

Groundwater Temperature (T_{IN}) by Location*

City	Groundwater Temperature (°F)
Indianapolis	58.1
South Bend	57.4
Terre Haute	60.5
Evansville	62.8
Ft Wayne	55.6

* Burch, J. and C. Christensen, National Renewable Energy Laboratory. *Towards Development of an Algorithm for Mains Water Temperature.* 2007. American Solar Energy Society, Colorado.

3,412 = Conversion factor (Btu/kWh)

EF_{BASE} = Baseline water heater energy factor (= depending on tank size; see table below)

Federal Standard Energy Factors for Water Heaters*

Tank Volume	EF_{BASE}
≤ 55 gallons	0.960−(0.003 × Rated Storage Volume in gallons)
< 55 gallons	2.057−(0.00113 × Rated Storage Volume in gallons)

* Minimum federal standard for capacity range. 2015 Federal Energy Conservation Standard for electric water heaters (e-CFR Title 10, Chapter II, Subchapter D, Part 430, Subpart C, Section 430.32)

EF_{EE} = Energy factor of HPWH system (= actual)

Summer Peak Coincident Demand Reduction

$$\Delta kW = \frac{GPH * 8.33 * (T_{OUT} - T_{IN})}{3{,}412} * \left(\frac{1}{EF_{BASE}} - \frac{1}{EF_{EE}}\right) * CF$$

Where:

GPH = Hot water consumption in gallons per hour (= determined from site-specific data)

CF = Summer peak coincidence factor (= 0.06)[260]

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.[261]

---

[260] "Technical Reference Manual (TRM) for Ohio Senate Bill 221 Energy Efficiency and Conservation Program and 09-512-GE- UNC." October 15, 2009. Based on Ohio utility supply profiles.

[261] The interactive effects between space heating and cooling requirements and HPWH have been neglected for this characterization but are candidates for future study. Heat pumps remove waste heat from surrounding air sources, which can reduce cooling loads and increase heating loads for HPWHs located in a conditioned space.

High Efficiency Storage Tank Water Heater (Time of Sale, Retrofit – Early Replacement)

	Measure Details
Official Measure Code	CI-SHW-StorWH-1
Measure Unit	Per water heater
Measure Category	Domestic Hot Water
Sector(s)	Commercial
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Fossil Fuel Savings (MMBtu)	Varies by project
Lifetime Energy Savings (kWh)	0
Lifetime Fossil Fuel Savings (MMBtu)	Varies by project
Water Savings (gal/yr)	0
Effective Useful Life (years)	12
Incremental Cost	$300.00
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

Stand-alone, or tank-type heaters, run off natural gas. These water heaters consist of a storage tank with an attached heat source; in this case, a high-efficiency natural gas burner. This measure achieves energy savings through the use of efficient heating equipment and superior tank insulation.

Definition of Efficient Equipment

The efficient case is a natural gas-fired tank-type water heater exceeding the efficiency requirements as mandated ASHRAE 90.1-2007.

Definition of Baseline Equipment

The baseline condition is a natural gas-fired tank-type water heater meeting the efficiency requirements as mandated by ASHRAE 90.1-2007.

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 12 years.[262]

---

[262] The interactive effects between space heating and cooling requirements and HPWH have been neglected for this characterization but are candidates for future study. Heat pumps remove waste heat from surrounding air sources, which can reduce cooling loads and increase heating loads for HPWHs located in a conditioned space.

Deemed Measure Cost

The deemed measure cost is \$300.00.[263]

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

There are no expected energy savings associated with this measure.

Summer Peak Coincident Demand Reduction

There is no expected peak demand reduction associated with this measure.

Fossil Fuel Impact Descriptions and Calculation

$$\Delta \text{MMBtu} = \frac{GPD * 365 * 8.3 * (T_{OUT} - T_{IN})}{1{,}000{,}000} * \left(\frac{1}{\eta_{BASE}} - \frac{1}{\eta_{EE}}\right) + \frac{8{,}760 * (STBY_{BASE} - STBY_{EE})}{1{,}000{,}000}$$

Where:

GPD = Water use of equipment in gallons per day (= see table in Reference Table section)

365 = Days of water heater operation per year

8.3 = Specific weight of water (8.3 lbs/gal) multiplied by the specify heat of water $(1.0 \frac{Btu}{lb*°F})$

T_{OUT} = Water heater set point (= actual; otherwise assume 130°F)[264]

T_{IN} = Cold water temperature entering the DWH system (= depending on climate; see table below)

Groundwater Temperature (T_{IN}) by Location*

City	Groundwater Temperature (°F)
Indianapolis	58.1
South Bend	57.4
Terre Haute	60.5
Evansville	62.8
Ft Wayne	55.6

* Burch, J. and C. Christensen, National Renewable Energy Laboratory. *Towards Development of an Algorithm for Mains Water Temperature.* 2007. American Solar Energy Society, Colorado.

---

[263] Ibid.

[264] National Association of Home Builders Research Center. *Performance Comparison of Residential Hot Water Systems.* Prepared for the National Renewable Energy Laboratory. 2002.

η_{BASE} = Rated efficiency (%) of baseline water heater expressed as energy factor or thermal efficiency (= see table below)

Efficiency of Baseline Water Heater by Size*

Equipment Type	Size Category (Input)	η_{BASE}	$STBY_{BASE}$
Storage water heaters, natural gas	≤ 155,000 Btu/h	0.80	$(Q/800) + 110V^{1/2}$
	> 155,000 Btu/h	0.80	$(Q/800) + 110V^{1/2}$

* Minimum federal standard for capacity range. 2015 Federal Energy Conservation Standard for electric water heaters (e-CFR Title 10, Chapter II, Subchapter D, Part 430, Subpart C, Section 430.32)

V = Rated tank volume in gallons (= actual)

Q = Nameplate input rate in Btu/hr (= actual)

η_{EE} = Rated efficiency (%) of efficient water heater expressed as energy factor or thermal efficiency (= actual)

8,760 = Hours per year

$STBY_{BASE}$ = Standby losses of baseline water heater in Btu/hr (= see table above)

$STBY_{EE}$ = Standby losses of efficient water heater in Btu/hr (= actual; note: for unit rated with energy factor, $STBY_{BASE}$ = 0)

1,000,000= Conversion factor from Btu to MMBtu

Reference Table

Rated Efficiency of Baseline Water Heater by Building Type

Building Type	GPD	Rate	Notes	Source
Assembly	150	5 per seat	Water not HOT water; assume 10% hot water, 300 seats	http://www.p2pays.org/ref/42/41980.pdf
Big Box	100		Assume like Small Office	Staff estimate
Fast Food	630	0.7 GPD per meal	50 meals per hour, 18 hours per day	NY TRM
Full Service Restaurant	1,152	2.4 GPD per meal	40 meals per hour, 18 hours per day	NY TRM
Grocery	200		Assume 2x Big Box	Staff estimate
Hospital	12,000	300 GDP per bed	Water not HOT water; assume 50% hot water, 80 beds	http://www.p2pays.org/ref/42/41980.pdf
Large Office	500	1.0 GPD per person	Assume 500 people	NY TRM
Light Industrial	1,250	25 GPD per person per shift	Water not HOT water; assume 50% hot water, 100 people per day	http://www.p2pays.org/ref/42/41980.pdf

Building Type	GPD	Rate	Notes	Source
Multifamily High-Rise	920	46 GPD per unit	20 units (2 people per unit, refer to table on page 66 of SF manual 12/16/09)	NY TRM
Multifamily Low-Rise	276	46 GPD per unit	6 units (2 people per unit, refer to table on page 66 of SF manual 12/16/09)	NY TRM
Primary School	300	0.6 GPD per student	500 students; reduce days per year to reflect school calendar	NY TRM
Small Office	100	1.0 GPD per person	100 people	NY TRM
Small Retail	50		Half of Big Box	Staff estimate
Auto repair	29		1-person household	Staff estimate
Community College	1,440		Assume like Secondary School	Staff estimate
Dormitory	14,700		Single-person household – 500 students	Staff estimate
Heavy Industrial	1,250	25 GPD per person per shift	Water not HOT water; assume 50% hot water, 100 people per day	http://www.p2pays.org/ref/42/41980.pdf
Hotel	9,000		75% of hotel	Staff estimate
Industrial Refrigeration	29		Assume like Auto Repair	Staff estimate
Motel	4,500		Assume half of Hotel – laundry done on site	Staff estimate
Multi Story Retail	75		150% of Small Retail	Staff estimate
Religious	150		Assume like Assembly	Staff estimate
Secondary School	1,440	1.8 GPD per student	800 students; reduce days per year to reflect school calendar	NY TRM
University	3,450	69 GPD per student	Water not HOT water; assume 10% hot water, 500 students	http://www.p2pays.org/ref/42/41980.pdf
Warehouse	100		Assume like Small Office	Staff estimate

Tankless Water Heaters (Time of Sale, Retrofit – Early Replacement)

	Measure Details
Official Measure Code	CI-SHW-TanklessWH-1
Measure Unit	Per water heater
Measure Category	Domestic Hot Water
Sector(s)	Commercial
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Fossil Fuel Savings (MMBtu)	Varies by project
Lifetime Energy Savings (kWh)	0
Lifetime Fossil Fuel Savings (MMBtu)	Varies by project
Water Savings (gal/yr)	0
Effective Useful Life (years)	20
Incremental Cost	$871.47
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is installing a natural gas-fired tankless or instantaneous water heater. Tankless water heaters essentially function like regular water heaters without the storage tank. When there is demand for hot water, the natural gas burner fires and heats water as it passes through the heater to the demand source. Because the water heater must heat water at the rate of flow through the device, tankless water heaters are not well suited to serve sources of significant demand. Tankless water heaters achieve savings by eliminating the standby losses that occur from stand-alone or tank-type water heaters.

Definition of Efficient Equipment

The efficient condition is a tankless natural gas-fired water heater exceeding the efficiency requirements as mandated by the 2006 International Energy Conservation Code, Table 504.2.

Definition of Baseline Equipment

The baseline condition is a natural gas-fired tank-type water heater meeting the efficiency requirements as mandated by the 2006 International Energy Conservation Code, Table 504.2.

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 20 years.[265]

---

[265] CenterPoint Energy. *Triennial CIP/DSM Plan 2010-2012 Report.*

Deemed Measure Cost

The deemed measure cost for full installation is $871.74.[266] The incremental material cost is $433.72.

Deemed O&M Cost Adjustments

The expected O&M cost adjustment for this measure is $9.60.[267]

Savings Algorithm

Energy Savings

There are no expected energy savings associated with this measure.

Summer Peak Coincident Demand Reduction

There is no expected peak demand reduction associated with this measure.

Fossil Fuel Impact Descriptions and Calculation

$$\Delta \text{MMBtu} = \frac{GPD * 365 * 8.3 * (T_{OUT} - T_{IN})}{1{,}000{,}000} * \left(\frac{1}{\eta_{BASE}} - \frac{1}{\eta_{EE}}\right) + \frac{8{,}760 * STBY_{BASE}}{1{,}000{,}000}$$

Where:

GPD = Water use for equipment in gallons per day (= see table in Reference Table section)

365 = Days of water heater operation per year

8.3 = Specific weight of water (8.3 lbs/gal) multiplied by the specific heat of water $(1.0\,\frac{Btu}{lb*°\text{F}})$

T_{OUT} = Water heater set point (= actual; otherwise assume 130°F)[268]

T_{IN} = Cold water temperature entering the DWH system (= depending on climate; see table below)

---

[266] California Public Utilities Commission. *2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05*. "Cost Values and Summary Documentation." December 16, 2008.

[267] CenterPoint Energy. *Triennial CIP/DSM Plan 2010-2012 Report.*

[268] National Association of Home Builders Research Center. *Performance Comparison of Residential Hot Water Systems.* Prepared for the National Renewable Energy Laboratory. 2002.

Groundwater Temperature (T_{IN}) by Location*

City	Groundwater Temperature (°F)
Indianapolis	58.1
South Bend	57.4
Terre Haute	60.5
Evansville	62.8
Ft Wayne	55.6

* Burch, J. and C. Christensen, National Renewable Energy Laboratory. *Towards Development of an Algorithm for Mains Water Temperature.* 2007. American Solar Energy Society, Colorado.

η_{BASE} = Rated efficiency (%) of baseline water heater expressed as energy factor or thermal efficiency (= see table below)

Efficiency of Baseline Water Heater by Size*

Equipment Type	Size Category (Input)	η_{BASE}	$STBY_{BASE}$
Storage water heaters, natural gas	≤ 155,000 Btu/h	0.80	$(Q/800) + 110V^{1/2}$
	> 155,000 Btu/h	0.80	$(Q/800) + 110V^{1/2}$

* Minimum federal standard for capacity range. 2015 Federal Energy Conservation Standard for electric water heaters (e-CFR Title 10, Chapter II, Subchapter D, Part 430, Subpart C, Section 430.32)

V = Rated tank volume in gallons (= actual)

Q = Nameplate input rate in Btu/hr (= actual)

η_{EE} = Rated efficiency (%) of efficient water heater expressed as energy factor or thermal efficiency (= actual)

8,760 = Hours of standby loss per year

$STBY_{BASE}$ = Standby losses of baseline water heater in Btu/hr (= see table above)

1,000,000= Conversion factor from Btu to MMBtu

Reference Table

Rated Efficiency of Baseline Water Heater by Building Type

Building Type	GPD	Rate	Notes	Source
Assembly	150	5 per seat	Water not HOT water; assume 10% hot water, 300 seats	http://www.p2pays.org/ref/42/41980.pdf
Big Box	100		Assume like Small Office	Staff estimate
Fast Food	630	0.7 GPD per meal	50 meals per hour, 18 hours per day	NY TRM
Full Service Restaurant	1,152	2.4 GPD per meal	40 meals per hour, 18 hours per day	NY TRM
Grocery	200		Assume 2x Big Box	Staff estimate

Building Type	GPD	Rate	Notes	Source
Hospital	12,000	300 GDP per bed	Water not HOT water; assume 50% hot water, 80 beds	http://www.p2pays.org/ref/42/41980.pdf
Large Office	500	1.0 GPD per person	Assume 500 people	NY TRM
Light Industrial	1,250	25 GPD per person per shift	Water not HOT water; assume 50% hot water, 100 people per day	http://www.p2pays.org/ref/42/41980.pdf
Multifamily High-Rise	920	46 GPD per unit	20 units (2 people per unit, refer to table on page 66 of SF manual 12/16/09)	NY TRM
Multifamily Low-Rise	276	46 GPD per unit	6 units (2 people per unit, refer to table on page 66 of SF manual 12/16/09)	NY TRM
Primary School	300	0.6 GPD per student	500 students; reduce days per year to reflect school calendar	NY TRM
Small Office	100	1.0 GPD per person	100 people	NY TRM
Small Retail	50		Half of Big Box	Staff estimate
Auto repair	29		1-person household	Staff estimate
Community College	1,440		Assume like Secondary School	Staff estimate
Dormitory	14,700		Single-person household – 500 students	Staff estimate
Heavy Industrial	1,250	25 GPD per person per shift	Water not HOT water; assume 50% hot water, 100 people per day	http://www.p2pays.org/ref/42/41980.pdf
Hotel	9,000		75% of hotel	Staff estimate
Industrial Refrigeration	29		Assume like Auto Repair	Staff estimate
Motel	4,500		Assume half of Hotel – laundry done on site	Staff estimate
Multi Story Retail	75		150% of Small Retail	Staff estimate
Religious	150		Assume like Assembly	Staff estimate
Secondary School	1,440	1.8 GPD per student	800 students; reduce days per year to reflect school calendar	NY TRM
University	3,450	69 GPD per student	Water not HOT water; assume 10% hot water, 500 students	http://www.p2pays.org/ref/42/41980.pdf
Warehouse	100		Assume like Small Office	Staff estimate

Food Service

Spray Nozzles for Food Service (Retrofit)

	Measure Details
Official Measure Code	CI-SHW-PRSV-1
Measure Unit	Per nozzle
Measure Category	Food Service
Sector(s)	Commercial
Annual Energy Savings (kWh)	Varies by project
Peak Demand Reduction (kW)	Varies by project
Annual Fossil Fuel Savings (MMBtu)	Varies by project
Lifetime Energy Savings (kWh)	Varies by project
Lifetime Fossil Fuel Savings (MMBtu)	Varies by project
Water Savings (gal/yr)	Varies by project
Effective Useful Life (years)	5
Incremental Cost	Varies by project
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

Pre-rinse valves use a spray of water to remove food waste from dishes prior to cleaning in a dishwasher. They reduce water consumption, water heating cost, and waste water (sewer) charges. Pre-rinse spray valves include a nozzle, squeeze lever, and dish guard bumper. The spray valves usually have a clip to lock the handle in the “on” position, and are inexpensive and easily interchangeable with different manufacturers’ assemblies. The primary impacts of this measure will be water savings. Energy savings depend on the type of water heating fuel; if the facility does not have electric water heating, there are no electric savings for this measure; if the facility does not have fossil fuel water heating, there are no MMBtu savings for this measure.

Definition of Efficient Equipment

The efficient equipment is a pre-rinse spray valve with a flow rate of 1.6 gallons per minute, and with a rate of cleaning performance of 26 seconds per plate or less.

Definition of Baseline Equipment

The baseline equipment is a spray valve with a flow rate of 3 gallons per minute.

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 5 years.[269]

Deemed Measure Cost

The actual measure installation cost should be used (including material and labor).

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

If water heating is electric-based:

$$\Delta kWh = \Delta Water * HOT_{\%} * 8.3 * (\mathrm{T}_{OUT} - \mathrm{T}_{IN}) * \frac{1}{EFF_E * 3{,}412}$$

Where:

ΔWater = Water savings in gallons (= see calculation in Water Impact Descriptions and Calculation section)

$HOT_{\%}$ = Percentage of water used by pre-rinse spray valve that is heated (= 69%)[270]

8.3 = Specific weight of water (8.3 lbs/gal) multiplied by the specific heat of water $(1.0\,\frac{Btu}{lb*°\mathrm{F}})$

T_{OUT} = Water heater set point (= actual; otherwise assume 130°F)[271]

T_{IN} = Cold water temperature entering the DWH system (= depending on climate; see table below)

---

[269] Federal Energy Management Program. *How to Buy a Low-Flow Pre-Rinse Spray Valve*. 2004. Used common assumption across efficiency programs.

[270] Navigant Consulting. *Measures and Assumptions for DSM Planning.* Prepared for the Ontario Energy Board. 2009. This factor is a candidate for future improvement through evaluation.

[271] National Association of Home Builders Research Center. *Performance Comparison of Residential Hot Water Systems.* Prepared for the National Renewable Energy Laboratory. 2002.

Groundwater Temperature (T_{IN}) by Location*

City	Groundwater Temperature (°F)
Indianapolis	58.1
South Bend	57.4
Terre Haute	60.5
Evansville	62.8
Ft Wayne	55.6

* Burch, J. and C. Christensen, National Renewable Energy Laboratory. *Towards Development of an Algorithm for Mains Water Temperature*. 2007. American Solar Energy Society, Colorado.

EFF_E = Water heater thermal efficiency (= 0.97)[272]

3,412 = Factor to convert from Btu to kWh

Summer Peak Coincident Demand Reduction

There is no expected peak demand reduction associated with this measure since there is insufficient peak coincident data.

Fossil Fuel Impact Descriptions and Calculation

If water heating is fossil fuel-based:

$$\Delta \text{MMBtu} = \Delta Water * HOT_{\%} * 8.33 * (\text{T}_{OUT} - \text{T}_{IN}) * \frac{1}{EFF_G} * 10^{-6}$$

Where:

ΔWater = Water savings in gallons (= see calculation in Water Impact Descriptions and Calculation section)

$HOT_{\%}$ = Percentage of water used by pre-rinse spray valve that is heated (= 69%)

EFF_G = Water heater thermal efficiency (= 0.58)[273]

10^{-6} = Factor to convert Btu to MMBtu

Water Impact Descriptions and Calculation

$$\Delta \text{Water} = (FLO_{BASE} - FLO_{EFF}) * 60 * \text{H} * 365$$

---

[272] ASHRAE 90.1-2007. Performance requirement for electric resistance water heaters.

[273] This is the baseline natural gas water heater thermal efficiency submitted in the natural gas utilities’ 2009 proposed predetermined values and protocols to the Ohio Public Utility Commission (case no. 09-512-GE-UNC).

Where:

FLO_{BASE} = Flow rate of baseline spray nozzle (= 3 gallons per minute)

FLO_{EFF} = Flow rate of efficient equipment (= 1.6 gallons per minute)

60 = Minutes per hour

365 = Days per year

H = Hours used per day (= depending on facility type; see table below)

Hours per Day by Facility Type*

Facility Type	Hours of Pre-Rinse Spray Valve Use per Day
Full Service Restaurant	4
Other	2
Limited Service (Fast Food) Restaurant	1

* Pacific Gas & Electric savings estimates, algorithms, and sources from 2005.

ENERGY STAR Hot Food Holding Cabinet (Time of Sale)

	Measure Details
Official Measure Code	CI-Food-HoldCab-1
Measure Unit	Per cabinet
Measure Category	Food Services
Sector(s)	Commercial
Annual Energy Savings (kWh)	Varies by size
Peak Demand Reduction (kW)	Varies by size
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	Varies by size
Lifetime Fossil Fuel Savings (MMBtu)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	12
Incremental Cost	$1,110.00
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

Commercial insulated hot food holding cabinet models that meet program requirements incorporate better insulation reduced heat loss, and may offer additional energy-saving devices such as magnetic door electric gaskets, auto-door closures, or Dutch doors. The insulation of the cabinet also offers better temperature uniformity within the cabinet from top to bottom. This means that qualified hot food holding cabinets are more efficient at maintaining food temperature while using less energy.

Definition of Efficient Equipment

The efficient equipment is an ENERGY STAR-qualified hot food holding cabinet with an idle energy rate of 0.04 kW per cubic foot.

Definition of Baseline Equipment

The baseline equipment is a standard hot food holding cabinet with an idle energy rate of 0.1 kW per cubic foot.

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 12 years.[274]

---

[274] Food Service Technology Center. Default value from life cycle cost calculator. Available online: http://www.fishnick.com/saveenergy/tools/calculators/holdcabcalc.php

Deemed Measure Cost

The incremental cost for ENERGY STAR hot food holding cabinet is $1,110.00.[275]

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\Delta \text{kWh} = \frac{W_{FOOT\ BASE} - W_{FOOT\ EFF}}{1{,}000} * V * HOURS$$

Where:

$W_{FOOT\ BASE}$ = Electrical demand per cubic foot of baseline equipment (= use table below)

$W_{FOOT\ EFF}$ = Electrical demand per cubic foot of efficient equipment (= actual; otherwise, use table below)[276]

1,000 = Conversion from watts to kW

V = Internal volume of the holding cabinet in cubic feet (= actual)

HOURS = Annual operating hours (= 5,475)[277]

Parameters Based on Cabinet Size

Parameter	Small	Medium	Large
V	V < 13	13 ≤ V < 28	28 ≤ V
$W_{FOOT\ BASE}$	40	40	40
$W_{FOOT\ EFF}$	21.5 * V	(2 * V) + 254	(3.8 * V) + 203.5

* Food Service Technology Center. Default value from life cycle cost calculator. Available online: http://www.fishnick.com/saveenergy/tools/calculators/holdcabcalc.php

---

[275] New York State Energy Research and Development Authority. *Deemed Savings Database.*

[276] ENERGY STAR requirements: http://www.energystar.gov/index.cfm?c=hfhc.pr_crit_hfhc

[277] Food Service Technology Center. Based on assumption that restaurant is open 15 hours a day, 365 days a year.

Summer Peak Coincident Demand Reduction

$$\Delta \text{kW} = \frac{W_{FOOT\ BASE} - W_{FOOT\ EFF}}{1{,}000} * VOLUME * CF$$

Where:

CF = Summer peak coincidence factor (= 0.84)[278]

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.

---

[278] RLW Analytics. *Coincidence Factor Study – Residential and Commercial Industrial Lighting Measures.* Spring 2007.

Steam Cookers (Time of Sale)

	Measure Details
Official Measure Code	CI-Food-StmCook-1
Measure Unit	Per steam cooker
Measure Category	Food Services
Sector(s)	Commercial
Annual Energy Savings (kWh)	Varies by pan quantity
Peak Demand Reduction (kW)	Varies by pan quantity
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	Varies by pan quantity
Lifetime Fossil Fuel Savings (MMBtu)	0
Water Savings (gal/yr)	Varies by pan quantity
Effective Useful Life (years)	12
Incremental Cost	$3,500.00
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

Energy-efficient steam cookers that have earned the ENERGY STAR designation offer shorter cook times, higher production rates, and reduced heat loss due to better insulation and a more efficient steam delivery system. Energy usage calculations are based on 12 hours a day, 365 days per year, with one preheat and cooking 100 pounds of food per day.

Definition of Efficient Equipment

The efficient condition is installing an ENERGY STAR-qualified steam cooker.

Definition of Baseline Equipment

The baseline condition is a conventional boiler-style steam cooker meeting minimum federal standards for electricity and water consumption.

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 12 years.[279]

---

[279] Food Service Technology Center. Default value from life cycle cost calculator. Available online: http://www.fishnick.com/saveenergy/tools/calculators/esteamercalc.php

Deemed Measure Cost

The incremental cost of an ENERGY STAR steam cooker is \$3,500.00.[280]

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\Delta kWh = kWh_{BASE} - kWh_{EFF}$$

$$kWh_{BASE} = \left(\frac{LB * E_{FOOD}}{EFF} + IDLE * \left(HOURS_{DAY} - \frac{LB}{PC} - \frac{PRE_{TIME}}{60}\right) + PRE_{ENERGY}\right) * DAYS$$

$$kWh_{EFF} = \left(\frac{LB * E_{FOOD}}{EFF} + IDLE * \left(HOURS_{DAY} - \frac{LB}{PC} - \frac{PRE_{TIME}}{60}\right) + PRE_{ENERGY}\right) * DAYS$$

Where:

kWh_{BASE} = Annual energy usage of baseline equipment

kWh_{EFF} = Annual energy usage of efficient equipment

$HOURS_{DAY}$ = Daily operating hours (= 12)[281]

PRE_{TIME} = Preheat time for a steamer to reach operating temperature when turned on (= 15 minutes/day)[282]

PRE_{ENERGY} = Preheat energy (= 1.5 kWh/day)[283]

E_{FOOD} = American Society for Testing Materials (ASTM) Energy to Food; the amount of energy absorbed by the food during cooking (= 0.0308 kWh/lb)

DAYS = Operating days per year (= 365)

The following variables are dependent on the pan capacity of efficient equipment, which is site specific (see table below).

EFF = Heavy load cooking energy efficiency percentage

IDLE = Idle energy rate

---

[280] Average of New York State Energy Research and Development Authority *Deemed Savings Database* and ENERGY STAR website.

[281] Food Service Technology Center. Based on assumption that restaurant is open 12 hours a day, 365 days a year.

[282] Food Service Technology Center. *Commercial Cooking Appliance Technology Assessment.* Chapter 8: Steamers. 2002.

[283] Ibid.

PC = Production capacity (lbs/hr)

LB = Pounds of food cooked per day (lbs/day)

Parameters that Vary by Number of Pans*

Number of Pans	Parameter	Baseline Model	Efficient Model
3	Idle Energy Rate (kW)*	1	0.24
	Production Capacity (lb/hr)	70	50
	Pounds of Food Cooked per Day	100	100
	Heavy Load Cooking Energy Efficiency**	20%	59%
4	Idle Energy Rate (kW)	1.325	0.27
	Production Capacity (lb/hr)	87	67
	Pounds of Food Cooked per Day	128	128
	Heavy Load Cooking Energy Efficiency**	20%	52%
5	Idle Energy Rate (kW)	1.675	0.24
	Production Capacity (lb/hr)	103	83
	Pounds of Food Cooked per Day	160	160
	Heavy Load Cooking Energy Efficiency**	20%	62%
6	Idle Energy Rate (kW)	2	0.31
	Production Capacity (lb/hr)	120	100
	Pounds of Food Cooked per Day	192	192
	Heavy Load Cooking Energy Efficiency**	20%	62%

* Values for ASTM parameters for baseline and efficient conditions (unless otherwise noted) were determined by FSTC according to ASTM F1484, the Standard Test Method for Performance of Steam Cookers. These parameters include the three of the four listed in the table below: Idle Energy Rate, Production Capacity, and Heavy Load Cooking Efficiency.

** Efficient values calculated from a list of ENERGY STAR qualified products. See “ES Steam Cooker Analysis.xls” for details.

Summer Peak Coincident Demand Reduction

$$\Delta \text{kW} = \frac{\Delta kWh}{HOURS} * CF$$

Where:

ΔkWh = Annual energy savings

HOURS = Equivalent full load hours (= 4,380)

CF = Summer peak coincidence factor (= 0.84)[284]

---

[284] RLW Analytics. *Coincidence Factor Study – Residential and Commercial Industrial Lighting Measures*. Spring 2007.

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.

Water Impact Descriptions and Calculation

$$\Delta\text{Water} = (Rate_{BASE} - Rate_{EFF}) * EFLH = 30 * \text{EFLH}$$

Where:

ΔWater = Annual water savings in gallons

$\text{Rate}_{\text{BASE}}$ = Water consumption rate of baseline equipment (= 40 gal/hr)[285]

Rate_{EFF} = Water consumption rate of efficient equipment (= 10 gal/hr)[286]

EFLH = Equivalent full load hours (= 4,380)

---

[285] Food Service Technology Center. *Commercial Cooking Appliance Technology Assessment.* Chapter 8: Steamers. 2002.

[286] Ibid.

ENERGY STAR Fryers (Time of Sale)

	Measure Details
Official Measure Code	CI-Food-Fryer-1
Measure Unit	Per fryer
Measure Category	Food Service
Sector(s)	Commercial
Annual Energy Savings (kWh)	983
Peak Demand Reduction (kW)	0.22
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	11,796
Lifetime Fossil Fuel Savings (MMBtu)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	12
Incremental Cost	$500.00
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

Commercial fryers that have earned the ENERGY STAR designation offer shorter cook times and higher production rates through advanced burner and heat exchanger designs. Fry pot insulation reduces standby losses, resulting in a lower idle energy rate. ENERGY STAR fryers are up to 30% more efficient than standard models. Energy savings estimates are based on a 15-inch fryer.

Definition of Efficient Equipment

The efficient equipment is an ENERGY STAR-qualified electric fryer.

Definition of Baseline Equipment

The baseline equipment is a standard electric fryer with a heavy load efficiency of 75%.

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 12 years.[287]

Deemed Measure Cost

The incremental cost for commercial combination ovens is $500.00.[288]

---

[287] Food Service Technology Center. Default value from lifecycle cost calculator. Available online: http://www.fishnick.com/saveenergy/tools/calculators/efryer.php

[288] New York State Energy Research and Development Authority. *Deemed Savings Database*.

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\Delta kWh = kWh_{BASE} - kWh_{EFF}$$

$$\text{kWh}_{\text{BASE}} = \left(\frac{LB * E_{FOOD}}{EFF} + \frac{IDLE}{1{,}000} * \left(HOURS_{DAY} - \frac{LB}{PC} - \frac{PRE_{TIME}}{60}\right) + PRE_{ENERGY}\right) * DAYS$$

$$\text{kWh}_{\text{EFF}} = \left(\frac{LB * E_{FOOD}}{EFF} + \frac{IDLE}{1{,}000} * \left(HOURS_{DAY} - \frac{LB}{PC} - \frac{PRE_{TIME}}{60}\right) + PRE_{ENERGY}\right) * DAYS$$

Where:

kWh_{BASE} = Annual energy usage of baseline equipment

kWh_{EFF} = Annual energy usage of efficient equipment

$\text{HOURS}_{\text{DAY}}$ = Daily operating hours (= 16)[289]

PRE_{TIME} = Preheat time for a fryer to reach operating temperature when turned on (= 15 min/day)[290]

E_{FOOD} = ASTM Energy to Food; the amount of energy absorbed by the food during cooking (= 0.167 kWh/lb)[291]

LB = Pounds of food cooked per day (= 150 lbs/day)[292]

DAYS = Days of operation in year (= 365)

EFF = Heavy load cooking energy efficiency

IDLE = Idle energy rate (kW)

PC = Production capacity (lbs/hr)

$\text{PRE}_{\text{ENERGY}}$ = Preheat energy kilowatt-hours per day (= see table below)

---

[289] Food Service Technology Center. Based on assumption that restaurant is open 16 hours a day, 365 days a year.

[290] Food Service Technology Center. *Commercial Cooking Appliance Technology Assessment.* Chapter 7: Fryers. 2002.

[291] American Society for Testing and Materials. *Industry Standard for Commercial Ovens.*

[292] Food Service Technology Center. Default value from lifecycle cost calculator. Available online: http://www.fishnick.com/saveenergy/tools/calculators/ecombicalc.php

Performance Metrics: Baseline and Efficient Values

Metric	Baseline Model*	Energy Efficient Model**
PRE_{ENERGY}	2.3	1.7
IDLE	1.05	0.84
EFF	75%	84%
PC	65	70

* Food Service Technology Center. Default value from life cycle cost calculator. Available online: http://www.fishnick.com/saveenergy/tools/calculators/ecombicalc.php

** For calculation, use actual values for these metrics if available. Table is populated with efficient values that reflect averages from a list of qualifying models found on the ENERGY STAR website.

Summer Peak Coincident Demand Reduction

$$\Delta kW = \frac{\Delta kWh}{HOURS} * CF$$

Where:

ΔkWh = Annual energy savings

HOURS = Equivalent full load hours (= 5,840)

CF = Summer peak coincidence factor (= 0.84)[293]

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.

---

[293] RLW Analytics. *Coincidence Factor Study – Residential and Commercial Industrial Lighting Measures*. Spring 2007.

ENERGY STAR Combination Oven (Time of Sale)

	Measure Details
Official Measure Code	CI-Food-CombiOven-1
Measure Unit	Per oven
Measure Category	Food Services
Sector(s)	Commercial
Annual Energy Savings (kWh)	18,432
Peak Demand Reduction (kW)	3.53
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	221,184
Lifetime Fossil Fuel Savings (MMBtu)	0
Water Savings (gal/yr)	87,600 gallons per year
Effective Useful Life (years)	12
Incremental Cost	$2,125.00
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

A combination oven is a convection oven that includes the added capability to inject steam into the oven cavity, and which typically offers at least three distinct cooking modes.

Definition of Efficient Equipment

The efficient equipment is an electric combination oven with a heavy load cooking energy efficiency of at least 60%.

Definition of Baseline Equipment

The baseline equipment is a typical low-efficiency oven with a heavy load efficiency of 44%.

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 12 years.[294]

Deemed Measure Cost

The incremental cost for commercial combination ovens is $2,125.00.[295]

---

[294] Food Service Technology Center. Default value from lifecycle cost calculator. Available online: http://www.fishnick.com/saveenergy/tools/calculators/ecombicalc.php

[295] New York State Energy Research and Development Authority. *Deemed Savings Database*.

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\Delta kWh \ = \ kWh_{BASE} - kWh_{EFF}$$

$$\text{kWh}_{\text{BASE}} = \left(\frac{LB*E_{FOOD}}{EFF} + IDLE * \left(HOURS_{DAY} - \frac{LB}{PC} - \frac{PRE_{TIME}}{60}\right) + PRE_{ENERGY}\right) * DAYS$$

$$\text{kWh}_{\text{EFF}} = \left(\frac{LB*E_{FOOD}}{EFF} + IDLE * \left(HOURS_{DAY} - \frac{LB}{PC} - \frac{PRE_{TIME}}{60}\right) + PRE_{ENERGY}\right) * DAYS$$

Where:

kWh_{BASE} = Annual energy usage of baseline equipment

kWh_{EFF} = Annual energy usage of efficient equipment

$\text{HOURS}_{\text{DAY}}$ = Daily operating hours (= 12)[296]

DAYS = Days per year of operation (= 365)

PRE_{TIME} = Preheat time for a steamer to reach operating temperature when turned on (= 15 min/day)[297]

E_{FOOD} = ASTM Energy to Food; the amount of energy absorbed by the food during cooking (= 0.0732 kWh/lb)[298]

LB = Pounds of food cooked per day (= 200)[299]

EFF = Heavy load cooking energy efficiency

IDLE = Idle energy rate (kW))

PC = Production capacity (lb/hr)

$\text{PRE}_{\text{ENERGY}}$ = Preheat energy kilowatt-hours per day (= see table below)

---

[296] Food Service Technology Center. Based on assumption that restaurant is open 12 hours a day, 365 days a year.

[297] Food Service Technology Center. *Commercial Cooking Appliance Technology Assessment.* Chapter 7: Ovens. 2002.

[298] American Society for Testing and Materials. *Industry Standard for Commercial Ovens.*

[299] Food Service Technology Center. Default value from lifecycle cost calculator. Available online: http://www.fishnick.com/saveenergy/tools/calculators/ecombicalc.php

Performance Metrics: Baseline and Efficient Values*

Metric	Baseline Model	Energy-Efficient Model
PRE_{ENERGY} (kWh)	3	1.5
IDLE (kW)	7.5	3
EFF	44%	60%
PC (lb/hr)	80	100

* Food Service Technology Center. Default value from lifecycle cost calculator. Available online: http://www.fishnick.com/saveenergy/tools/calculators/ecombicalc.php

Summer Peak Coincident Demand Reduction

$$\Delta kW = \frac{\Delta kWh}{HOURS} * CF$$

Where:

ΔkWh = Annual energy savings

HOURS = Equivalent full load hours (= 4,380)

CF = Summer peak coincidence factor (= 0.84)[300]

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.

Water Impact Descriptions and Calculation

The water savings for commercial combination ovens are 87,600 gallons per year.[301]

---

[300] RLW Analytics. *Coincidence Factor Study – Residential and Commercial Industrial Lighting Measures*. Spring 2007.

[301] Food Service Technology Center. Based on assumption that baseline ovens use water at an average rate of 40 gallons per hour while efficient models use water at an average rate of 20 gallons per hour.

ENERGY STAR Convection Oven (Time of Sale)

	Measure Details
Official Measure Code	CI-Food-ConvOven-1
Measure Unit	Per oven
Measure Category	Food Service
Sector(s)	Commercial
Annual Energy Savings (kWh)	3,235
Peak Demand Reduction (kW)	0.62
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	38,820
Lifetime Fossil Fuel Savings (MMBtu)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	12
Incremental Cost	$1,113.00
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

Commercial convection ovens that are ENERGY STAR-certified have higher heavy load cooking efficiencies and lower idle energy rates, making them an average of 20% more efficient than standard models. Energy savings estimates are for ovens using full size (18-inch x 36-inch) sheet pans.

Definition of Efficient Equipment

The efficient equipment is an ENERGY STAR-qualified electric convection oven.

Definition of Baseline Equipment

The baseline equipment is a standard convection oven with a heavy load efficiency of 65%.

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 12 years.[302]

Deemed Measure Cost

The incremental cost for commercial convection ovens is $1,113.00.[303]

---

[302] Food Service Technology Center. Default value from lifecycle cost calculator. Available online: http://www.fishnick.com/saveenergy/tools/calculators/ecombicalc.php

[303] New York State Energy Research and Development Authority. *Deemed Savings Database.*

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\Delta kWh = kWh_{BASE} - kWh_{EFF}$$

$$kWh_{BASE} = \left(\frac{LB*E_{FOOD}}{EFF} + \frac{IDLE}{1{,}000} * \left(HOURS_{DAY} - \frac{LB}{PC} - \frac{PRE_{TIME}}{60}\right) + PRE_{ENERGY}\right) * DAYS$$

$$kWh_{EFF} = \left(\frac{LB*E_{FOOD}}{EFF} + \frac{IDLE}{1{,}000} * \left(HOURS_{DAY} - \frac{LB}{PC} - \frac{PRE_{TIME}}{60}\right) + PRE_{ENERGY}\right) * DAYS$$

Where:

kWh_{BASE} = Annual energy usage of baseline equipment

kWh_{EFF} = Annual energy usage of efficient equipment

$HOURS_{DAY}$ = Daily operating hours (= 12)[304]

DAYS = Days per year of operation (= 365)

PRE_{TIME} = Preheat time for a steamer to reach operating temperature when turned on (= 15 min/day)[305]

E_{FOOD} = ASTM Energy to Food; the amount of energy absorbed by the food during cooking (= 0.0732 kWh/lb)[306]

LB = Pounds of food cooked (= 100 lb/day)[307]

EFF = Heavy load cooking energy efficiency percentage (= see table below)

IDLE = Idle energy rate (= see table below)

PC = Production capacity in pounds per hour (= see table below)

PRE_{ENERGY} = Preheat energy in kilowatt-hours per day (= see table below)

---

[304] Food Service Technology Center. Based on assumption that restaurant is open 12 hours a day, 365 days a year.

[305] Food Service Technology Center. *Commercial Cooking Appliance Technology Assessment*. Chapter 7: Ovens. 2002.

[306] American Society for Testing and Materials. *Industry Standard for Commercial Ovens*.

[307] Food Service Technology Center. Default value from lifecycle cost calculator. Available online: http://www.fishnick.com/saveenergy/tools/calculators/ecombicalc.php

Performance Metrics: Baseline and Efficient Values*

Metric	Baseline Model	Energy-Efficient Model
PRE_{ENERGY} (kWh)	1.5	1
IDLE (kW)	2	1.3**
EFF	65%	74%**
PC (lb/hr)	70	80

* Food Service Technology Center. Default value from lifecycle cost calculator. Available online: http://www.fishnick.com/saveenergy/tools/calculators/ecombicalc.php

** For calculation, use actual values for these metrics, if available. Table is populated with efficient values which reflect averages from a list of qualifying models found on the ENERGY STAR website.

Summer Peak Coincident Demand Reduction

$$\Delta kW = \frac{\Delta\, kWh}{HOURS} * CF$$

Where:

ΔkWh = Annual energy savings

HOURS = Equivalent full load hours (= 4,380)

CF = Summer peak coincidence factor (= 0.84)[308]

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.

---

[308] RLW Analytics. *Coincidence Factor Study – Residential and Commercial Industrial Lighting Measures*. Spring 2007.

ENERGY STAR Griddle (Time of Sale)

	Measure Details
Official Measure Code	CI-Food-Griddle-1
Measure Unit	Per griddle
Measure Category	Food Service
Sector(s)	Commercial
Annual Energy Savings (kWh)	Varies by project
Peak Demand Reduction (kW)	Varies by project
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	
Lifetime Fossil Fuel Savings (MMBtu)	
Water Savings (gal/yr)	0
Effective Useful Life (years)	12
Incremental Cost	$2,090.00
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

ENERGY STAR-qualified commercial griddles have higher cooking energy efficiency and lower idle energy rates than standard equipment. This results in more energy being absorbed by the food compared with the total energy use, and less wasted energy when the griddle is in standby mode.

Definition of Efficient Equipment

The efficient equipment is an ENERGY STAR-qualified griddle with a cooking energy efficiency greater than 70%.

Definition of Baseline Equipment

The baseline equipment is a conventional electric griddle with a cooking energy efficiency of 60%.

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 12 years.[309]

Deemed Measure Cost

The incremental cost of an ENERGY STAR griddle is $2,090.00.[310]

---

[309] Food Service Technology Center. Default value from lifecycle cost calculator. Available online: http://www.fishnick.com/saveenergy/tools/calculators/egridcalc.php

[310] New York State Energy Research and Development Agency. *Deemed Savings Database, Rev. 12*. 2008.

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\Delta kWh = kWh_{BASE} - kWh_{EE}$$

$$kWh_{BASE} = \left(\frac{LB * E_{FOOD}}{\eta_{BASE}} + \mathrm{IE}_{BASE} * \left(H - \frac{LB}{PC_{BASE}} - \frac{T_P}{60}\right) + E_{P,BASE}\right) * DAYS$$

$$kWh_{EFF} = \left(\frac{LB * E_{FOOD}}{\eta_{EFF}} + \mathrm{IE}_{EFF} * \left(H - \frac{LB}{PC_{EFF}} - \frac{T_{PRE}}{60}\right) + E_{P,EFF}\right) * DAYS$$

Where:

kWh_{BASE} = Annual energy usage of baseline equipment

kWh_{EFF} = Annual energy usage of efficient equipment

LB = Pounds of food cooked per day (= actual; otherwise = 100)

E_{FOOD} = ASTM Energy to Food; the amount of energy absorbed by the food during cooking (= 0.139 kWh/lb)[311]

η_{BASE} = Heavy load cooking energy efficiency of baseline griddle (= see table below)

IE_{BASE} = Idle energy rate of baseline griddle (= see table below)

H = Daily operating hours (= actual; otherwise = 12)[312]

PC_{BASE} = Production capacity of baseline griddle (= see table below)

T_P = Preheat time for a steamer to reach operating temperature when turned on (= actual; otherwise 15 min/day)[313]

60 = Minutes per hour

$E_{P,BASE}$ = Preheat energy per day for baseline griddle (= see table below)

DAYS = Operating days per year (= actual; otherwise = 365)

η_{EFF} = Heavy load cooking energy efficiency of efficient griddle (= actual, otherwise, see table below)

---

[311] American Society for Testing and Materials. Industry Standard.

[312] Food Service Technology Center. Based on assumption that restaurant is open 12 hours a day, 365 days a year.

[313] Food Service Technology Center. *Commercial Cooking Appliance Technology Assessment*. Chapter 3: Griddles. 2002.

IE_{EFF} = Idle energy rate of efficient griddle (= see table below)

PC_{EFF} = Production capacity of efficient griddle (= see table below)

$E_{P,EFF}$ = Preheat energy per day for efficient griddle (= see table below)

Efficient Griddle Performance Metrics: Baseline and Efficient Values*

Parameter	Baseline Model	Efficient Model
η (%)	60%	75%
IE (kW)	2.4	0.05
PC (lb/hr)	35	51
E_{PRE} (kWh/day)	4	2

* An average pan width of 3 feet has been assumed based on a survey of available equipment. Baseline values based on assumptions from FSTC lifecycle cost calculator. Efficient values reflect averages from a list of qualifying models found on the ENERGY STAR website (accessed June 2015).

Summer Peak Coincident Demand Reduction

$$\Delta \text{kW} = \frac{\Delta\, kWh}{HOURS} * CF$$

Where:

ΔkWh = Annual energy savings

HOURS = Annual operating hours (= 4,380)

CF = Summer peak coincidence factor (= 0.84)[314]

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.

---

[314] Verification of summer peak coincidence factor is pending further information from the utilities.

HVAC

Electric Chiller (Time of Sale)

	Measure Details
Official Measure Code	CI-HVAC-chiller-1
Measure Unit	Per chiller
Measure Category	HVAC
Sector(s)	Commercial
Annual Energy Savings (kWh)	Varies by equipment type and location
Peak Demand Reduction (kW)	Varies by equipment type and location
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	Varies by equipment type and location
Lifetime Fossil Fuel Savings (MMBtu)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	20
Incremental Cost	Varies by equipment type and location
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure relates to the installation of a new electric chiller meeting the efficiency standards presented below. This measure could relate to replacing an existing unit at the end of its useful life, or installing a new system in an existing building (i.e., time of sale). Only single-chiller applications should be assessed with this methodology. Multiple chiller projects should be evaluated on a custom basis.

Definition of Efficient Equipment

The efficient equipment is assumed to exceed the efficiency requirements of ASHRAE Standard 90.1-2007 Table 6.8.1.

Definition of Baseline Equipment

The baseline equipment is assumed to meet the efficiency requirements of the ASHRAE Standard 90.1-2007 Table 6.8.1.

Deemed Lifetime of Efficient Equipment

The expected measure life is 20 years.[315]

---

[315] California Public Utilities Commission. *2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05.* Effective/Remaining Useful Life Values. December 16, 2008. Available online: http://deeresources.com/deer0911planning/downloads/EUL_Summary_10-1-08.xls

Deemed Measure Cost

The incremental capital cost for this measure is provided below.

Incremental Capital Cost by Equipment Type

Equipment Type	Size Category	IPLV	COP	Incremental Cost ($/ton)
Air-Cooled Electrically Operated	All Capacities	3.36	3.08	$58.58
		3.66	3.36	$106.23
Water-Cooled Screw Chiller	<150 Ton	5.58	4.95	$55.63
		6.28	5.58	$111.25
	150 - 300 Ton	6.17	5.41	$39.76
		6.89	6.17	$79.52
	>300 Ton	6.89	6.06	$27.94
		7.64	6.89	$55.87
Water-Cooled Centrifugal Chiller	<150 Ton	5.86	5.58	$83.05
		6.63	6.28	$166.10
	150 - 300 Ton	6.51	6.17	$61.44
		7.33	6.89	$122.87
	>300 Ton	7.18	6.76	$46.11
		7.99	7.64	$92.22

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\Delta \text{kWh} = TONS * \left(\frac{3.516}{IPLV_{BASE}} - \frac{3.516}{IPLV_{EE}}\right) * EFLH$$

Where:

TONS = Chiller nominal cooling capacity in tons (= actual; 1 ton = 12,000 Btu/hr)

3.516 = Conversion factor to express integrated part load value in kW per ton

$IPLV_{BASE}$ = Efficiency of baseline equipment expressed as integrated part load value (= dependent on chiller type; see table below)

Baseline Efficiency Values by Chiller Type and Capacity

Equipment Type	Size Category	Baseline Efficiency ($IPLV_{BASE}$, COP_{BASE})
Air cooled, with condenser, electrically operated	All capacities	3.05 IPLV, 2.80 COP
Air cooled, without condenser, electrically operated	All capacities	3.45 IPLV, 3.10 COP
Water cooled, electrically operated, positive displacement (reciprocating)	All capacities	5.05 IPLV, 4.20 COP
Water cooled, electrically operated, positive displacement (rotary screw and scroll)	< 150 tons	5.20 IPLV, 4.45 COP
	≥ 150 tons and < 300 tons	5.60 IPLV, 4.90 COP
	≥ 300 tons	6.15 IPLV, 5.50 COP
Water cooled, electrically operated, centrifugal	< 150 tons	5.25 IPLV, 5.00 COP
	≥ 150 tons and < 300 tons	5.90 IPLV, 5.55 COP
	≥ 300 tons	6.40 IPLV, 6.10 COP

Source: ASHRAE 90.1-2007 Table 6.8.1B.

$IPLV_{EE}$ = Efficiency of high-efficiency equipment expressed as integrated part load value (= actual)[316]

EFLH = Equivalent full load hours (= dependent on location and building type, see table below)

Equivalent Full Load Hours by Building Type and Location

Building	System	Indianapolis	South Bend	Evansville	Ft. Wayne	Terre Haute
Community College	Constant Volume No Economizer	1,314	1,090	1,632	1,124	1,320
	Constant Volume Economizer	966	840	1,167	821	955
	Variable Air Volume Economizer	736	621	881	642	680
Hotel	Constant Volume No Economizer	3,999	3,766	4,424	3,999	4,240
	Constant Volume Economizer	3,786	3,541	4,238	3,786	4,034
	Variable Air Volume Economizer	3,732	3,480	4,161	3,732	3,899
Large Retail	Constant Volume No Economizer	2,065	1,899	2,243	2,006	2,164
	Constant Volume Economizer	1,289	1,118	1,545	1,183	1,405
	Variable Air Volume Economizer	1,065	904	1,297	969	1,196
University	Constant Volume No Economizer	1,927	1,805	2,140	1,958	1,833
	Constant Volume Economizer	727	739	917	754	682
	Variable Air Volume Economizer	950	927	1,157	884	795

---

[316] Integrated Part Load Value is simply a seasonal average efficiency rating calculated in accordance with ARI Standard 550/590. It may be calculated using any measure of efficiency (EER, kW/ton, COP), but for consistency with IECC 2006, it is expressed in terms of COP here.

Building	System	Indianapolis	South Bend	Evansville	Ft. Wayne	Terre Haute
Large Office	Constant Volume No Economizer	3,302	2,786	3,300	3,107	3,197
	Constant Volume Economizer	876	897	1,118	916	981
	Variable Air Volume Economizer	992	864	1,042	801	999
High School	Constant Volume No Economizer	1,039	1,003	1,125	995	979
	Constant Volume Economizer	558	519	696	513	570
	Variable Air Volume Economizer	426	359	505	397	383
Hospital	Constant Volume No Economizer	3,777	3,199	4,267	3,538	3,870
	Constant Volume Economizer	2,182	1,830	2,684	1,997	2,416
	Variable Air Volume Economizer	1,554	1,365	1,860	1,442	1,746

Summer Peak Coincident Demand Reduction

$$\Delta \text{kW} = TONS * \left(\frac{3.516}{COP_{BASE}} - \frac{3.516}{COP_{EE}}\right) * CF$$

Where:

COP_{BASE} = Efficiency of baseline equipment (= dependent on chiller type; see table above)

COP_{ee} = Efficiency of high-efficiency equipment (= actual)

CF = Summer peak coincidence factor (= 74%)[317]

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.

---

[317] The summer peak coincidence factor has been preserved from the *Technical Reference Manual (TRM) for Ohio Senate Bill 221 Energy Efficiency and Conservation Program and 09-512-GE-UNC*, dated October 15, 2009. This is likely a conservative estimate, and is recommended for further study.

Chiller Tune-Up

	Measure Details
Official Measure Code	CI-HVAC-ChillerTune-1
Measure Unit	Per Unit
Measure Category	HVAC
Sector(s)	Commercial
Annual Energy Savings (kWh)	Varies by equipment type and location
Peak Demand Reduction (kW)	Varies by equipment type and location
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	Varies by equipment type and location
Lifetime Fossil Fuel Savings (MMBtu)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	5
Incremental Cost	Varies by equipment type and location
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is the tune-up of an existing air-cooled or water-cooled chiller. The tune-up consists of tube cleaning, chilled and condenser water temperature adjustments, and reciprocating compressor unloading switch adjustments.

Definition of Efficient Equipment

The efficient condition is an existing chiller post tune-up.

Definition of Baseline Equipment

The baseline condition is an existing chiller pre tune-up.

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 5 years.

Deemed Measure Cost

The incremental cost for this measure varies.

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\Delta\text{kWh} = TONS * \frac{3.516}{IPLV_{BASE}} * EFLH * ESF$$

Where:

TONS = Chiller nominal cooling capacity in tons (= actual; 1 ton = 12,000 Btu/hr)

3.516 = Conversion factor to express integrated part load value in kW per ton

$IPLV_{BASE}$ = Efficiency of existing equipment expressed as integrated part load value (= dependent on chiller type; see table below)

Baseline Efficiency Values by Chiller Type and Capacity

Equipment Type	Size Category	Baseline Efficiency ($IPLV_{BASE}$, COP_{BASE})
Air cooled, with condenser, electrically operated	All capacities	3.05 IPLV, 2.80 COP
Air cooled, without condenser, electrically operated	All capacities	3.45 IPLV, 3.10 COP
Water cooled, electrically operated, positive displacement (reciprocating)	All capacities	5.05 IPLV, 4.20 COP
Water cooled, electrically operated, positive displacement (rotary screw and scroll)	< 150 tons	5.20 IPLV, 4.45 COP
	≥ 150 tons and < 300 tons	5.60 IPLV, 4.90 COP
	≥ 300 tons	6.15 IPLV, 5.50 COP
Water cooled, electrically operated, centrifugal	< 150 tons	5.25 IPLV, 5.00 COP
	≥ 150 tons and < 300 tons	5.90 IPLV, 5.55 COP
	≥ 300 tons	6.40 IPLV, 6.10 COP

Source: ASHRAE 90.1-2007 Table 6.8.1B.

ESF = Energy savings factor (= 0.08)

EFLH = Equivalent full load hours (= dependent on location and building type;[318] see table below)

Equivalent Full Load Hours by Building Type and Location

Building	System	Indianapolis	South Bend	Evansville	Ft. Wayne	Terre Haute
Community College	CAV no econ	1,314	1,090	1,632	1,124	1,320
	CAV econ	966	840	1,167	821	955
	VAV econ	736	621	881	642	680
Hotel	CAV no econ	3,999	3,766	4,424	3,999	4,240
	CAV econ	3,786	3,541	4,238	3,786	4,034

---

[318] EFLH data were derived from building energy simulation models. See Appendix A.

Building	System	Indianapolis	South Bend	Evansville	Ft. Wayne	Terre Haute
	VAV econ	3,732	3,480	4,161	3,732	3,899
Large Retail	CAV no econ	2,065	1,899	2,243	2,006	2,164
	CAV econ	1,289	1,118	1,545	1,183	1,405
	VAV econ	1,065	904	1,297	969	1,196
University	CAV no econ	1,927	1,805	2,140	1,958	1,833
	CAV econ	727	739	917	754	682
	VAV econ	950	927	1,157	884	795
Large Office	CAV no econ	3,302	2,786	3,300	3,107	3,197
	CAV econ	876	897	1,118	916	981
	VAV econ	992	864	1,042	801	999
High School	CAV no econ	1,039	1,003	1,125	995	979
	CAV econ	558	519	696	513	570
	VAV econ	426	359	505	397	383
Hospital	CAV no econ	3,777	3,199	4,267	3,538	3,870
	CAV econ	2,182	1,830	2,684	1,997	2,416
	VAV econ	1,554	1,365	1,860	1,442	1,746

For example, energy savings for the tune-up of a 300-ton chiller with an IPLV of 6.0 serving an office with a variable air volume system in Indianapolis is calculated as:

$$\Delta\text{kWh} = TONS * \frac{3.516}{IPLV_{BASE}} * EFLH * ESF = 300 * \frac{3.516}{6.0} * 992 * 0.08 = 13{,}951 \text{ kWh}$$

Summer Peak Coincident Demand Reduction

$$\Delta\text{kW} = TONS * \frac{3.516}{COP_{BASE}} * CF * DSF$$

Where:

COP_{BASE} = Efficiency of baseline equipment (= dependent on chiller type; see table below)

Baseline Efficiency Values by Chiller Type and Capacity

Equipment Type	Size Category	Baseline Efficiency ($IPLV_{BASE}$, COP_{BASE})
Air cooled, with condenser, electrically operated	All capacities	3.05 IPLV, 2.80 COP
Air cooled, without condenser, electrically operated	All capacities	3.45 IPLV, 3.10 COP
Water cooled, electrically operated, positive displacement (reciprocating)	All capacities	5.05 IPLV, 4.20 COP
Water cooled, electrically operated, positive displacement (rotary screw and scroll)	< 150 tons	5.20 IPLV, 4.45 COP
	≥ 150 tons and < 300 tons	5.60 IPLV, 4.90 COP
	≥ 300 tons	6.15 IPLV, 5.50 COP
Water cooled, electrically operated, centrifugal	< 150 tons	5.25 IPLV, 5.00 COP
	≥ 150 tons and < 300 tons	5.90 IPLV, 5.55 COP
	≥ 300 tons	6.40 IPLV, 6.10 COP

Source: ASHRAE 90.1-2007 Table 6.8.1B.

CF = Summer peak coincidence factor (= 74%)

DSF = Demand savings factor (= 0.08)

For example, demand reduction for the tune-up of a 300-ton chiller with a COP of 5.0 is calculated as:

$$\Delta\text{kW} = TONS * \frac{3.516}{COP_{BASE}} * CF * DSF = 300 * \frac{3.516}{5} * 0.74 * 0.08 = 12.489 \text{ kW}$$

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.

ENERGY STAR Room Air Conditioner for Commercial Use (Time of Sale)

	Measure Details
Official Measure Code	CI-HVAC-RAC-1
Measure Unit	Per unit
Measure Category	HVAC
Sector(s)	Commercial
Annual Energy Savings (kWh)	Varies by capacity and location
Peak Demand Reduction (kW)	Varies by capacity and location
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	Varies by capacity and location
Lifetime Fossil Fuel Savings (MMBtu)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	12
Incremental Cost	Varies by project
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure relates to the purchase and installation of a room air conditioning unit that meets either the ENERGY STAR[319] or Consortium for Energy Efficiency Super-Efficient Home Appliances Initiative Tier 1[320] minimum qualifying efficiency specifications, in place of a baseline unit meeting minimum federal standard efficiency ratings. Applicable units are with and without louvered sides, and without reverse cycle (i.e., heating) or casement.

Definition of Efficient Equipment

To qualify for this measure, the new room air conditioning unit must meet either the ENERGY STAR or Consortium for Energy Efficiency Super-Efficient Home Appliances Initiative Tier 1 efficiency standards.

Definition of Baseline Equipment

The baseline assumption is a new room air conditioning unit that meets the current minimum federal efficiency standard.

---

[319] U.S. Environmental Protection Agency. ENERGY STAR Program Requirements for Room Air Conditioners, Partner Commitments." Accessed July 17, 2010. http://www.energystar.gov/ia/partners/product_specs/program_reqs/room_air_conditioners_prog_req.pdf

[320] Consortium for Energy Efficiency. "CEE Super-Efficient Home Appliances Initiative – High-Efficiency Specifications for Room Air Conditioners." Accessed July 17, 2010. http://www.cee1.org/resid/seha/rm-ac/rm-ac_specs.pdf

Deemed Lifetime of Efficient Equipment

The measure life is 12 years.[321]

Deemed Measure Cost

The incremental cost for this measure is $40.00 for an ENERGY STAR unit and $80.00 for a Consortium for Energy Efficiency Tier 1 unit.[322]

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\Delta kWh = EFLH * Btuh * \frac{\frac{1}{EER_{BASE}} - \frac{1}{EER_{EE}}}{1{,}000}$$

Where:

Btuh = Cooling capacity of the unit in Btuh (= actual)

EER_{BASE} = Energy efficiency ratio of the baseline equipment (= see table below)[323]

Federal Standards for Baseline Energy Efficiency Ratio

Capacity (Btuh)	With Louvered Sides	Without Louvered Sides	Casement Only	Casement Slider
< 8,000	≥ 11	≥ 10	≥ 8.7	≥ 9.5
8,000 to 13,999	≥ 10.9	≥ 9.6	≥ 8.7	≥ 9.5
14,000 to 19,999	≥ 10.7	≥ 9.3	≥ 8.7	≥ 9.5
≥ 20,000	≥ 9.4	≥ 9.4	≥ 8.7	≥ 9.5

EER_{EE} = Energy efficiency ratio of the energy-efficient equipment (= actual; otherwise, see table below)[324]

---

[321] GDS Associates. *Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures.* June 2007. Available online: http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf

[322] Based on field study conducted by Efficiency Vermont.

[323] Minimum Federal Standard for capacity range. 2015 Federal Energy Conservation Standard for Room ACs (e-CFR Title 10, Chapter II, Subchapter D, Part 430, Subpart C, Section 430.32)

[324] ENERGY STAR standards from: http://www.energystar.gov/index.cfm?c=roomac.pr_crit_room_ac
CEE Tier 1 standards from:
http://library.cee1.org/sites/default/files/library/9296/CEE_ResApp_RoomAirConditionerSpecification_2003_Updated_Again.pdf

ENERGY STAR and CEE SEHA Standards for Efficient Equipment Energy Efficiency Ratio

Capacity (Btuh)	CEE SEHA Tier 1	ENERGY STAR			
	With Louvered Sides	With Louvered Sides	Without Louvered Sides	Casement Only	Casement Slider
< 8,000	≥ 11.2	≥ 11.2	≥ 10.4	≥ 10.0	≥ 10.9
8,000 to 13,999	≥ 11.3	≥ 11.3	≥ 9.8	≥ 10.0	≥ 10.9
14,000 to 19,999	≥ 11.2	≥ 11.2	≥ 9.8	≥ 10.0	≥ 10.9
≥ 20,000	≥ 9.8	≥ 9.8	≥ 9.8	≥ 10.0	≥ 10.9

EFLH = Cooling equivalent full load hours (= see table below)

Equivalent Full Load Hours by City

Building	Indianapolis	South Bend	Evansville	Ft Wayne	Terre Haute
Assembly	810	721	1,047	716	955
Auto Repair	538	484	721	431	675
Big Box Retail	1,123	1,006	1,422	1,056	1,251
Fast Food Restaurant	798	738	1,066	694	905
Full Service Restaurant	729	641	967	633	837
Grocery	1,123	1,006	1,422	1,056	1,251
Light Industrial	690	598	842	642	760
Primary School	514	456	573	454	503
Religious Worship	401	360	516	357	444
Small Office	1,096	1,015	1,299	1,035	1,151
Small Retail	1,032	906	1,294	977	1,142
Warehouse	690	598	842	642	760
Other	795	711	1,001	725	886

Summer Peak Coincident Demand Reduction

$$\Delta kW = Btuh * \frac{\frac{1}{EER_{BASE}} - \frac{1}{EER_{eEE}}}{1{,}000} * CF$$

Where:

CF = Summer peak coincidence factor (= 0.74)[325]

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.

---

[325] Coincidence factor supplied by Duke Energy for the commercial HVAC end-use. Pending verification based on information from the utilities.

Single-Package and Split System Unitary Air Conditioners (Time of Sale, New Construction)

	Measure Details
Official Measure Code	CI-HVAC-AC-1
Measure Unit	Per unit
Measure Category	HVAC
Sector(s)	Commercial
Annual Energy Savings (kWh)	Varies by system type and capacity
Peak Demand Reduction (kW)	Varies by system type and capacity
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	Varies by system type and capacity
Lifetime Fossil Fuel Savings (MMBtu)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15
Incremental Cost	$100.00 per ton
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is the installation of high-efficiency unitary air-, water-, and evaporative cooled air conditioning equipment, both single-package and split systems. Air conditioning systems are a major consumer of electricity and systems that exceed baseline efficiencies can save considerable amounts of energy. This measure applies to the replacement of an existing unit at the end of its useful life or to the installation of a new unit in a new or existing building.

Definition of Efficient Equipment

The efficient equipment is a high-efficiency air-, water-, or evaporative cooled air conditioner that exceeds the energy efficiency requirements of ASHRAE 90.1-2007.

Definition of Baseline Equipment

The baseline equipment is assumed to be a standard-efficiency air-, water-, or evaporative cooled air conditioner that meets the energy efficiency requirements of ASHRAE 90.1-2007. The rating conditions for the baseline and efficient equipment efficiencies must be equivalent.

Deemed Lifetime of Efficient Equipment

The expected measure life is 15 years.[326]

Deemed Measure Cost

The incremental capital cost for this measure is $100.00 per ton.[327]

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

For units with cooling capacities less than 65 kBtuh:

$$\Delta\text{kWh} = Btuh * (\frac{1}{SEER_{BASE}} - \frac{1}{SEER_{EE}}) * \frac{EFLH}{1{,}000}$$

For units with cooling capacities equal to or greater than 65 kBtuh:

$$\Delta\text{kWh} = Btuh * (\frac{1}{EER_{BASE}} - \frac{1}{EER_{EE}}) * \frac{EFLH}{1{,}000}$$

Where:

Btuh = Capacity of the cooling equipment actually installed (1 ton of cooling capacity equals 12 kBtuh)

$SEER_{BASE}$ = Seasonal energy efficiency ratio of the baseline equipment (= see table below)

---

[326] GDS Associates, Inc. *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*. June 2007.

[327] Based on a review of TRM incremental cost assumptions from California, Vermont, and Wisconsin.

Seasonal Energy Efficiency Ratio by Equipment Size

Size Category	Subcategory	Baseline Condition ASHRAE 90.1-2007*
<65,000 Btuh	Split system	13.0 SEER
	Single package	13.0 SEER
≥65,000 Btuh and <135,000 Btuh	Split system	11.0 EER
	Single package	11.2 IEER
≥135,000 Btuh and <240,000 Btuh	Split system	10.8 EER
	Single package	11.0 IEER
≥240,000 Btuh and <760,000 Btuh	Split system	9.8 EER
	Single package	9.9 IEER
≥760,000 Btuh	Split system	9.5 EER
	Single package	9.6 IEER

* As mandated by federal equipment manufacturing standards: http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/74fr12058.pdf

$SEER_{EE}$ = Seasonal energy efficiency ratio of the energy efficient equipment (= actual)

$IEER_{BASE}$ = Integrated energy efficiency ratio of the baseline equipment (= see table above)

$IEER_{EE}$ = Integrated energy efficiency ratio of the energy efficient equipment (= actual)

EFLH = Cooling equivalent full load hours (= see table below)

Equivalent Full Load Hours by Building Type and City

Building	Indianapolis	South Bend	Evansville	Ft Wayne	Terre Haute
Assembly	810	721	1,047	716	955
Auto Repair	538	484	721	431	675
Big Box Retail	1,123	1,006	1,422	1,056	1,251
Fast Food Restaurant	798	738	1,066	694	905
Full Service Restaurant	729	641	967	633	837
Grocery	1,123	1,006	1,422	1,056	1,251
Light Industrial	690	598	842	642	760
Primary School	514	456	573	454	503
Religious Worship	401	360	516	357	444
Small Office	1,096	1,015	1,299	1,035	1,151
Small Retail	1,032	906	1,294	977	1,142
Warehouse	690	598	842	642	760
Other	795	711	1,001	725	886

Summer Peak Coincident Demand Reduction

$$\Delta\mathrm{kW} = \left(\frac{1}{EER_{BASE}} - \frac{1}{EER_{EE}}\right) * \mathrm{Btu} * \frac{CF}{1000}$$

Where:

EER_{BASE} = Energy efficiency ratio of baseline equipment (= see table above)

EER_{EE} = Energy efficiency ratio of energy-efficient equipment (= actual)

For air-cooled air conditioners < 65 kBtuh, if the actual EER is unknown, assume the following conversion from SEER to EER: EER = SEER/1.1.

CF = Summer peak coincidence factor (= 0.74)[328]

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.

---

[328] Duke Energy supplied the coincidence factor for the commercial HVAC end-use (pending verification based on information from the utilities).

Heat Pump Systems (Time of Sale, New Construction)

	Measure Details
Official Measure Code	CI-HVAC-ASHP-1
Measure Unit	Per heat pump
Measure Category	HVAC
Sector(s)	Commercial
Annual Energy Savings (kWh)	Varies by building type and location
Peak Demand Reduction (kW)	Varies by building type and location
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	Varies by building type and location
Lifetime Fossil Fuel Savings (MMBtu)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15
Incremental Cost	$100.00 per ton
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure applies to the installation of high-efficiency air cooled, water source, ground water source, and ground source heat pump systems. This measure could apply to replacing an existing unit at the end of its useful life or installing a new unit in a new or existing building.

Definition of Efficient Equipment

The efficient equipment is a high-efficiency air cooled, water source, ground water source, or ground source heat pump system that exceeds the energy efficiency requirements of ASHRAE 90.1-2007.

Definition of Baseline Equipment

The baseline equipment is a standard efficiency air cooled, water source, ground water source, or ground source heat pump system that meets the energy efficiency requirements of ASHRAE 90.1-2007. The rating conditions for the baseline and efficient equipment efficiencies must be equivalent.

Deemed Lifetime of Efficient Equipment

The expected measure life is 15 years.[329]

---

[329] GDS Associates, Inc. *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*. June 2007.

Deemed Measure Cost

For analysis purposes, the incremental capital cost for this measure is $100.00 per ton for air-cooled units.[330] The incremental cost for all other equipment types should be determined on a site-specific basis.

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

For air cooled units with cooling capacities less than 65 kBtuh:

$$\Delta \text{kWh} = \text{Annual kWh Savings}_{\text{COOL}} + \text{Annual kWh Savings}_{\text{HEAT}}$$

$$\text{Annual kWh Savings}_{\text{COOL}} = kBtuh_{COOL} * \left(\frac{1}{SEER_{BASE}} - \frac{1}{SEER_{EE}}\right) * EFLH_{COOL}$$

$$\text{Annual kWh Savings}_{\text{HEAT}} = kBtuh_{HEAT} * \left(\frac{1}{HSPF_{BASE}} - \frac{1}{HSPF_{EE}}\right) * EFLH_{HEAT}$$

For air cooled units with cooling capacities greater than or equal to 65 kBtuh:

$$\Delta \text{kWh} = \text{Annual kWh Savings}_{\text{COOL}} + \text{Annual kWh Savings}_{\text{HEAT}}$$

$$\text{Annual kWh Savings}_{\text{COOL}} = \left(\frac{1}{IEER_{BASE}} - \frac{1}{IEER_{EE}}\right) * EFLH_{COOL} * kBtuh_{COOL}$$

$$\text{Annual kWh Savings}_{\text{HEAT}} = \left(\frac{1}{COP_{BASE}} - \frac{1}{COP_{EE}}\right) * EFLH_{HEAT} * \frac{kBtuh_{HEAT}}{3.412}$$

Where:

$\text{kBtuh}_{\text{COOL}}$ = Cooling capacity of equipment in kBtu per hour (= actual; 1 ton of cooling capacity equals 12 kBtuh)

$\text{SEER}_{\text{BASE}}$ = Seasonal energy efficiency ratio of baseline equipment (= see table below)

---

[330] Based on a review of TRM incremental cost assumptions from California, Vermont, and Wisconsin.

Baseline Efficiencies by Size

Size Category	Subcategory	Baseline Condition (ASHRAE 90.1-2007)
<65,000 Btuh	Split system	13.0 SEER / 7.7 HSPF
	Single package	13.0 SEER / 7.7 HSPF
≥65,000 Btuh and <135,000 Btuh	Split system and single package	11.0 EER / 11.2 IEER / 3.3 COP
≥135,000 Btuh and <240,000 Btuh	Split system and single package	10.8 EER / 11.0 IEER / 3.2 COP
≥240,000 Btuh	Split system and single package	9.8 EER / 9.9 IEER / 3.2 COP

$SEER_{EE}$ = Seasonal energy efficiency ratio of energy efficient equipment (= actual)

$EFLH_{COOL}$ = Cooling mode equivalent full load hours (= see table below)

Cooling Equivalent Full Load Hours by Building Type

Building	Indianapolis	South Bend	Evansville	Ft Wayne	Terre Haute
Assembly	810	721	1,047	716	955
Auto Repair	538	484	721	431	675
Big Box Retail	1,123	1,006	1,422	1,056	1,251
Fast Food Restaurant	798	738	1,066	694	905
Full Service Restaurant	729	641	967	633	837
Grocery	1,123	1,006	1,422	1,056	1,251
Light Industrial	690	598	842	642	760
Primary School	514	456	573	454	503
Religious Worship	401	360	516	357	444
Small Office	1,096	1,015	1,299	1,035	1,151
Small Retail	1,032	906	1,294	977	1,142
Warehouse	690	598	842	642	760
Other	795	711	1,001	725	886

$HSPF_{BASE}$ = Heating seasonal performance factor of baseline equipment (= see table above, “Baseline Efficiencies by Size”)

$HSPF_{EE}$ = Heating seasonal performance factor of energy efficient equipment (= actual)

$EFLH_{heat}$ = Heating mode equivalent full load hours (= see table below)

Heating Equivalent Full Load Hours by Building Type

Building	Indianapolis	South Bend	Evansville	Ft Wayne	Terre Haute
Assembly	874	954	611	1,009	659
Auto Repair	3,319	3,930	2,582	3,299	2,918
Big Box Retail	519	538	325	607	367
Fast Food Restaurant	1,253	1,383	824	1,463	907
Full Service Restaurant	1,164	1,396	768	1,441	893
Grocery	519	538	325	607	367
Light Industrial	1,113	1,205	718	1,289	775
Primary School	1,192	1,266	785	1,359	845
Religious Worship	923	1,070	677	1,085	779
Small Office	670	710	487	826	526
Small Retail	939	977	591	1,125	661
Warehouse	1,113	1,205	718	1,289	775
Other	1,133	1,264	784	1,283	873

$IEER_{BASE}$ = Integrated energy efficiency ratio of baseline equipment (= see table above, "Baseline Efficiencies by Size")

$IEER_{EE}$ = Integrated energy efficiency ratio of energy efficient equipment (= actual)

$kBtuh_{HEAT}$ = Heating capacity of the equipment in kBtu per hour (= actual)

3.412 = Btus per watt-hour

COP_{BASE} = Coefficient of performance of baseline equipment (= see table above)

COP_{EE} = Coefficient of performance of energy efficient equipment (= actual)

Summer Peak Coincident Demand Reduction

$$\Delta\text{kW} = kBtuh_{COOL} * \left(\frac{1}{EER_{BASE}} - \frac{1}{EER_{EE}}\right) * CF$$

Where:

EER_{BASE} = Energy efficiency ratio of baseline equipment (= see table above)

EER_{ee} = Energy efficiency ratio of energy efficient equipment (= actual)

CF = Summer peak coincidence factor (= 0.74)[331]

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.

---

[331] Duke Energy provided the coincidence factor for the commercial HVAC end-use (pending information from the utilities).

Outside Air Economizer with Dual-Enthalpy Sensors (Time of Sale, Retrofit – New Equipment)

	Measure Details
Official Measure Code	CI-HVAC-Econ-1
Measure Unit	HVAC
Measure Category	Per HVAC system
Sector(s)	Commercial
Annual Energy Savings (kWh)	Varies by building type and location
Peak Demand Reduction (kW)	0
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	Varies by building type and location
Lifetime Fossil Fuel Savings (MMBtu)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	10
Incremental Cost	$400.00
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is to upgrade the outside air dry-bulb economizer to a dual enthalpy controlled economizer. The new control system will continuously monitor the enthalpy of both the outside air and return air, controlling and adjusting the system dampers based on the two readings.

Definition of Efficient Equipment

The efficient equipment is a dual-enthalpy economizer on the HVAC system.

Definition of Baseline Equipment

The existing condition is an outside air dry-bulb economizer.

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 10 years.[332]

---

[332] California Public Utilities Commission. *2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05*. “Effective/Remaining Useful Life Values.” December 16, 2008.

Deemed Measure Cost

The incremental cost for this measure is $400.00.[333]

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\Delta \text{kWh} = TONS * \Delta kWh_{TON}$$

Where:

TONS = Rated capacity of unit controlled by economizer (= actual; collect with application)

$\Delta \text{kWh}_{\text{TON}}$ = Energy savings per ton, based on building and region (see table below)

Dual Enthalpy Economizer Savings (kWh/Ton)*

Building	Indianapolis	South Bend	Evansville	Ft Wayne	Terre Haute
Assembly	22	21	24	23	32
Big Box Retail	137	125	145	139	215
Fast Food Restaurant	34	32	37	33	35
Full Service Restaurant	19	18	18	18	31
Hospital	1,014	1,033	1,125	1,212	1,149
Hotel	766	823	1,444	1,641	1,563
Large Office	996	947	999	980	1,056
Light Industrial	40	39	38	34	40
Primary School	54	47	50	50	84
Small Office	183	176	173	192	186
Small Retail	115	105	109	110	146
Warehouse	40	39	38	34	40
Other	285	290	350	367	380

* Unit energy savings, demand reduction, and natural gas savings data is based on a series of prototypical small commercial building simulation runs. The prototypes are based on the California DEER study prototypes, modified for local construction practices. Simulations were run using TMY3 weather data for each of the cities listed. Building prototypes used in the energy modeling are described in Appendix A - Prototypical Building Energy Simulation Model Development.

---

[333] Efficiency Vermont. *Technical Reference Manual (TRM) Measure Savings Algorithms and Cost Assumptions*. February 19, 2010. Value derived from Efficiency Vermont project experience and conversations with suppliers.

For example, the energy savings from an economizer on a 10-ton air conditioning unit in a big-box retail building in Indianapolis would be:

$$\Delta\text{kWh} = 10 * 137 = 1{,}370 \text{ kWh}$$

Summer Peak Coincident Demand Reduction

There is no expected peak demand reduction associated with this measure.

Fossil Fuel Impact Descriptions and Calculation

There are no expected fossil fuel impacts associated with this measure.

Demand Controlled Ventilation

	Measure Details
Official Measure Code	CI-HVAC-DCV-1
Measure Unit	Per square foot
Measure Category	HVAC
Sector(s)	Commercial
Annual Energy Savings (kWh)	Varies by building type and location
Peak Demand Reduction (kW)	Varies by building type and location
Annual Fossil Fuel Savings (MMBtu)	Varies by building type and location
Lifetime Energy Savings (kWh)	Varies by building type and location
Lifetime Fossil Fuel Savings (MMBtu)	Varies by building type and location
Water Savings (gal/yr)	0
Effective Useful Life (years)	15
Incremental Cost	$115.00 per 1,000 square feet of floor area
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is the installation of a demand controlled ventilation (DCV) systems with an air-side economizer with zone-level CO_2 sensor controls to packaged rooftop equipment. The savings represent the combined effect of the DCV and the air-side economizer.

Definition of Efficient Equipment

The efficient condition is an HVAC system with DCV systems added.

Definition of Baseline Equipment

The baseline condition is an HVAC system without DCV systems.

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 15 years.

Deemed Measure Cost

The incremental cost for this measure is $115.00 per 1,000 square feet of floor area.

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\Delta\text{kWh} = \frac{SF}{1{,}000} * \Delta kWh_{kSF}$$

Where:

SF = Conditioned square footage served by system with DCV controls installed

$\Delta\text{kWh}_{\text{kSF}}$ = Energy savings per 1,000 square feet of conditioned floor area (= dependent on building type and region, see table in Reference Table section)

For example, the energy savings from a DCV system being installed on an HVAC system serving a 2,000 square foot small retail store in Indianapolis would be:

$$\Delta\text{kWh} = \frac{SF}{1{,}000} * \Delta kWh_{kSF} = \frac{2{,}000}{1{,}000} * 668 = 1{,}336 \text{ kWh}$$

Summer Peak Coincident Demand Reduction

$$\Delta\text{kW} = \frac{SF}{1{,}000} * \Delta kW_{kSF} * CF$$

Where:

$\Delta\text{kW}_{\text{kSF}}$ = Demand reduction per 1,000 square feet of conditioned floor area (= dependent on building type and region, see table in Reference Table section)

CF = Summer peak coincident peak (= 0.74)

For example, the demand reduction from a DCV system being installed on an HVAC system serving a 2,000 square foot small retail store in Indianapolis would be:

$$\Delta\text{kW} = \frac{2{,}000}{1{,}000} * 0.109 * 0.74 = 0.161 \text{ kW}$$

Fossil Fuel Impact Descriptions and Calculation

$$\Delta\text{MMBtu} = \frac{SF}{1{,}000} * \Delta MMBtu_{kSF}$$

Where:

$\Delta\text{MMBtu}_{\text{kSF}}$ = Unit natural gas savings per 1,000 square feet of conditioned floor space (= dependent on building type and region, see table in Reference Table section)

For example, the natural gas savings from a DCV system being installed on an HVAC system serving a 2,000 square foot small retail store in Indianapolis would be:

$$\Delta\text{MMBtu} = \frac{SF}{1{,}000} * \Delta MMBtu_{kSF} = \frac{2{,}000}{1{,}000} * 29.7 = 59.4 \text{ MMBtu}$$

Reference Table

Building	City	kWh	kW	MMBtu
Assembly	Evansville	747	0.394	78.2
	Ft. Wayne	536	0.129	98.0
	Indianapolis	599	0.138	97.4
	South Bend	629	0.224	100.1
	Terre Haute	614	0.181	98.8
Big Box Retail	Evansville	742	0.314	9.8
	Ft. Wayne	547	0.212	15.6
	Indianapolis	578	0.383	16.1
	South Bend	676	0.505	16.1
	Terre Haute	627	0.444	16.1
Fast Food Restaurant	Evansville	1,817	0.588	84.0
	Ft. Wayne	1,193	0.588	122.7
	Indianapolis	1,408	0.588	125.2
	South Bend	1,428	0.850	129.0
	Terre Haute	1,418	0.325	127.1
Full Service Restaurant	Evansville	1,046	0.325	62.7
	Ft. Wayne	739	0.325	91.9
	Indianapolis	836	0.175	93.3
	South Bend	874	0.475	97.0
	Terre Haute	855	0.325	95.2
Light Industrial	Evansville	129	0.040	7.6
	Ft. Wayne	105	0.032	11.5
	Indianapolis	124	0.033	11.8
	South Bend	101	0.069	12.0
	Terre Haute	113	0.051	11.9
Primary School	Evansville	668	1.122	39.5
	Ft. Wayne	412	0.616	56.1
	Indianapolis	496	1.322	55.9
	South Bend	519	1.986	58.9
	Terre Haute	508	1.654	57.4
Small Office	Evansville	732	0.00	5.9
	Ft. Wayne	644	0.00	8.9
	Indianapolis	658	0.00	9.2
	South Bend	670	0.00	9.6

Building	City	kWh	kW	MMBtu
	Terre Haute	664	0.00	9.4
Small Retail	Evansville	827	0.156	18.3
	Ft. Wayne	633	0.078	28.8
	Indianapolis	668	0.109	29.7
	South Bend	737	0.422	31.6
	Terre Haute	703	0.266	30.7
Warehouse	Evansville	11	0.003	0.6
	Ft. Wayne	14	0.004	1.5
	Indianapolis	20	0.005	1.9
	South Bend	24	0.016	2.9
	Terre Haute	22	0.010	2.3

Chilled Water Reset Controls (Retrofit – New Equipment)

	Measure Details
Official Measure Code	CI-HVAC-CHWReset-1
Measure Unit	Per reset
Measure Category	HVAC
Sector(s)	Commercial
Annual Energy Savings (kWh)	Varies by system and location
Peak Demand Reduction (kW)	Varies by system and location
Annual Fossil Fuel Savings (MMBtu)	Varies by system and location
Lifetime Energy Savings (kWh)	Varies by system and location
Lifetime Fossil Fuel Savings (MMBtu)	Varies by system and location
Water Savings (gal/yr)	0
Effective Useful Life (years)	10
Incremental Cost	$681.34 per control
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is the installation of chilled water reset controls in large commercial buildings with built-up HVAC systems. Reset controls allow the chillers to operate at a higher chilled water temperature during periods of low cooling loads. The baseline condition is a constant chilled water temperature of 45°F. The reset strategies use a 5°F reset.[334] Energy savings are realized through improved chiller efficiency. Data for both air-cooled and water-cooled chillers are shown. The approach uses DOE-2.2 simulations on a series of commercial prototypical building models, adapted from the California DEER study, with changes to reflect Indiana climate and building practices. Energy and demand impacts are normalized per ton of chiller capacity controlled.

Definition of Efficient Equipment

The efficient condition is a chilled water reset with the maximum chilled water temperature of 50°F.

Definition of Baseline Equipment

The baseline condition is a fixed chilled water temperature of 45°F.

---

[334] ASHRAE 90.1 2007 requires chilled and hot water temperature resets for systems with a capacity greater than 300,000 Btu/hr. To avoid incenting code, this applies to smaller systems and retrofits only.

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 10 years.[335]

Deemed Measure Cost

The full installed cost for this measure is $681.34 per control.[336]

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\Delta \text{kWh} = TONS * \Delta kWh_{TON}$$

Where:

TONS = Rated capacity of unit controlled by reset controller (= actual, to collect with application)

$\Delta \text{kWh}_{\text{TON}}$ = Energy savings per ton (= dependent on whether chiller is air cooled or water cooled, see tables in Reference Tables section).

For example, the energy savings from a chilled water reset on a 10-ton variable air volume, water-cooled chiller in an Indianapolis large office would be:

$$\Delta \text{kWh} = 10 \ * 102 = 1{,}020 \text{ kWh}$$

Summer Peak Coincident Demand Reduction

$$\Delta \text{kW} = TONS * \Delta kW_{TON} * CF$$

Where:

$\Delta \text{kW}_{\text{TON}}$ = Demand reduction per ton (=dependent on whether chiller is air cooled or water cooled, see tables in Reference Tables section)

CF = Summer peak coincident factor (= 0.74)[337]

---

[335] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, “Effective/Remaining Useful Life Values”, California Public Utilities Commission, December 16, 2008

[336] Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010. Value derived from Efficiency Vermont project experience and conversations with suppliers.

[337] Duke Energy provided the coincidence factor for the commercial HVAC end-use (pending information from the utilities).

For example, the demand reduction from a chilled water reset on a 10-ton variable air volume, water-cooled chiller in an Indianapolis large office:

$$\Delta\text{kW} = 10 * 0.023 * 0.74 = 0.17 \text{ kW}$$

Fossil Fuel Impact Descriptions and Calculation

$$\Delta\text{MMBtu} = TONS * \Delta MMBtu_{TON}$$

Where:

$\Delta MMBtu_{TON}$ = Natural gas savings per ton (= see tables in Reference Tables section)

For example, the natural gas savings from a chilled water reset on a 10-ton variable air volume, water-cooled chiller in an Indianapolis large office:

$$\Delta\text{MMBtu} = 10 * 0.12 = 1.2 \text{ MMBtu}$$

Reference Tables

Chilled Water Reset Controls - Hospitals

System	City	kWh*	kW*	MMBtu*
Constant Volume Reheat Economizers	Evansville	332	0.052	0.25
	Indianapolis	308	0.036	0.30
	South Bend	287	0.001	0.29
	Ft. Wayne	309	0.037	0.49
	Terre Haute	316	0.034	0.43
Constant Volume Reheat No Economizers	Evansville	237	0.035	0.17
	Ft. Wayne	245	0.024	0.25
	Indianapolis	223	0.024	0.19
	South Bend	211	0.001	0.18
	Terre Haute	240	0.023	0.22
Variable Air Volume Reheat Economizers	Evansville	120	0.001	0.13
	Indianapolis	123	0.011	0.25
	South Bend	122	0.007	0.29
	Ft. Wayne	152	0.019	0.26
	Terre Haute	154	0.083	0.16

* Unit energy savings, demand reduction, and natural gas savings data is based on a series of prototypical commercial building simulation runs. The prototypes are based on the California DEER study prototypes, modified for local construction practices. Simulations were run using TMY3 weather data for each of the cities listed. Building prototypes used in the energy modeling are described in Appendix A - Prototypical Building Energy Simulation Model Development.

Chilled Water Reset Controls - Hotels

System	City	kWh*	kW*	MMBtu*
Constant Volume Reheat Economizers	Indianapolis	121	0.016	0.01
	South Bend	114	0.016	0.01
	Evansville	147	0.016	-0.02
	Ft. Wayne	155	0.014	-0.01
	Terre Haute	139	0.020	-0.01
Constant Volume Reheat No Economizers	Evansville	155	0.016	-0.01
	Ft. Wayne	160	0.014	0.01
	Indianapolis	56	0.015	0.00
	South Bend	51	0.017	0.00
	Terre Haute	153	0.020	0.00
Variable Air Volume Reheat Economizers	Indianapolis	125	0.016	0.00
	South Bend	121	0.016	0.00
	Evansville	173	0.018	0.02
	Ft. Wayne	177	0.014	0.05
	Terre Haute	168	0.020	0.02

* Unit energy savings, demand reduction, and natural gas savings data is based on a series of prototypical commercial building simulation runs. The prototypes are based on the California DEER study prototypes, modified for local construction practices. Simulations were run using TMY3 weather data for each of the cities listed. Building prototypes used in the energy modeling are described in Appendix A - Prototypical Building Energy Simulation Model Development.

Chilled Water Reset Controls - Large Office

System	City	kWh*	kW*	MMBtu*
Constant Volume Reheat Economizers with Water Cooled Chiller	Evansville	125	0.011	0.24
	Ft. Wayne	130	0.016	0.26
	Indianapolis	122	0.011	0.19
	South Bend	125	0.010	0.25
	Terre Haute	112	0.007	0.19
Constant Volume Reheat No Economizers with Water Cooled Chiller	Evansville	168	0.024	0.16
	Ft. Wayne	162	0.017	0.15
	Indianapolis	164	0.019	0.13
	South Bend	154	0.014	0.16
	Terre Haute	171	0.009	0.10
Variable Air Volume Reheat Economizers with Water Cooled Chiller	Evansville	104	0.026	0.11
	Ft. Wayne	112	0.013	0.14
	Indianapolis	102	0.023	0.12
	South Bend	104	0.008	0.10
	Terre Haute	103	0.023	0.10

* Unit energy savings, demand reduction, and natural gas savings data is based on a series of prototypical commercial building simulation runs. The prototypes are based on the California DEER study prototypes, modified for local construction practices. Simulations were run using TMY3 weather data for each of the cities listed. Building prototypes used in the energy modeling are described in Appendix A - Prototypical Building Energy Simulation Model Development.

Variable Frequency Drives for HVAC Applications (Time of Sale, Retrofit – New Equipment)

	Measure Details
Official Measure Code	CI-HVAC-VFD-1
Measure Unit	Per VFD
Measure Category	HVAC
Sector(s)	Commercial
Annual Energy Savings (kWh)	Varies by system
Peak Demand Reduction (kW)	Varies by system
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	Varies by system
Lifetime Fossil Fuel Savings (MMBtu)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15
Incremental Cost	Varies by project
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is installing a variable frequency drive (VFD) on an HVAC system pump or fan motor. The VFD will modulate the speed of the motor when it is not needed to run at full load. Since the power of the motor is proportional to the cube of the speed, this will result in significant energy savings.

Definition of Efficient Equipment

The efficient condition is a VFD on an HVAC system pump or fan motor.

Definition of Baseline Equipment

For VFDs on fans, the baseline is a variable volume fan with variable inlet vanes. For VFDs on pumps, the baseline is a constant volume motor.

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 15 years.[338]

Deemed Measure Cost

The full installed cost for this measure is dependent on horsepower (see table below).

---

[338] California Public Utilities Commission. *2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05.* "Effective/Remaining Useful Life Values." December 16, 2008.

Deemed Measure Cost by Horsepower

HP	Total Installed Cost*
5	$1,330
7.5	$1,622
10	$1,898
15	$2,518
20	$3,059

* Equipment costs from Granger 2008 Catalog pp. 286-289, average across available voltages and models. Labor costs from RSMeans Mechanical Cost Data, 2008. Used average cost adjustment for all cities listed in Indiana.

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\Delta \text{kWh} = hp * SF_{kWh}$$

Where:

hp = Nameplate horsepower of motor controlled by VFD

SF_{kWh} = Energy savings factor for installing a VFD (= dependent on horsepower, see table)

Summer Peak Coincident Demand Reduction

$$\Delta \text{kW} = hp * SF_{kW}$$

Where:

SF_{kW} = Demand reduction factor for installing a VFD (= dependent on horsepower, see table)

Fossil Fuel Impact Descriptions and Calculation

There are no expected fossil fuel impacts associated with this measure.

Reference Tables

Energy and Demand Savings Factors for Hospitals

Measure	City	System	SF_{kWh} (kWh/unit)	SF_{kW} (kW/unit)
VFD Return Fan	Indianapolis	VAV reheat econ	1,836	0.250
	South Bend		1,758	0.221
	Evansville		1,907	0.257
	Fort Wayne		1,774	0.238
	Terre Haute		1,857	0.244
VFD Supply Fan	Indianapolis		2,069	0.306
	South Bend		1,994	0.269
	Evansville		2,205	0.309
	Fort Wayne		1,982	0.572
	Terre Haute		2,184	0.297
VFD Tower Fan	Indianapolis	CV reheat no econ	933	0.00
		CV reheat econ	784	0.00
		VAV reheat econ	477	0.00
	South Bend	CV reheat no econ	861	0.00
		CV reheat econ	711	0.00
		VAV reheat econ	452	0.00
	Evansville	CV reheat no econ	1,091	0.00
		CV reheat econ	937	0.00
		VAV reheat econ	538	0.00
	Fort Wayne	CV reheat no econ	846	0.00
		CV reheat econ	713	0.00
		VAV reheat econ	421	0.00
	Terre Haute	CV reheat no econ	1,003	0.00
		CV reheat econ	848	0.00
		VAV reheat econ	545	0.00
VFD CHW Pump	Indianapolis	CV reheat no econ	6,655	0.735
		CV reheat econ	6,814	0.735
		VAV reheat econ	6,685	0.709
	South Bend	CV reheat no econ	6,722	0.511
		CV reheat econ	6,814	0.511
		VAV reheat econ	6,718	0.689
	Evansville	CV reheat no econ	6,639	0.763
		CV reheat econ	6,833	0.763
		VAV reheat econ	6,669	0.723
	Fort Wayne	CV reheat no econ	6,671	0.719
		CV reheat econ	6,789	0.719
		VAV reheat econ	6,689	1.314
	Terre Haute	CV reheat no econ	6,586	0.696
		CV reheat econ	6,747	0.697

Measure	City	System	SF$_{kWh}$ (kWh/unit)	SF$_{kW}$ (kW/unit)
		VAV reheat econ	6,645	0.697
VFD HW Pump	Indianapolis	CV reheat no econ	6,146	0.766
		CV reheat econ	5,665	0.766
		VAV reheat econ	5,142	0.829
	South Bend	CV reheat no econ	6,242	0.622
		CV reheat econ	5,738	0.622
		VAV reheat econ	5,375	0.826
	Evansville	CV reheat no econ	6,057	0.761
		CV reheat econ	5,622	0.761
		VAV reheat econ	5,409	0.852
	Fort Wayne	CV reheat no econ	6,226	0.764
		CV reheat econ	5,720	0.764
		VAV reheat econ	5,369	0.820
	Terre Haute	CV reheat no econ	6,091	0.779
		CV reheat econ	5,647	0.779
		VAV reheat econ	5,211	0.851
VFD CW Pump	Indianapolis	CV reheat no econ	1,989	0.097
		CV reheat econ	1,995	0.097
		VAV reheat econ	2,083	0.097
	South Bend	CV reheat no econ	1,979	0.095
		CV reheat econ	1,985	0.095
		VAV reheat econ	2,069	0.097
	Evansville	CV reheat no econ	2,005	0.097
		CV reheat econ	2,011	0.097
		VAV reheat econ	2,085	0.234
	Fort Wayne	CV reheat no econ	2,007	0.095
		CV reheat econ	2,010	0.095
		VAV reheat econ	2,082	0.234
	Terre Haute	CV reheat no econ	1,953	0.096
		CV reheat econ	1,956	0.096
		VAV reheat econ	2,078	0.096

Energy and Demand Savings Factors for Hotels

Measure	City	System	SF$_{kWh}$ (kWh/unit)	SF$_{kW}$ (kW/unit)
VFD Return Fan	Indianapolis	VAV reheat econ	276	0.133
	South Bend		276	0.117
	Evansville		150	0.00
	Fort Wayne		243	0.126
	Terre Haute		200	0.065
VFD Supply Fan	Indianapolis		163	0.126
	South Bend		164	0.121

Measure	City	System	SF_{kWh} (kWh/unit)	SF_{kW} (kW/unit)
	Evansville		59	0.004
	Fort Wayne		127	0.124
	Terre Haute		95	0.052
VFD Tower Fan	Indianapolis	CV reheat no econ	1,416	0.00
		CV reheat econ	1,124	0.00
		VAV reheat econ	832	0.00
	South Bend	CV reheat no econ	1,536	0.00
		CV reheat econ	1,193	0.00
		VAV reheat econ	850	0.00
	Evansville	CV reheat no econ	1,428	0.00
		CV reheat econ	1,176	0.00
		VAV reheat econ	924	0.00
	Fort Wayne	CV reheat no econ	1,378	0.00
		CV reheat econ	1,103	0.00
		VAV reheat econ	828	0.00
	Terre Haute	CV reheat no econ	1,349	0.00
		CV reheat econ	1,076	0.00
		VAV reheat econ	804	0.00
VFD CHW Pump	Indianapolis	CV reheat no econ	6,657	0.639
		CV reheat econ	6,938	0.639
		VAV reheat econ	6,977	0.609
	South Bend	CV reheat no econ	6,709	0.646
		CV reheat econ	7,021	0.646
		VAV reheat econ	7,109	0.612
	Evansville	CV reheat no econ	6,596	0.597
		CV reheat econ	6,857	0.597
		VAV reheat econ	6,874	0.597
	Fort Wayne	CV reheat no econ	6,760	0.606
		CV reheat econ	7,014	0.606
		VAV reheat econ	7,085	0.606
	Terre Haute	CV reheat no econ	6,643	0.594
		CV reheat econ	6,898	0.594
		VAV reheat econ	6,945	0.621
VFD HW Pump	Indianapolis	CV reheat no econ	7,903	0.704
		CV reheat econ	6,557	0.704
		VAV reheat econ	6,574	0.704
	South Bend	CV reheat no econ	7,978	0.704
		CV reheat econ	6,521	0.704
		VAV reheat econ	6,540	0.704
	Evansville	CV reheat no econ	8,086	0.704
		CV reheat econ	6,681	0.704
		VAV reheat econ	6,720	0.704

Measure	City	System	SF_{kWh} (kWh/unit)	SF_{kW} (kW/unit)
	Fort Wayne	CV reheat no econ	8,117	0.704
		CV reheat econ	6,592	0.704
		VAV reheat econ	6,621	0.704
	Terre Haute	CV reheat no econ	8,037	0.704
		CV reheat econ	6,607	0.704
		VAV reheat econ	6,610	0.704
VFD CW Pump	Indianapolis	CV reheat no econ	77	0.00
		CV reheat econ	72	0.00
		VAV reheat econ	67	0.00
	South Bend	CV reheat no econ	82	0.00
		CV reheat econ	75	0.00
		VAV reheat econ	67	0.00
	Evansville	CV reheat no econ	79	0.00
		CV reheat econ	73	0.00
		VAV reheat econ	67	0.00
	Fort Wayne	CV reheat no econ	79	0.00
		CV reheat econ	72	0.00
		VAV reheat econ	64	0.00
	Terre Haute	CV reheat no econ	78	0.00
		CV reheat econ	72	0.00
		VAV reheat econ	67	0.00

Energy and Demand Savings Factors for Large Offices

Measure	City	System	SF_{kWh} (kWh/unit)	SF_{kW} (kW/unit)
VFD Return Fan	Indianapolis	VAV reheat econ	1,406	0.287
	South Bend		1,339	0.189
	Evansville		1,387	0.239
	Fort Wayne		1,384	0.225
	Terre Haute		1,415	0.287
VFD Supply Fan	Indianapolis		1,771	0.356
	South Bend		1,689	0.234
	Evansville		1,782	0.297
	Fort Wayne		1,771	0.350
	Terre Haute		1,790	0.356
VFD Tower Fan	Indianapolis	CV reheat no econ	49	0.00
		CV reheat econ	71	0.00
		VAV reheat econ	10	0.00
	South Bend	CV reheat no econ	39	0.00
		CV reheat econ	59	0.00
		VAV reheat econ	28	0.00
	Evansville	CV reheat no econ	63	0.00

Measure	City	System	SF_{kWh} (kWh/unit)	SF_{kW} (kW/unit)
		CV reheat econ	77	0.00
		VAV reheat econ	45	0.00
	Fort Wayne	CV reheat no econ	23	0.00
		CV reheat econ	38	0.00
		VAV reheat econ	11	0.00
	Terre Haute	CV reheat no econ	84	0.00
		CV reheat econ	107	0.00
		VAV reheat econ	35	0.00
VFD CHW Pump	Indianapolis	CV reheat no econ	3,865	0.474
		CV reheat econ	4,099	0.476
		VAV reheat econ	4,016	0.432
	South Bend	CV reheat no econ	3,947	0.417
		CV reheat econ	4,249	0.417
		VAV reheat econ	4,101	0.159
	Evansville	CV reheat no econ	3,913	0.595
		CV reheat econ	4,064	0.587
		VAV reheat econ	3,701	0.390
	Fort Wayne	CV reheat no econ	4,114	0.441
		CV reheat econ	4,354	0.441
		VAV reheat econ	4,242	0.140
	Terre Haute	CV reheat no econ	3,603	0.423
		CV reheat econ	3,778	0.423
		VAV reheat econ	3,783	0.483
VFD HW Pump	Indianapolis	CV reheat no econ	3,933	1.001
		CV reheat econ	3,470	1.001
		VAV reheat econ	4,010	0.903
	South Bend	CV reheat no econ	3,557	0.887
		CV reheat econ	3,122	0.882
		VAV reheat econ	4,139	0.877
	Evansville	CV reheat no econ	3,637	0.833
		CV reheat econ	3,349	0.852
		VAV reheat econ	4,431	0.979
	Fort Wayne	CV reheat no econ	3,699	0.962
		CV reheat econ	3,183	0.971
		VAV reheat econ	4,038	2.035
	Terre Haute	CV reheat no econ	4,391	1.039
		CV reheat econ	3,840	1.035
		VAV reheat econ	4,206	0.961
VFD CW Pump	Indianapolis	CV reheat no econ	951	0.100
		CV reheat econ	1,123	0.100
		VAV reheat econ	1,328	0.100
	South Bend	CV reheat no econ	1,047	0.102

Measure	City	System	SF_{kWh} (kWh/unit)	SF_{kW} (kW/unit)
		CV reheat econ	1,165	0.100
		VAV reheat econ	1,298	0.100
	Evansville	CV reheat no econ	908	0.102
		CV reheat econ	1,028	0.100
		VAV reheat econ	1,206	0.102
	Fort Wayne	CV reheat no econ	1,079	0.101
		CV reheat econ	1,200	0.101
		VAV reheat econ	1,367	0.100
	Terre Haute	CV reheat no econ	826	0.101
		CV reheat econ	1,038	0.100
		VAV reheat econ	1,258	0.101

Energy Efficient Furnace (Time of Sale, Retrofit – Early Replacement)

	Measure Details
Official Measure Code	CI-HVAC-Furnace-1
Measure Unit	Per furnace
Measure Category	HVAC
Sector(s)	Commercial
Annual Energy Savings (kWh)	Varies by location
Peak Demand Reduction (kW)	Varies by location
Annual Fossil Fuel Savings (MMBtu)	Varies by location
Lifetime Energy Savings (kWh)	Varies by location
Lifetime Fossil Fuel Savings (MMBtu)	Varies by location
Water Savings (gal/yr)	0
Effective Useful Life (years)	20
Incremental Cost	$900.00
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is the installation of a high-efficiency natural gas furnace in lieu of a standard efficiency natural gas furnace. High-efficiency natural gas furnaces achieve savings through the use of a sealed, super insulated combustion chamber, more efficient burners, and multiple heat exchangers that remove a significant portion of the waste heat from the flue gasses. Because multiple heat exchangers are used to remove waste heat from the escaping flue gasses, most of the flue gasses condense and must be drained. Furnaces equipped with ECM fan motors can save additional electric energy.

Definition of Efficient Equipment

The efficient equipment is a natural gas-fired furnace with a minimum AFUE of 93%.

Definition of Baseline Equipment

The baseline equipment is a natural gas-fired furnace with an AFUE of 80%.

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 20 years.[339]

---

[339] Based on engineering modeling by Michael Blasnik (M. Blasnik & Associates) and KEMA in support of "Application of Columbia Gas of Ohio, Inc. to Establish Demand Side Management Programs for Residential and Commercial Consumers," Filed with the Ohio Public Utilities Commission, Case No. 08-0833-GA-UNC, July 1, 2008.

Deemed Measure Cost

Incremental costs for this measure are estimated at $900.00.[340]

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.[341]

Savings Algorithm

Energy Savings

If the furnace is equipped with ECM fan motors, the following algorithm can be used to calculate energy savings; otherwise, electric energy savings are zero:

$$\Delta kWh = CAP * EFLH_H * \left(10 * \frac{\eta_{EE}}{\eta_{BASE}} - 5\right)$$

Where:

CAP = Heating input capacity of installed equipment in MMBtu/hr

$EFLH_H$ = Equivalent full load heating hours (= dependent on building type and location, see table below)

Equivalent Full Load Heating Hours by Building Type and Location

Building	Indianapolis	South Bend	Evansville	Ft Wayne	Terre Haute
Assembly	874	954	611	1,009	659
Auto Repair	3,319	3,930	2,582	3,299	2,918
Big Box Retail	519	538	325	607	367
Fast Food Restaurant	1,253	1,383	824	1,463	907
Full Service Restaurant	1,164	1,396	768	1,441	893
Grocery	519	538	325	607	367
Light Industrial	1,113	1,205	718	1,289	775
Primary School	1,192	1,266	785	1,359	845
Religious Worship	923	1,070	677	1,085	779
Small Office	670	710	487	826	526
Small Retail	939	977	591	1,125	661
Warehouse	1,113	1,205	718	1,289	775
Other	1,133	1,264	784	1,283	873

---

[340] Ibid.

[341] Ibid.

10 = Non-ECM kWh per MMBtu of heating fuel consumption[342]

5 = ECM kWh per MMBtu of heating fuel consumption[343]

η_{EE} = Installed equipment efficiency (= actual)

η_{BASE} = Baseline equipment efficiency (= actual, otherwise, 80%)[344]

Summer Peak Coincident Demand Reduction

There is no expected peak demand reduction associated with this measure.

Fossil Fuel Impact Descriptions and Calculation

$$\Delta\text{MMBtu} = CAP * EFLH_H * \left(\frac{\eta_{BASE}}{\eta_{EE}} - 1\right) - MMBtu_{ECM}$$

Where:

$\text{MMBtu}_{\text{ECM}}$ = Increased heating fuel consumption due to decreased fan motor waste heat (for furnaces with ECM fan ONLY)

$$\Delta MMBtu_{ECM} = 0.019 * CAP * EFLH_H * \frac{\eta_{BASE}}{\eta_{EE}}$$

---

[342] Adapted from “Electricity Use by New Furnaces: A Wisconsin Field Study,” Energy Center of Wisconsin, October 2003. Assumes ECM fan motor savings scale linearly with annual fuel consumption.

[343] Adapted from “Electricity Use by New Furnaces: A Wisconsin Field Study,” Energy Center of Wisconsin, October 2003. Assumes ECM fan motor savings scale linearly with annual fuel consumption.

[344] *ASHRAE 90.1-2007 Warm Air Furnaces and Combination Warm Air Furnaces/Air-Conditioning Units, Warm Air Duct Furnaces and Unit Heaters, Minimum Efficiency Requirements*. Dependent on equipment type and capacity. Minimum efficiency levels range from 78% to 81% and are either expressed as AFUE, combustion efficiency, or thermal efficiency. For analysis purposes, assume 80%.

Stack Damper (Retrofit – New Equipment)

	Measure Details
Official Measure Code	CI-HVAC-StackDamp-1
Measure Unit	Per damper
Measure Category	HVAC
Sector(s)	Commercial
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Fossil Fuel Savings (MMBtu)	100
Lifetime Energy Savings (kWh)	0
Lifetime Fossil Fuel Savings (MMBtu)	1,200
Water Savings (gal/yr)	0
Effective Useful Life (years)	12
Incremental Cost	$150.00
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is the installation of a servo-controlled, exhaust vent stack damper on a boiler. The vent damper should be installed in the flue pipe, between the heating equipment and the chimney. A stack damper works like a flue damper on a fireplace by reducing draft, improving comfort, and minimizing heat loss. The vent damper can either be controlled by a heat sensor installed directly in the vent stack or by a mechanical switch connected to the thermostat, which is wired to work in unison with the ignition control switch on the boiler.

In combustion appliances that are directly vented to the atmosphere, there is a decrease in operating efficiency during standby, start-up, and shut-down. During these times, warm room air is drawn through the stack via the draft hood or dilution air inlet at a rate proportional to the stack height, diameter, and outdoor temperature. The most air is drawn through the vent immediately after the appliance shuts off and the flue is still hot. A vent damper can prevent residual heat from being drawn up the warm vent stack by closing itself. Vent dampers can also reduce the amount of air that passes through the furnace or boiler heat exchanger by regulating the start-up exhaust pressure, which can increase operating efficiency by reducing the time needed to achieve steady-state operating conditions. Lastly, by reducing air infiltration in the building, vent dampers can help to retain humidity, which can improve comfort during periods of high heating degree days.

Definition of Efficient Equipment

The efficient equipment is a vent stack with a damper installed.

Definition of Baseline Equipment

The baseline condition is a vent stack with no stack damper installed.

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 12 years.[345]

Deemed Measure Cost

Incremental costs for this measure are estimated at $150.00.[346]

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

There are not expected electrical energy savings associated with this measure.

Summer Peak Coincident Demand Reduction

There is no expected peak demand reduction associated with this measure.

Fossil Fuel Impact Descriptions and Calculation

$$\Delta \text{MMBtu} = 100\ \text{MMBtu}^{347}$$

---

[345] CenterPoint Energy. *Triennial CIP/DSM Plan 2010-2012 Report*.

[346] Manufacturer research suggests a range of $80.00 to $200.00 in materials cost, depending on size, safety controls, and motor quality, as well as one to two hour average installation time.

[347] CenterPoint Energy – Triennial CIP/DSM Plan 2010-2012 Report. Based on information published by Natural Resources Canada and the Minneapolis Energy Office, savings estimates for stack dampers range from to 0 to 9.5% of total boiler gas consumption. This implies that the boiler capacity assumed to determine the deemed savings value is quite large and may overstate savings for smaller boilers. If significant participation for this measure is realized, it is suggested that the deemed savings estimate be abandoned in favor of a deemed calculated approach.

Natural Gas-Fired Infrared Heater (Time of Sale)

	Measure Details
Official Measure Code	CI-HVAC-IRHeater-1
Measure Unit	Per heater
Measure Category	HVAC
Sector(s)	Commercial
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Fossil Fuel Savings (MMBtu)	11.4
Lifetime Energy Savings (kWh)	0
Lifetime Fossil Fuel Savings (MMBtu)	171
Water Savings (gal/yr)	0
Effective Useful Life (years)	15
Incremental Cost	$920.00
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is the installation of a natural gas-fired infrared heater.

Definition of Efficient Equipment

An infrared heater heats primarily through radiation and conduction, as opposed to traditional forced-air space heaters that heat through convection. Infrared heaters are able to heat more efficiently because they directly heat the objects in the space, including the floor slab, which then radiate heat into the air space. With a forced hot air system, the heated air rises to the ceiling and stratifies, gradually working its way down to the floor level. The floor slab and equipment act as heat sinks, causing the ceiling level to be much warmer than the floor area, which will cause the forced air system to work much harder to heat the same space. What is more, forced-air systems can experience drastic losses of heated air-to-ventilation air changes. There is also a negligible amount of electricity use (burner ignition and natural gas valve) compared to a forced-air system that requires large fans to move air around the conditioned space.

Definition of Baseline Equipment

The baseline equipment is a standard natural gas-fired convection space heater.

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 15 years.[348]

Deemed Measure Cost

Incremental costs for this measure are estimated at $920.00.[349]

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

There are not expected electrical energy savings associated with this measure.

Summer Peak Coincident Demand Reduction

There is no expected peak demand reduction associated with this measure.

Fossil Fuel Impact Descriptions and Calculation

$$\Delta MMBtu = 11.4\ MMBtu^{350}$$

---

[348] Based on engineering modeling by GSE in support of "Application of Columbia Gas of Ohio, Inc., to Establish Demand Side Management Programs for Residential and Commercial Consumers," Filed with the Ohio Public Utilities Commission, Case No. 08-0833-GA-UNC, July 1, 2008. A review of savings assumptions used in Massachusetts indicates that this estimate is very conservative. The proposed value is only 85% of what is assumed for Massachusetts and should be considered for future study if this measure receives significant participation.

[349] Ibid.

[350] Ibid.

Energy Efficient Boiler (Time of Sale)

	Measure Details
Official Measure Code	CI-HVAC-Boiler-1
Measure Unit	Per boiler
Measure Category	HVAC
Sector(s)	Commercial
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Fossil Fuel Savings (MMBtu)	Varies by system and location
Lifetime Energy Savings (kWh)	0
Lifetime Fossil Fuel Savings (MMBtu)	Varies by system and location
Water Savings (gal/yr)	0
Effective Useful Life (years)	20
Incremental Cost	$5,000.00
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is the replacement of an irreparable existing boiler with a high-efficiency, natural gas-fired steam or hot water boiler. High-efficiency boilers achieve natural gas savings through a sealed combustion chamber and multiple heat exchangers that remove a significant portion of the waste heat from flue gasses. Because multiple heat exchangers are used to remove waste heat from the escaping flue gasses, some of the flue gasses condense and must be drained.

Definition of Efficient Equipment

The efficient equipment is a natural gas-fired hot water or steam boiler exceeding the efficiency requirements as mandated by ASHRAE 90.1-2007.

Definition of Baseline Equipment

The baseline equipment is a natural gas-fired boiler meeting the efficiency requirements as mandated by ASHRAE 90.1-2007.

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 20 years.[351]

---

[351] Based on engineering modeling by Michael Blasnik (M. Blasnik & Associates) in support of "Application of Columbia Gas of Ohio, Inc., to Establish Demand Side Management Programs for Residential and Commercial Consumers," Filed with the Ohio Public Utilities Commission, Case No. 08-0833-GA-UNC, July 1, 2008.

Deemed Measure Cost

The incremental cost is estimated at $5,000.00.[352]

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.[353]

Savings Algorithm

Energy Savings

There are no expected energy savings associated with this measure.

Summer Peak Coincident Demand Reduction

There is no expected peak demand reduction associated with this measure.

Fossil Fuel Impact Descriptions and Calculation

$$\text{Annual MMBtu Savings} = CAP * EFLH_H * \frac{\eta_{EE}}{\eta_{BASE}} - 1$$

Where:

CAP = Equipment heating input capacity in MMBtu/hr (= actual)

$EFLH_h$ = Equivalent full load heating hours (= determined with site-specific data; otherwise see table below)

Small Commercial Building Heating EFLH

Building	Indianapolis	South Bend	Evansville	Ft Wayne	Terre Haute
Assembly	874	954	611	1,009	659
Auto Repair	3,319	3,930	2,582	3,299	2,918
Big Box Retail	519	538	325	607	367
Fast Food Restaurant	1,253	1,383	824	1,463	907
Full Service Restaurant	1,164	1,396	768	1,441	893
Grocery	519	538	325	607	367
Light Industrial	1,113	1,205	718	1,289	775
Primary School	1,192	1,266	785	1,359	845
Religious Worship	923	1,070	677	1,085	779
Small Office	670	710	487	826	526
Small Retail	939	977	591	1,125	661
Warehouse	1,113	1,205	718	1,289	775
Other	1,133	1,264	784	1,283	873

---

[352] Ibid.

[353] Ibid.

Large Commercial Building Heating EFLH

Building Type	System	Indianapolis	South Bend	Evansville	Ft Wayne	Terre Haute
Hotel	CAV no econ	703	697	585	703	782
	CAV econ	877	898	784	877	958
	VAV econ	401	367	229	401	437
Large Office	CAV no econ	2,627	2,066	1,785	2,543	2,389
	CAV econ	2,566	2,087	1,761	2,526	2,328
	VAV econ	531	333	294	538	386
Hospital	CAV no econ	3,503	3,073	3,476	3,227	3,005
	CAV econ	3,713	3,359	3,625	3,504	3,367
	VAV econ	604	604	363	613	302

η_{EE} = Installed equipment efficiency; expressed as AFUE, combustion efficiency, or thermal efficiency (= actual)

η_{BASE} = Baseline equipment efficiency; expressed as AFUE, combustion efficiency, or thermal efficiency (= see table below)

Equipment Type	Size Category (Input)	Subcategory Or Rating Condition	Minimum Efficiency*
Boilers, natural gas fired	< 300,000 Btu/hr	Hot water	80% AFUE
		Steam	75% AFUE
	≥ 300,000 Btu/hr and ≤ 2,500,000 Btu/hr	Minimum capacity	75% Thermal Efficiency
	>2,500,000 Btu/hr	Hot water	80% Combustion Efficiency
		Steam	80% Combustion Efficiency

* ASHRAE 90.1-2007 Boilers, Gas- and Oil-Fired, Minimum Efficiency Requirements.

Commercial Boiler Tune-Up

	Measure Details
Official Measure Code	CI-HVAC-BoilerTune-1
Measure Unit	Per tune-up
Measure Category	HVAC
Sector(s)	Commercial
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Fossil Fuel Savings (MMBtu)	Varies by system and location
Lifetime Energy Savings (kWh)	0
Lifetime Fossil Fuel Savings (MMBtu)	Varies by system and location
Water Savings (gal/yr)	0
Effective Useful Life (years)	5
Incremental Cost	$850.00
Important Comments	
Effective Date	January 2012
End Date	TBD

Description

This measure is the tune-up of an existing commercial boiler to improve the seasonal heating efficiency.

Definition of Efficient Equipment

The efficient condition is the boiler after a tune-up is performed.

Definition of Baseline Equipment

The baseline condition is the existing boiler before a tune-up is performed.

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 5 years.

Deemed Measure Cost

The incremental cost for this measure is $850.00[354] per boiler tune-up.

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

---

[354] This reflects tune-up costs for commercial boilers as listed in the Michigan Efficiency Measures Database.

Savings Algorithm

Energy Savings

There are no expected energy savings associated with this measure.

Summer Peak Coincident Demand Reduction

There is no expected peak demand reduction associated with this measure.

Fossil Fuel Impact Descriptions and Calculation

$$\Delta MMBtu = CAP * EFLH_H * ESF$$

Where:

CAP = Equipment heating input capacity in MMBtu/hr (= actual)

$EFLH_H$ = Equivalent full load heating hours (= actual; otherwise see table below)

ESF = Energy savings factor (= 0.02)[355]

Small Commercial Building Heating EFLH

Building	Indianapolis	South Bend	Evansville	Ft Wayne	Terre Haute
Assembly	874	954	611	1,009	659
Auto Repair	3,319	3,930	2,582	3,299	2,918
Big Box Retail	519	538	325	607	367
Fast Food Restaurant	1,253	1,383	824	1,463	907
Full Service Restaurant	1,164	1,396	768	1,441	893
Grocery	519	538	325	607	367
Light Industrial	1,113	1,205	718	1,289	775
Primary School	1,192	1,266	785	1,359	845
Religious Worship	923	1,070	677	1,085	779
Small Office	670	710	487	826	526
Small Retail	939	977	591	1,125	661
Warehouse	1,113	1,205	718	1,289	775
Other	1,133	1,264	784	1,283	873

---

[355] The Michigan Efficiency Measures Database uses energy savings of approximately 2% for commercial boiler tune ups.

Large Commercial Building Heating EFLH

Building Type	System	Indianapolis	South Bend	Evansville	Ft Wayne	Terre Haute
Hotel	CAV no econ	703	697	585	703	782
	CAV econ	877	898	784	877	958
	VAV econ	401	367	229	401	437
Large Office	CAV no econ	2,627	2,066	1,785	2,543	2,389
	CAV econ	2,566	2,087	1,761	2,526	2,328
	VAV econ	531	333	294	538	386
Hospital	CAV no econ	3,503	3,073	3,476	3,227	3,005
	CAV econ	3,713	3,359	3,625	3,504	3,367
	VAV econ	604	604	363	613	302

For example, the fossil fuel impacts from conducting a tune-up of a 3,000,000 Btu/hr boiler serving a large office with a VAV system in Indianapolis would be:

$$\Delta MMBtu = 3{,}000{,}000\ *\ 531 * \ 0.02\ *\ 10^{-6} = 31.9\ MMBtu$$

Boiler Combustion Controls

	Measure Details
Official Measure Code	CI-HVAC-BlrCombCtrl-1
Measure Unit	Per Control
Measure Category	HVAC
Sector(s)	Commercial
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Fossil Fuel Savings (MMBtu)	Varies by system
Lifetime Energy Savings (kWh)	0
Lifetime Fossil Fuel Savings (MMBtu)	Varies by system
Water Savings (gal/yr)	0
Effective Useful Life (years)	10
Incremental Cost	$0.85 per kBtuh of boiler output
Important Comments	
Effective Date	January 2012
End Date	TBD

Description

This measure is an oxygen trim control for a commercial boiler, which provides a 1.1% improvement in boiler efficiency.[356]

Definition of Efficient Equipment

The efficient condition is an existing boiler with an oxygen trim controller installed.

Definition of Baseline Equipment

The baseline condition is an existing boiler without oxygen trim controls.

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 10 years.

Deemed Measure Cost

The incremental cost for this measure is $0.85 per kBtuh of boiler output.

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

---

[356] Oxygen trim control savings taken from Michigan Boiler Oxygen Trim Control Work paper, prepared by Franklin Energy Services for the Michigan Efficiency Measures Database.

Savings Algorithm

Energy Savings

There are no expected energy savings associated with this measure.

Summer Peak Coincident Demand Reduction

There is no expected peak demand reduction associated with this measure.

Fossil Fuel Impact Descriptions and Calculation

$$\Delta MMBtu = CAP * EFLH_H * ESF * 10^{-6}$$

Where:

CAP = Equipment heating input capacity in Btuh (= actual)

ESF = Energy savings factor (= 0.011)

$EFLH_H$ = Equivalent full load heating hours (= actual; otherwise see table below)

Small Commercial Building Heating EFLH

Building	Indianapolis	South Bend	Evansville	Ft Wayne	Terre Haute
Assembly	874	954	611	1,009	659
Auto Repair	3,319	3,930	2,582	3,299	2,918
Big Box Retail	519	538	325	607	367
Fast Food Restaurant	1,253	1,383	824	1,463	907
Full Service Restaurant	1,164	1,396	768	1,441	893
Grocery	519	538	325	607	367
Light Industrial	1,113	1,205	718	1,289	775
Primary School	1,192	1,266	785	1,359	845
Religious Worship	923	1,070	677	1,085	779
Small Office	670	710	487	826	526
Small Retail	939	977	591	1,125	661
Warehouse	1,113	1,205	718	1,289	775
Other	1,133	1,264	784	1,283	873

Large Commercial Building Heating EFLH

Building Type	System	Indianapolis	South Bend	Evansville	Ft Wayne	Terre Haute
Hotel	CAV no econ	703	697	585	703	782
	CAV econ	877	898	784	877	958
	VAV econ	401	367	229	401	437
Large Office	CAV no econ	2,627	2,066	1,785	2,543	2,389
	CAV econ	2,566	2,087	1,761	2,526	2,328
	VAV econ	531	333	294	538	386
Hospital	CAV no econ	3,503	3,073	3,476	3,227	3,005
	CAV econ	3,713	3,359	3,625	3,504	3,367
	VAV econ	604	604	363	613	302

For example, the fossil fuel impact from installing combustion controls on a 3,000,000 Btuh boiler serving a large office with a VAV system in Indianapolis would be:

$$\text{Annual MMBtu Savings} = CAP * EFLH_H * ESF * 10^{-6}$$
$$= 3{,}000{,}000 * \ 531 * 0.011 * \ 10^{-6} = 17.5 \text{ MMBtu}$$

Lighting

C&I Lighting Controls (Time of Sale, Retrofit)

	Measure Details
Official Measure Code	CI-Ltg-Control-1
Measure Unit	Per control
Measure Category	Lighting
Sector(s)	Commercial
Annual Energy Savings (kWh)	Varies by project
Peak Demand Reduction (kW)	Varies by project
Annual Fossil Fuel Savings (MMBtu)	Varies by project
Lifetime Energy Savings (kWh)	Varies by project
Lifetime Fossil Fuel Savings (MMBtu)	Varies by project
Water Savings (gal/yr)	0
Effective Useful Life (years)	8
Incremental Cost	Varies by project
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is the installation of a new lighting control on a new or existing lighting system. Lighting control types include wall- or ceiling-mounted occupancy sensors, fixture-mounted occupancy sensors, remote-mounted daylight dimming sensors, fixture-mounted daylight dimming sensors, central lighting controls (time clocks), and switching controls for multi-level lighting. This measure relates to installing a new system in an existing building or a new construction application (i.e., time of sale). Lighting controls required by state energy codes are not eligible.

Definition of Efficient Equipment

The efficient equipment is a lighting system controlled by one of the lighting controls systems listed above.

Definition of Baseline Equipment

The baseline equipment is an uncontrolled lighting system operated by a manual switch.

Deemed Lifetime of Efficient Equipment

The expected measure lifetime for all lighting controls is 8 years.[357]

---

[357] California Public Utilities Commission. *2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05*. “Effective/Remaining Useful Life Values.” December 16, 2008.

Deemed Measure Cost

The incremental capital cost for this measure is provided below.

Deemed Incremental Measure Cost by Type of Lighting Control

Lighting Control Type	Incremental Cost
Wall-Mounted Occupancy Sensors	$42*
Ceiling-Mounted Occupancy Sensors	$66*
Fixture-Mounted Occupancy Sensors	$125**
Remote-Mounted Daylight Dimming Sensors	$65**
Fixture-Mounted Daylight Dimming Sensors	$50**
Switching Controls for Multi-Level Lighting	$274*
Central Lighting Controls (Time Clocks)	$103***

* Source: Goldberg et al., KEMA. *State of Wisconsin Public Service Commission of Wisconsin, Focus on Energy Evaluation, Business Programs: Incremental Cost Study*. October 28, 2009.

** Source: Efficiency Vermont. *Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions.* February, 19, 2010.

*** Source: California Public Utilities Commission. *2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05*. "Cost Values and Summary Documentation." December 16, 2008.

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\Delta \text{kWh} = kW_{CONTROLLED} * Hours * (1 + WHF_E) * ESF$$

Where:

$kW_{CONTROLLED}$ = Total lighting load connected to the control in kW (= actual)

HOURS = Total lighting operating hours before lighting controls are installed (= actual from audit report; otherwise see table below)

Lighting Hours of Operation by Building Type

Building Type	HOURS	Source
Food Sales	5,544	OH TRM*
Food Service	3,357	Duke OH** + NC***
Health Care	6,802	Duke OH + NC
Hotel/Motel	3,754	Duke OH + NC
Office	3,253	Duke OH
Public Assembly	2,867	Duke OH + NC
Public Services (non-food)	3,299	Duke OH
Retail	4,984	Duke OH, I&M

Warehouse	3,824	Duke OH, I&M
School	2,379	Duke OH, I&M
College	3,749	Duke OH + NC
Industrial – 1 Shift	2,857	OH TRM
Industrial – 2 Shift	4,730	OH TRM
Industrial – 3 Shift	6,631	OH TRM
Exterior	4,300	OH TRM
Other	4,408	Duke OH

* Source: Kuiken et al., KEMA. *Focus on Energy Evaluation, Business Programs: Deemed Savings Manual V1.0.* March 22, 2010.

** Source: Hall, et al., TecMarket Works. *Evaluation of the Non-Residential Smart Saver Prescriptive Program in Ohio.* Prepared for Duke Energy Inc. 2010.

*** Source: Hall, et al., TecMarket Works. *Evaluation of the Non-Residential Smart Saver Prescriptive Program in North and South Carolina*. Prepared for Duke Energy Inc. 2011.

WHF_E = Lighting-HVAC interaction factor for energy representing the reduced electric space cooling requirements due to the reduction of waste heat rejected by the efficient lighting (= 0 if exterior lighting; otherwise see Appendix B)

ESF = Energy savings factor; the percentage of operating hours reduced due to installing occupancy lighting controls or time clocks, or the percentage of wattage reduction multiplied by the hours of dimming for dimming lighting controls and multilevel switching (= dependent on control type, see table below)

Energy Saving Factor Percentage by Lighting Control Type

Lighting Control Type	ESF*
Wall- or Ceiling-Mounted Occupancy Sensors	30%
Fixture-Mounted Occupancy Sensors	30%
Remote-Mounted Daylight Dimming Sensors	30%
Fixture-Mounted Daylight Dimming Sensors	30%
Switching Controls for Multi-Level Lighting	30%
Central Lighting Controls (Time Clocks)	10%

* Sources: (1) Efficiency Vermont. *Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions*. February, 19, 2010. (2) TecMarket Works. *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Measures in Commercial and Industrial Programs.* September 1, 2009. (3) Kuiken et al., KEMA. *Focus on Energy Evaluation, Business Programs: Deemed Savings Manual V1.0.* March 22, 2010.

Summer Peak Coincident Demand Reduction

$$\Delta\text{kW} = kW_{CONTROLLED} * (1 + WHF_D) * CF$$

Where:

WHF_D = Lighting-HVAC interaction factor for demand representing the reduced electric space cooling requirements due to the reduction of waste heat rejected by the efficient lighting (= 0 if exterior lighting, otherwise see Appendix B)

CF = Summer peak coincidence factor (= dependent on control type, see table below)

Summer Peak Coincidence Factor by Lighting Control Type

Lighting Control Type	CF
Wall- or Ceiling-Mounted Occupancy Sensors	0.15*
Fixture-Mounted Occupancy Sensors	0.15*
Remote-Mounted Daylight Dimming Sensors	0.90**
Fixture-Mounted Daylight Dimming Sensors	0.90**
Switching Controls for Multi-Level Lighting	0.77**
Central Lighting Controls (Time Clocks)	0.00***

* Source: RLW Analytics. *Coincidence Factor Study Residential and Commercial Industrial Lighting Measures.* Spring 2007.

** Source: Kuiken et al., KEMA. *Focus on Energy Evaluation, Business Programs: Deemed Savings Manual V1.0.* March 22, 2010.

*** This is a conservative assumption based on professional judgment considering that time clocks are unlikely to produce significant savings during the summer peak period.

Fossil Fuel Impact Descriptions and Calculation

$$\Delta \text{MMBtu} = \Delta kWh * WHF_G$$

Where:

WHF_G = Lighting-HVAC interaction factor for natural gas heating impacts representing the increased natural gas space heating requirements due to the reduction of waste heat rejected by the efficient lighting (= 0 if exterior lighting, otherwise see Appendix B)

Lighting Systems (Non-Controls) (Time of Sale, New Construction)

	Measure Details
Official Measure Code	CI-Ltg-FixtRep-NC-1
Measure Unit	Per unit
Measure Category	Lighting
Sector(s)	Commercial
Annual Energy Savings (kWh)	Varies by project
Peak Demand Reduction (kW)	Varies by project
Annual Fossil Fuel Savings (MMBtu)	Varies by project
Lifetime Energy Savings (kWh)	Varies by project
Lifetime Fossil Fuel Savings (MMBtu)	Varies by project
Water Savings (gal/yr)	0
Effective Useful Life (years)	Varies by project
Incremental Cost	Varies by project
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is the installation of new lighting equipment with an efficiency that exceeds that of the equipment that would have been installed following standard market practices. This characterization includes CFLs and fixtures, linear fluorescent lamps and fixtures, linear fluorescent fixtures replacing HID fixtures in high-bay applications, and HID fixtures. This measure could relate to replacing an existing unit at the end of its useful life or installing a new unit in a new or existing facility.

Definition of Efficient Equipment

The efficient equipment must have a higher efficiency than the existing equipment and meet program-specific equipment criteria.

Definition of Baseline Equipment

The assumed baseline equipment varies by technology type.

The assumed baseline for installation of a high bay fluorescent fixture is a metal halide system. The Energy Independence and Security Act of 2007 (EISA) requires that as of January 1, 2009, metal halide fixtures designed for use with lamps ≥150 W and ≤500W must use "probe start" ballasts with ballast efficiency ≥94% or "pulse start" ballasts with ballast efficiency ≥88. It is therefore likely that new metal halide fixtures will utilize "pulse start" technology. Therefore, the assumed baseline system is a magnetic ballast "pulse start" metal halide system.

The assumed baseline for installation of a fluorescent fixture varies by the efficient system installed. High Performance and Reduced Wattage T8s must comply with the requirements as published by the Consortium for Energy Efficiency[358].

Deemed Lifetime of Efficient Equipment

The expected measure lifetime is dependent on technology type; see table below.

Measure Lifetime by Technology Type

Technology Type	Lifetime
Screw-in CFL	3.2 years*
CFL Fixture	12 years**
High Bay Fluorescent Fixture	15 years***
High-Efficiency Linear Fluorescent Fixtures (4 foot lamps)	15 years+
High-Efficiency Linear Fluorescent Fixtures (all other lamp sizes)	15 years***
Metal Halide Track Lighting	15 years***
Ceramic Metal Halide	15 years***

* Kuiken et al., KEMA. *Focus on Energy Evaluation, Business Programs: Deemed Savings Manual V1.0.* March 22, 2010. Assumes a 12,000 hours lamp lifetime with extended burn times per start typical in commercial applications. Assumes 3,730 annual lighting operating hours for the commercial sector. Lamp lifetime is calculated as: 12,000 / 3,730 = 3.2 years.

** California Public Utilities Commission. *2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05*. "Effective/Remaining Useful Life Values." December 16, 2008.

*** GDS Associates. *Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures*. June 2007.

\+ See discussion in Energy Savings section and Summer Peak Coincident Demand Reduction section.

Deemed Measure Cost

The incremental capital costs for this measure vary by the assumed baseline and efficient equipment scenarios (see table below).

---

[358] The Consortium for Energy Efficiency publishes the High Performance T8 Specifications and the Reduced Wattage T8 Specifications periodically including a list of qualifying equipment at the following address: http://www.cee1.org

Incremental Costs by Measure Type

Measure Type	Incremental Cost
Screw-in CFL	$3.00*
CFL Fixture (1-lamp)	$35.00**
CFL Fixture (2-lamp)	$40.00**
High Bay Fluorescent Fixture	$150.00***
High-Efficiency Linear Fluorescent Fixture	$25.00+
20 Watt Ceramic Metal Halide	$130.00***
39 Watt Ceramic Metal Halide	$130.00***
50 Watt Ceramic Metal Halide	$95.00***
70 Watt Ceramic Metal Halide	$95.00***
100 Watt Ceramic Metal Halide	$90.00***
150 Watt Ceramic Metal Halide	$90.00***
20 Watt Metal Halide Track	$155.00***
39 Watt Metal Halide Track	$155.00***
70 Watt Metal Halide Track	$145.00***

* Based on a review of TRM assumptions from Connecticut, New Jersey, New York, and Vermont.

** Based on review of TRM assumptions from California, New York, Vermont, and Northwestern states.

*** Efficiency Vermont. *Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions*. February, 19, 2010.

+ Ibid, p. 110 (incremental costs vary from $20 to $27.50 for 1 to 4 lamps).

Deemed O&M Cost Adjustment

In order to account for the shift in baseline due to federal legislation, the levelized baseline replacement cost over the lifetime of the CFL is calculated using the key assumptions shown in the table below.

Baseline Replacement Cost Assumptions

	Standard Incandescent	Efficient Incandescent
Replacement Cost	$0.50	$2.00
Component Life (years; based on lamp life / assumed annual run hours)	0.27*	0.81**

* Assumes rated life of incandescent bulb of approximately 1,000 hours.

** Best estimate of future technology from Ohio Technical Reference Manual.

The calculated net present value of the baseline replacement costs for CFL is $7.50.

Deemed O&M cost adjustments for high-bay fluorescent fixtures were developed assuming a typical baseline system and two typical efficient equipment scenarios. For T5HO high bay fixtures replacing pulse-start metal halide fixtures, the levelized annual baseline replacement cost assumption is $5.87. For

T8VHO high bay fixtures replacing pulse-start metal halide fixtures, the levelized annual baseline replacement cost assumption is -$1.69. The assumptions used to calculate these adjustments are detailed below.

- Baseline 320 Watt Metal-Halide Lamp Cost: $25.00
- Baseline 320 Watt Lamp Life: 15,000 hrs
- Baseline Lamp Labor Cost: $5.00 (15 min @ $20 per hour labor)
- Baseline 320 Watt Ballast Cost: $60.00
- Baseline Ballast Life: 40,000 hrs
- Baseline Ballast Labor Cost: $22.50 (30 min @ $45 per hour labor)
- T5 High-Bay Lamp Cost: $5.00 per lamp (assumes 4 lamps fixture)
- T5 High-Bay Lamp Life: 20,000 hrs
- T5 High-Bay Lamp Labor Cost: $6.67 (20 min @ $20 per hour labor)
- T5 High-Bay Ballast Cost: $51.00
- T5 High-Bay Ballast Life: 70,000 hrs
- T5 High-Bay Ballast Labor Cost: $22.50 (30 min @ $45 per hour labor)
- T8 High-Bay Lamp Cost: $10.00 per lamp (assumes 6 lamp fixture)
- T8 High-Bay Lamp Life: 18,000 hrs
- T8 High-Bay Lamp Labor Cost: $13.33 (40 min @ $20 per hour labor)
- T8 High-Bay Ballast Cost: $100.00 (2 ballasts)
- T8 High-Bay Ballast Life: 70,000 hrs
- T8 High-Bay Ballast Labor Cost: $45.00 (60 min @ $45 per hour labor)

O&M cost adjustments were developed assuming a typical baseline and efficient equipment scenario. For ceramic metal halide fixtures replacing halogen fixtures, the levelized annual baseline replacement cost assumption is $24.29. The assumptions used to calculate these adjustments are detailed below.

- Baseline 75 Watt Halogen Lamp Cost: $30.00 (3 lamps)
- Baseline 75 Watt Halogen Lamp Life: 2,500 hrs
- Baseline 75 Watt Halogen Lamp Labor Cost: $2.67
- 70 Watt CMH Lamp Cost: $60.00
- 70 Watt CMH Lamp Life: 12,000 hrs
- 70 Watt CMH Lamp Labor Cost: $2.67
- 70 Watt CMH Ballast Cost: $90.00
- 70 Watt CMH Ballast Life: 40,000 hrs
- 70 Watt CMH Ballast Labor Cost: $22.50 (30 min @ $45 per hour labor)

Savings Algorithm

Energy Savings

Non-CFLs

$$\Delta \text{kWh} = (WATTS_{BASE} - WATTS_{EE}) * Hours * \frac{(1+WHF_E)}{1{,}000}$$

Where:

$WATTS_{BASE}$ = Connected wattage of baseline fixtures (= assumed baseline wattage for time of sale application; see Appendix D – Standard Wattage Table) [359]

$WATTS_{EE}$ = Connected wattage of high-efficiency fixtures (= actual; otherwise see Appendix D – Standard Wattage Table)[360]

HOURS = Annual lighting operating hours (= actual from audit report or application; otherwise assume default values dependent on building type as shown in table below)

Annual Lighting Operating Hours by Building Type

Building Type	HOURS	Source
Food Sales	5,544	OH TRM*
Food Service	3,357	Duke OH** + NC***
Health Care	6,802	Duke OH + NC
Hotel/Motel	3,754	Duke OH + NC
Office	3,253	Duke OH
Public Assembly	2,867	Duke OH + NC
Public Services (non-food)	3,299	Duke OH
Retail	4,984	Duke OH, I&M
Warehouse	3,824	Duke OH, I&M
School	2,379	Duke OH, I&M
College	3,749	Duke OH + NC
Industrial – 1 Shift	2,857	OH TRM
Industrial – 2 Shift	4,730	OH TRM
Industrial – 3 Shift	6,631	OH TRM

---

[359] In cases where Appendix D – Standard Wattage Table does not provide sufficient results, The Consortium for Energy Efficiency publishes the High Performance T8 Specifications and the Reduced Wattage T8 Specifications periodically including a list of qualifying equipment at the following address: http://www.cee1.org

[360] Ibid

Exterior	4,300	OH TRM
Other	4,408	Duke OH

* Source: Kuiken et al., KEMA. *Focus on Energy Evaluation, Business Programs: Deemed Savings Manual V1.0.* March 22, 2010.
** Source: Hall, et al., TecMarket Works. *Evaluation of the Non-Residential Smart Saver Prescriptive Program in Ohio*. Prepared for Duke Energy Inc. 2010.
*** Source: Hall, et al., TecMarket Works. *Evaluation of the Non-Residential Smart Saver Prescriptive Program in North and South Carolina*. Prepared for Duke Energy Inc. 2011.

WHF_E = Lighting-HVAC interaction factor for energy representing the reduced electric space cooling requirements due to reduced waste heat rejected by the efficient lighting (= see Appendix B)

1,000 = Conversion factor from watts to kilowatts

CFL Bulbs and Fixtures

This measure is installing a new ENERGY STAR-certified CFL (for those equipment types with an ENERGY STAR category). This measure could relate to replacing an existing unit at the end of its useful life, or installing a new unit in a new or existing building (i.e., time of sale). This measure applies to installing a screw-in CFL to replace a standard general service incandescent lamp.

$$\text{Annual kWh Savings} = WATTS_{EE} * \text{DWM} * Hours * \frac{(1+WHF_E)}{1,000}$$

Where:

DWM = Delta Watts Multiplier (use table below) [361]

---

[361] Kuiken et al., KEMA. *Focus on Energy Evaluation, Business Programs: Deemed Savings Manual V1.0*.March 22, 2010. Source document cited several evaluations indicating that the overall average existing incandescent lamp was 75.7 watts, and that the overall average replacement lamp was 20.0 watts for CFLs smaller or equal to 32 watts. For the purposes of the characterization, it was assumed that the baseline and efficient wattages were directly proportional, and W_{BASE} to W_{EFF} ratio was 3.79 to 1, which means the DWM was 2.79. Since 2014 however, federal legislation stemming from the Energy Independence and Security Act of 2007 has required all general-purpose light bulbs between 40 and 100W to be approximately 30% more energy efficient than incandescent bulbs, in essence beginning the phase out of standard incandescent bulbs. New DWMs were calculated by finding the new baseline after incandescent bulb wattage was reduced (from 100W to 72W, 75W to 53W, 60W to 43W, and 40W to 29W). For example, prior to the phase-out, the average-sized CFL replacing a 60W incandescent was 60/ (3.79) = 16 W. Now that the 60W incandescent is replaced by a 43W halogen, the delta watts becomes 43 – 16 = 27, and the delta watts multiplier becomes 27/16 = 1.69.

Delta Watts Multiplier for Calculating Energy Savings

CFL Wattage	Delta Watts Multiplier
15 or less	1.72
16-20	1.69
21 or more	1.73

Summer Peak Coincident Demand Reduction

Non-CFLs

$$\Delta \text{kW} = (WATTS_{BASE} - WATTS_{EE}) * CF * \frac{(1+WHF_D)}{1{,}000}$$

Where:

WHF_D = Lighting-HVAC waste heat factor for demand that represents the reduced electric space cooling requirements due to the reduction of waste heat rejected by the efficient lighting (= see Appendix B)

CF = Summer peak coincidence factor (= dependent on building type as shown in table below)

Summer Peak Coincidence Factor by Building Type

Building Type	CF*
Food Sales	0.92
Food Service	0.83
Health Care	0.78
Hotel/Motel	0.37
Office	0.76
Public Assembly	0.65
Public Services (non-food)	0.64
Retail	0.84
Warehouse	0.79
School	0.50
College	0.68
Industrial	0.76
Garage	1.00**

Building Type	CF*
Exterior	0.00***
Other	0.65

* Methodology adapted from: Kuiken et al., KEMA. *State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Deemed Savings Parameter Development*. November 13, 2009. (defining the summer peak coincident period as June through August on weekdays between 3:00 p.m. and 6:00 p.m., unless otherwise noted).

** Assumption consistent with 8,760 operating hours.

*** Assumes that no exterior lighting is operating during summer peak demand.

CFL Bulbs and Fixtures

$$\Delta \text{kW} = WATTS_{EE} * \text{DWM} * Hours * \frac{(1+WHF_D)}{1,000}$$

Fossil Fuel Impact Descriptions and Calculation

$$\Delta \text{MMBtu} = \Delta kWh * WHF_G$$

Where:

WHF_G = Lighting-HVAC interaction factor for natural gas heating impacts that represents the increased natural gas space heating requirements due to the reduction of waste heat rejected by the efficient lighting (= see Appendix B)

Lighting Power Density Reduction (New Construction)

	Measure Details
Official Measure Code	CI-Ltg-LPD-1
Measure Unit	Per unit
Measure Category	Lighting
Sector(s)	Commercial
Annual Energy Savings (kWh)	Varies by project
Peak Demand Reduction (kW)	Varies by project
Annual Fossil Fuel Savings (MMBtu)	Varies by project
Lifetime Energy Savings (kWh)	Varies by project
Lifetime Fossil Fuel Savings (MMBtu)	Varies by project
Water Savings (gal/yr)	0
Effective Useful Life (years)	15
Incremental Cost	Varies by project
Important Comments	
Effective Date	
End Date	

Description

This measure is implementing various lighting design principles to create a quality and appropriate lighting experience while reducing unnecessary light usage. This is often done by a professional in a new construction situation. Techniques like maximizing daylighting, task lighting, and efficient fixtures are used to create a system of optimal functionality while reducing total lighting power density.

Definition of Efficient Equipment

The efficient condition is high-efficiency equipment consisting of a lighting system that exceeds the lighting power density requirements as mandated by ASHRAE 90.1-2007 Table 9.5.1 or Table 9.6.1.

Definition of Baseline Equipment

The baseline efficiency assumes compliance with lighting power density requirements as mandated by ASHRAE 90.1-2007 Table 9.5.1 or Table 9.6.1.

Deemed Lifetime of Efficient Equipment

The expected measure life is 15 years.[362]

---

[362] GDS Associates. *Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures*. June 2007. Available online: http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf

Deemed Measure Cost

The incremental capital costs for this measure vary by the assumed baseline and efficient equipment scenarios.

Deemed O&M Cost Adjustments

There are no cost adjustments associated with this measure.

Savings Algorithm

Energy Savings

$$\Delta \text{kWh} = \frac{LPD_{BASE} - LPD_{EE}}{1{,}000} * AREA * HOURS * (1 + WHF_E)$$

Where:

LPD_{BASE} = Allowed lighting power density (watts per square foot) based on energy code requirements for building or space type (= see ASHRAE 90.1-2007 Table 9.5.1 or Table 9.6.1)

LPD_{EE} = Installed lighting wattage per square foot of the efficient lighting system for building type as determined by site-surveys or design diagrams (= actual)

1,000 = Conversion factor from watts to kilowatts

AREA = Square footage of building (= determined from site-specific information)

HOURS = Annual operating hours of lighting system (= actual from audit report or application; otherwise assume default values dependent on building type as shown in table below)

Annual Lighting Operating Hours by Building Type

Building Type	HOURS	Source
Food Sales	5,544	OH TRM*
Food Service	3,357	Duke OH** + NC***
Health Care	6,802	Duke OH + NC
Hotel/Motel	3,754	Duke OH + NC
Office	3,253	Duke OH
Public Assembly	2,867	Duke OH + NC
Public Services (non-food)	3,299	Duke OH
Retail	4,984	Duke OH, I&M
Warehouse	3,824	Duke OH, I&M
School	2,379	Duke OH, I&M
College	3,749	Duke OH + NC
Industrial – 1 Shift	2,857	OH TRM
Industrial – 2 Shift	4,730	OH TRM
Industrial – 3 Shift	6,631	OH TRM

Building Type	HOURS	Source
Exterior	4,300	OH TRM
Other	4,408	Duke OH

* Kuiken et al., KEMA. *Focus on Energy Evaluation, Business Programs: Deemed Savings Manual V1.0*. March 22, 2010.

** Hall, et al., TecMarket Works. *Evaluation of the Non-Residential Smart Saver Prescriptive Program in Ohio*. Prepared for Duke Energy Inc. 2010.

*** Hall, et al., TecMarket Works. *Evaluation of the Non-Residential Smart Saver Prescriptive Program in North and South Carolina*. Prepared for Duke Energy Inc. 2011.

WHF_E = Lighting-HVAC interaction factor for energy representing the reduced electric space cooling requirements due to the reduction of waste heat rejected by the efficient lighting (= see Appendix B)

Summer Peak Coincident Demand Reduction

$$\Delta kW = \frac{LPD_{BASE} - LPD_{EE}}{1{,}000} * AREA * CF * (1 + WHF_D)$$

Where:

WHF_D = Lighting-HVAC waste heat factor for demand representing the reduced electric space cooling requirements due to the reduction of waste heat rejected by the efficient lighting (= see Appendix B)

CF = Summer peak coincidence factor (= dependent on building type as shown in table below)

Summer Peak Coincidence Factor by Building Type

Building Type	CF*
Food Sales	0.92
Food Service	0.83
Health Care	0.78
Hotel/Motel	0.37
Office	0.76
Public Assembly	0.65
Public Services (non-food)	0.64
Retail	0.84
Warehouse	0.79
School	0.50
College	0.68
Industrial	0.76
Garage	1.00**

Building Type	CF*
Exterior	0.00***
Other	0.65

* Methodology adapted from: Kuiken et al., KEMA. *State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Deemed Savings Parameter Development*. November 13, 2009. (defining the summer peak coincident period as June through August on weekdays between 3:00 p.m. and 6:00 p.m., unless otherwise noted).

** Assumption consistent with 8,760 operating hours.

*** Assumes that no exterior lighting is operating during summer peak demand.

Fossil Fuel Impact Descriptions and Calculation

$$\Delta \text{MMBtu} = \Delta kWh \, * \, WHF_G$$

Where:

WHF_G = Lighting-HVAC interaction factor for natural gas heating impacts representing the increased natural gas space heating requirements due to the reduction of waste heat rejected by the efficient lighting (= see Appendix B)

Lighting Systems (Non-Controls) (Early Replacement, Retrofit)

	Measure Details
Official Measure Code	CI-Ltg-FixtRep-ER-1
Measure Unit	Per unit
Measure Category	Lighting
Sector(s)	Commercial
Annual Energy Savings (kWh)	Varies by project
Peak Demand Reduction (kW)	Varies by project
Annual Fossil Fuel Savings (MMBtu)	Varies by project
Lifetime Energy Savings (kWh)	Varies by project
Lifetime Fossil Fuel Savings (MMBtu)	Varies by project
Water Savings (gal/yr)	0
Effective Useful Life (years)	Varies by project
Incremental Cost	Varies by project
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is installing new lighting equipment with efficiency that exceeds that of the existing equipment. This applies to CFLs and fixtures, linear fluorescent lamps and fixtures, linear fluorescent fixtures replacing HID fixtures in high bay applications, HID fixtures, and delamping. This measure could relate to the early replacement of an existing unit before the end of its useful life or the retrofit of a unit in an existing facility.

Note: See the Lighting Systems (Non-Controls) (Time of Sale, New Construction) measure above for calculation procedures for commercial screw-in CFLs and CFL fixtures.

Definition of Efficient Equipment

The efficient equipment must have higher efficiency than the existing equipment.

Definition of Baseline Equipment

The baseline equipment is the existing equipment before efficient equipment is installed. Default assumptions of the baseline equipment are presented in the tables below.

Deemed Lifetime of Efficient Equipment

The expected measure lifetime is dependent on technology type as shown in the table below.

Deemed Lifetime by Measure Type

Measure Type	Lifetime
Screw-in CFL	3.2 years*
Hardwired CFL	12 years**
High Bay Fluorescent Fixture	7 years***
High-Efficiency Linear Fluorescent Fixture	15 years***
Pulse Start Metal Halide	7.5 years+
Metal Halide Track Lighting	5 years***
Ceramic Metal Halide	15 years++
Delamping	10+++

* Kuiken et al., KEMA. *Focus on Energy Evaluation, Business Programs: Deemed Savings Manual V1.0*. March 22, 2010. Assumes a 12,000 hour lamp lifetime with extended burn times per start typical in commercial applications. Assumes 3,730 annual lighting operating hours for the commercial sector. The lamp lifetime is calculated as: 12,000 / 3,730 = 3.2 years.

** California Public Utilities Commission. *2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05*. "Effective/Remaining Useful Life Values." December 16, 2008.

*** GDS Associates. *Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures*. June 2007. Available online: http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf

\+ The Energy Independence and Security Act of 2007 requires that as of January 1, 2009, metal halide fixtures designed for use with lamps ≥ 150 watts and ≤ 500 watts must use probe start ballasts with ballast efficiency ≥ 94% or pulse start ballasts with ballast efficiency ≥ 88%. This essentially means that new metal halide fixtures will use pulse start technology. Assuming that the age of the existing equipment being replaced is half of the total expected lifetime for a metal halide fixture (7.5 years), savings are only achieved for half of the lifetime of the new fixture (at which point the customer would have had to replace the inefficient technology with pulse start technology, negating any savings).

++ Efficiency Vermont. *Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions.* February, 19, 2010.

+++ Based on a review of delamping measure life assumptions ranging from 9 to 16 years in California, Iowa, and Oregon as presented in: Energy & Resource Solutions. *Measure Life Study*. November 17, 2005. The high end of this range exceeds the assumed fixture lifetime and has been adjusted down to a more conservative 10 years to reflect expected persistence issues.

Deemed Measure Cost

The actual lighting measure installation cost should be used (including material and labor).

Deemed O&M Cost Adjustments

The deemed O&M cost adjustments should be determined on a case-by-case basis.

Savings Algorithm

Energy Savings

$$\Delta\text{kWh} = (WATTS_{BASE} - WATTS_{EE}) * HOURS * \frac{1+WHF_E}{1{,}000}$$

Where:

$WATTS_{BASE}$= Connected wattage of the baseline fixtures (= actual for early replacement application; otherwise see Appendix D – Standard Wattage Table)[363]

$WATTS_{EE}$ = Connected wattage of high-efficiency fixtures (= actual; otherwise see Appendix D – Standard Wattage Table)[364]

HOURS = Annual lighting operating hours (= actual from audit report or application; otherwise assume default values dependent on building type as shown in table below)

Annual Lighting Operating Hours by Building Type

Building Type	HOURS	Source
Food Sales	5,544	OH TRM*
Food Service	3,357	Duke OH** + NC***
Health Care	6,802	Duke OH + NC
Hotel/Motel	3,754	Duke OH + NC
Office	3,253	Duke OH
Public Assembly	2,867	Duke OH + NC
Public Services (non-food)	3,299	Duke OH
Retail	4,984	Duke OH, I&M
Warehouse	3,824	Duke OH, I&M
School	2,379	Duke OH, I&M
College	3,749	Duke OH + NC
Industrial – 1 Shift	2,857	OH TRM
Industrial – 2 Shift	4,730	OH TRM
Industrial – 3 Shift	6,631	OH TRM

---

[363] In cases where Appendix D – Standard Wattage Table does not provide sufficient results, The Consortium for Energy Efficiency publishes the High Performance T8 Specifications and the Reduced Wattage T8 Specifications periodically including a list of qualifying equipment at the following address: http://www.cee1.org

[364] Ibid

Exterior	4,300	OH TRM
Other	4,408	Duke OH

* Kuiken et al., KEMA. *Focus on Energy Evaluation, Business Programs: Deemed Savings Manual V1.0*. March 22, 2010.

** Hall, et al., TecMarket Works. *Evaluation of the Non-Residential Smart Saver Prescriptive Program in Ohio*. Prepared for Duke Energy Inc. 2010.

*** Hall, et al., TecMarket Works. *Evaluation of the Non-Residential Smart Saver Prescriptive Program in North and South Carolina*. Prepared for Duke Energy Inc. 2011.

WHF_E = Lighting-HVAC interaction factor for energy representing the reduced electric space cooling requirements due to the reduction of waste heat rejected by the efficient lighting (= see Appendix B)

1 / 1,000 = Conversion factor from watts to kilowatts

Summer Peak Coincident Demand Reduction

$$\Delta kW = (WATTS_{BASE} - WATTS_{EE}) * CF * \frac{1+WHF_D}{1{,}000}$$

Where:

WHF_D = Lighting-HVAC waste heat factor for demand representing the reduced electric space cooling requirements due to the reduction of waste heat rejected by the efficient lighting (= see Appendix B)

CF = Summer peak coincidence factor (= dependent on building type, see table below)

Summer Peak Coincidence Factor by Building Type

Building Type	CF*
Food Sales	0.92
Food Service	0.83
Health Care	0.78
Hotel/Motel	0.37
Office	0.76
Public Assembly	0.65
Public Services (non-food)	0.64
Retail	0.84
Warehouse	0.79
School	0.50
College	0.68
Industrial	0.76
Garage	1.00**

Exterior	0.00***
Other	0.65

* Methodology adapted from: Kuiken et al., KEMA. *State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Deemed Savings Parameter Development.* November 13, 2009. (defining summer peak coincident period as June through August on weekdays between 3:00 p.m. and 6:00 p.m., unless otherwise noted).

** Assumption consistent with 8,760 operating hours.

*** Assumes that no exterior lighting is operating during summer peak demand.

Fossil Fuel Impact Descriptions and Calculation

$$\Delta \text{MMBtu} = \Delta kWh\ *\ WHF_G$$

Where:

WHF_G = Lighting-HVAC interaction factor for natural gas heating impacts representing the increased natural gas space heating requirements due to the reduction of waste heat rejected by the efficient lighting (= see Appendix B)

LED Exit Signs (Retrofit)

	Measure Details
Official Measure Code	CI-Ltg-LEDExit-1
Measure Unit	Per sign
Measure Category	Lighting
Sector(s)	Commercial
Annual Energy Savings (kWh)	Varies by project
Peak Demand Reduction (kW)	Varies by project
Annual Fossil Fuel Savings (MMBtu)	Varies by project
Lifetime Energy Savings (kWh)	Varies by project
Lifetime Fossil Fuel Savings (MMBtu)	Varies by project
Water Savings (gal/yr)	0
Effective Useful Life (years)	16
Incremental Cost	Varies by project
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

These exit signs have a string of very small (typically red or green) glowing LEDs arranged in a circle or oval. The LEDs may also be arranged in a line on the side, top, or bottom of the exit sign. LED exit signs provide the best balance of safety, low maintenance, and very low energy usage compared to other exit sign technologies.

Definition of Efficient Equipment

The efficient equipment is an exit sign illuminated by light emitting diodes.

Definition of Baseline Equipment

The baseline equipment is a fluorescent exit sign.

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 16 years.[365]

---

[365] California Public Utilities Commission. *2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05*. "Effective/Remaining Useful Life Values." December 16, 2008.

Deemed Measure Cost

The deemed measure cost is \$30.00.[366]

Deemed O&M Cost Adjustments

The stream of replacement costs over the lifetime of the measure results in a net present value of \$59.00. This computes to a levelized annual baseline replacement cost of \$6.04.[367]

Savings Algorithm

Energy Savings

$$\Delta\text{kWh} = kW_{SAVE} * HOURS * ISR * (1 + WHF_E)$$

Where:

kW_{SAVE} = The difference in connected load between baseline equipment and efficient equipment (= 0.009)[368]

HOURS = Annual operating hours (= 8,760)

ISR = In-service rate; the percentage of rebated units actually in service (= 98%)[369]

WHF_E = Waste heat factor for energy accounting for cooling savings from efficient lighting (= see Appendix B)

Summer Peak Coincident Demand Reduction

$$\Delta\text{kW} = kW_{SAVE} * ISR * (1 + WHF_D)$$

---

[366] New York State Energy Research and Development Authority. *Deemed Savings Database*. Labor cost assumes 25 minutes @ \$18/hr.

[367] This calculation assumes a replacement baseline CFL cost of \$4.00 with an estimated labor cost of \$5.00 (assuming \$20/hour and a task time of 15 minutes). Lamp life is approximated as 2 years, assuming a 16,000 hour lamp life operating 8,760 hours per year.

[368] Efficiency Vermont. *Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions*. February, 19, 2010.

[369] Ibid.

Where:

ISR = In-service rate; the percentage of rebated units actually in service (= 98%)[370]

kW_{SAVE}= The difference in connected load between baseline equipment and efficient equipment (= 0.009)[371]

WHF_D = Waste heat factor for demand to account for cooling savings from efficient lighting (= see Appendix B)

The summer peak coincidence factor for this measure is 100%.[372]

Fossil Fuel Impact Descriptions and Calculation

$$\Delta \text{MMBtu} = \Delta kWh\ *\ WHF_G$$

Where:

WHF_G = Lighting-HVAC interaction factor for natural gas heating impacts representing the increased natural gas space heating requirements due to the reduction of waste heat rejected by the efficient lighting (= see Appendix B)

---

[370] Efficiency Vermont. *Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions*. February, 19, 2010.

[371] Ibid.

[372] Assuming continuous operation of an LED exit sign, the summer peak coincidence factor is 1.0.

Traffic Signals (Retrofit)

	Measure Details
Official Measure Code	CI-Ltg-LEDTraffic-1
Measure Unit	Per signal
Measure Category	Lighting
Sector(s)	Commercial
Annual Energy Savings (kWh)	Varies by project
Peak Demand Reduction (kW)	Varies by project
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	Varies by project
Lifetime Fossil Fuel Savings (MMBtu)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	10
Incremental Cost	Varies by project
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is illuminating traffic and pedestrian signals with LEDs instead of incandescent lamps.

Definition of Efficient Equipment

The efficient condition is LED traffic and pedestrian signals.

Definition of Baseline Equipment

The baseline condition is incandescent traffic and pedestrian signals.

Deemed Lifetime of Efficient Equipment

The assumed lifetime of an LED traffic signal is 100,000 hours (manufacturer estimate), capped at 10 years.[373] The life in years is calculated by dividing 100,000 hours by the annual operating hours for the particular signal type.

Deemed Measure Cost

The actual measure installation cost should be used (including material and labor).

---

[373] Suozzo, Margaret. “A Market Transformation Opportunity Assessment for LED Traffic Signals.” Paper presented at the annual meeting for the American Council for an Energy-Efficient Economy, April 1, 1998. Available online: http://www.cee1.org/gov/led/led- ace3/ace3led.pdf

Deemed O&M Cost Adjustments

Because LEDs last much longer than incandescent bulbs, they offer O&M savings from avoided replacement lamps and the labor to install them. The following assumptions[374] are used to calculate the O&M savings:

Incandescent bulb cost:	\$3.00 per bulb
Labor cost to replace incandescent lamp:	\$60.00 per signal
Life of incandescent bulb:	8,000 hours

Savings Algorithm

Energy Savings

$$\Delta \text{kWh} = \frac{W_{BASE} - W_{EFF}}{1{,}000} * HOURS$$

Where:

W_{BASE} = Connected load of baseline equipment (= see table in Reference Table section)

W_{eff} = The connected load of the efficient equipment (= see table in Reference Table section)

HOURS = Annual operating hours of the lamp (= see table in Reference Table section)

1,000 = Conversion factor from watts to kilowatts

For example, the energy savings from an 8-inch red, round signal would be:

$$\Delta \text{kWh} = \frac{69-7}{1{,}000} * 4{,}818 = 299 \text{ kWh}$$

Summer Peak Coincident Demand Reduction

$$\Delta \text{kW} = \frac{W_{BASE} - W_{EFF}}{1{,}000} * CF$$

---

[374] Efficiency Vermont. *Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions*. February, 19, 2010.

Where:

W_{BASE} = Connected load of baseline equipment (= see table in Reference Table section)

W_{EFF} = Connected load of efficient equipment (= see table in Reference Table section)

CF = Summer peak coincidence factor (= see table below)[375]

Coincidence Factors by Traffic Lamp Type

Lamp Type	CF
Red Balls	0.55
Red Arrows	0.86
Green Balls	0.43
Green Arrow	0.08
Yellow Balls	0.02
Yellow Flashing	0.50
Yellow Arrow	0.08
Pedestrian	1.00

For example, the demand reduction from an 8-inch red, round signal would be:

$$\Delta kW = \frac{69-7}{1,000} * 0.55 = 0.0341 \text{ kW}$$

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.

Reference Table

Traffic Signals Technology Equivalencies (Incandescent to LED)*

Traffic Fixture Type	Fixture Size and Color	HOURS	Efficient Fixture Wattage	Baseline Fixture Wattage	Energy Savings (kWh)	Demand Reduction (kW)
Flashing Signal	8” Red	4,380	7	69	272	0.034
	12” Red	4,380	6	150	631	0.079
	8” Yellow	4,380	10	69	258	0.03
	12” Yellow	4380	13	150	600	0.069
Round Signals	8” Red	4,818	7	69	299	0.034

---

[375] Pennsylvania Public Utility Commission. Technical Reference Manual for Pennsylvania Act 129 Energy Efficiency and Conservation Program and Act 213 Alternative Energy Portfolio Standards. June 2015

	12” Red	4,818	6	150	694	0.079
	8” Yellow	175	10	69	10	0.001
	12” Yellow	175	13	150	24	0.003
	8” Green	3,767	9	69	226	0.026
	12” Green	3,767	12	150	520	0.059
Turn Arrows	8” Red	7,358	5	116	817	0.095
	12” Red	7,358	6	116	809	0.095
	8” Yellow	701	7	116	76	0.009
	12” Yellow	701	9	116	75	0.009
	8” Green	701	7	116	76	0.009
	12” Green	701	7	116	76	0.009
Pedestrian Sign	12” Hand	8,760	8	116	946	0.108

* Pennsylvania Public Utility Commission. *Technical Reference Manual for Pennsylvania Act 129 Energy Efficiency and Conservation Program and Act 213 Alternative Energy Portfolio Standards*. June 2015.

Reference specifications for above traffic signal wattages are from the following manufacturers:

1. 8” incandescent traffic signal bulbs: General Electric Traffic Signal Model 17325-69A21/TS
2. 12” incandescent traffic signal bulbs: General Electric Signal Model 35327-150PAR46/TS
3. Incandescent arrows and hand/man pedestrian signs: General Electric Traffic Signal Model 19010-116A21/TS
4. 8” and 12” LED traffic signals: Leotek Models TSL-ES08 and TSL-ES12
5. 8” LED yellow arrows: General Electric Model DR4-YTA2-01A
6. 8” LED green arrows: General Electric Model DR4-GCA2-01A
7. 12” LED yellow arrows: Dialight Model 431-3334-001X
8. 12” LED green arrows: Dialight Model 432-2324-001X
9. LED hand/man pedestrian signs: Dialight 430-6450-001X

Light Tube Commercial Skylight (Time of Sale)

	Measure Details
Official Measure Code	CI-Ltg-LiteTube-1
Measure Unit	Per light tube
Measure Category	Lighting
Sector(s)	Commercial
Annual Energy Savings (kWh)	250
Peak Demand Reduction (kW)	0.104
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	Varies by project
Lifetime Fossil Fuel Savings (MMBtu)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	10
Incremental Cost	$500.00
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is a tubular skylight 10-inches to 21-inches in diameter with a prismatic or translucent lens installed on the roof of a commercial facility. The lens reflects light captured from the roof opening through a highly specular reflective tube down to the mounted fixture height. When in use, a light tube fixture resembles a metal halide fixture. Uses include grocery, school, retail, and other businesses in single-story commercial buildings.

Definition of Efficient Equipment

The efficient equipment is a tubular skylight that concentrates and directs light from the roof to an area inside the facility.

Definition of Baseline Equipment

The baseline equipment is a T8 fluorescent lamp with comparable luminosity. The specifications for the baseline lamp depend on the size of the light tube being installed.

Deemed Lifetime of Efficient Equipment

The estimated useful life for a light tube commercial skylight is 10 years.[376]

---

[376] Equal to the manufacturer standard warranty.

Deemed Measure Cost

If available, actual incremental cost should be used. For analysis purposes, assume an incremental cost for a light tube commercial skylight of $500.00.[377]

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\Delta \text{kWh} = kW_F * EFLH$$

Where:

kW_F = Kilowatts saved per fixture (= see table)

EFLH = Equivalent full load hours (= 2,400)[378]

Energy Savings per Fixture

Brand/Size	Lumen Output*	Equivalent Fixture	kW	kWh
Solatube 21”	13,500-20,500	2-3LF32T8 172 Watt	0.172	412.8
14”	6,000-9,100	1-3LF32T8	0.086	206.4
10”	3,000-4,600	3-18 Watt quad	0.054	129.6
Average			**0.104**	**249.6**

* Solatube. *Test Report No.: Solatube40.IES - Preliminary BETA Test Report.* 2005. Available online: http://www.mainegreenbuilding.com/files/file/solatube/stb_lumens_datasheet.pdf

Summer Peak Coincident Demand Reduction

$$\Delta \text{kW} = kW_F * CF$$

Where:

ΔkW_F = Kilowatts saved per fixture (= see table above, “Energy Savings per Fixture”)

CF = Coincidence factor (= 0.75)[379]

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.

---

[377] Based on a review of available manufacturer pricing information.

[378] Based on replacing electric lighting with daylight for 8 hour a day, 300 day a year.

[379] Determined by taking the average of several building types for the 4p-5p peak period from the following report: RLW Analytics. Coincidence Factor Study - Residential and Commercial Industrial Lighting Measures. Spring 2007.

Plug Load

Vending Machine Occupancy Sensors (Time of Sale, New Construction, Retrofit – New Equipment)

	Measure Details
Official Measure Code	CI-Plug-Vending-1
Measure Unit	Per control
Measure Category	Plug Load
Sector(s)	Commercial
Annual Energy Savings (kWh)	Varies by equipment type
Peak Demand Reduction (kW)	Varies by equipment type
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	Varies by equipment type
Lifetime Fossil Fuel Savings (MMBtu)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	5
Incremental Cost	$215.50 (Refrigerated), $108.00 (Non-Refrigerated)
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is the installation of new controls on refrigerated beverage vending machines, non-refrigerated snack vending machines, and glass front refrigerated coolers. Controls can significantly reduce the energy consumption of vending machine and refrigeration systems. Qualifying controls must power these systems down during periods of inactivity but, in the case of refrigerated machines, must always maintain a cool product that meets customer expectations. This measure relates to installing a new control on a new or existing unit. This measure should **not** be applied to ENERGY STAR-qualified vending machines, which already have built-in controls.

Definition of Efficient Equipment

The efficient equipment is a standard efficiency refrigerated beverage vending machine, non-refrigerated snack vending machine, or glass front refrigerated cooler with a control system capable of powering down lighting and refrigeration systems during periods of inactivity.

Definition of Baseline Equipment

The baseline equipment is a standard efficiency refrigerated beverage vending machine, non-refrigerated snack vending machine, or glass front refrigerated cooler without a control system capable of powering down lighting and refrigeration systems during periods of inactivity.

Deemed Lifetime of Efficient Equipment

The expected measure life is 5 years.[380]

Deemed Measure Cost

The actual measure installation cost should be used (including material and labor), but the following can be assumed for analysis purposes:[381]

- Refrigerated Vending Machine: $215.50
- Non-Refrigerated Vending Machine: $108.00

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\Delta \text{kWh} = \frac{WATTS_{BASE}}{1{,}000} * HOURS * ESF$$

Where:

$WATTS_{BASE}$ = Connected kilowatts of controlled equipment (= actual, see table below)

Equipment Type	$WATTS_{BASE}$*
Refrigerated Beverage Vending Machines	400
Non-Refrigerated Snack Vending Machines	85
Glass Front Refrigerated Coolers	460

* USA Technologies. *Energy Management Product Sheets*. July 2006.

1,000 = Conversion factor from watts to kilowatts

HOURS = Operating hours of connected equipment (= 8,760)

ESF = Energy savings factor; represents the percentage reduction in annual kWh consumption of equipment controlled (= see table below)

---

[380] Energy & Resource Solutions. *Measure Life Study*. Prepared for the Massachusetts Joint Utilities. November 2005.

[381] *2005 Database for Energy-Efficiency Resources (DEER), Version 2005.21*. "Cost Data for Supporting Documents."

Equipment Type	Energy Savings Factor*
Refrigerated Beverage Vending Machines	46%
Non-Refrigerated Snack Vending Machines	46%
Glass Front Refrigerated Coolers	30%

* USA Technologies. *Energy Management Product Sheets*. July 2006.

Summer Peak Coincident Demand Reduction

There is no expected peak demand reduction associated with this measure.[382]

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.

---

[382] Assumed that the peak period is coincident with periods of high traffic, diminishing the demand reduction potential of occupancy based controls.

Commercial Plug Load – Smart Strip Plug Outlets (Time of Use, Retrofit – New Equipment)

	Measure Details
Official Measure Code	CI-Plug-Strip-1
Measure Unit	Per smart strip
Measure Category	Plug Load
Sector(s)	Commercial
Annual Energy Savings (kWh)	Varies by measure
Peak Demand Reduction (kW)	0
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	
Lifetime Fossil Fuel Savings (MMBtu)	
Water Savings (gal/yr)	0
Effective Useful Life (years)	8
Incremental Cost	$15.00
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

A smart strip plug outlet is a multi-plug power strip with the ability to automatically disconnect specific loads plugged in depending on the power draw of a control load, which is also plugged in. The energy savings are measured by estimating the number of hours that electronic devices at typical workstations are either in sleep mode or shut off and the standby loads consumed by the devices at those times. The smart strip will eliminate these standby loads and result in measureable energy savings. A smart strip plug outlet is purchased through a retail outlet and installed in an office environment where standby loads are uncontrolled.

Definition of Efficient Equipment

The efficient condition assumes that peripheral electronic office equipment is plugged into the controlled smart strip outlets, resulting in a reduction in standby load. No savings are associated with the control load, or loads plugged into the uncontrolled outlets.

Definition of Baseline Equipment

The baseline condition is a mix of typical office equipment (computer and peripherals) with uncontrolled standby load.

Deemed Lifetime of Efficient Equipment

The estimated useful life for a smart strip plug outlet is 8 years.[383]

Deemed Measure Cost

The estimated incremental cost for smart strip plug outlets is $15.00.[384]

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\Delta kWh = \frac{WORKDAYS * \Delta Wh_{WORKDAY} + (365 - WORKDAYS) * \Delta Wh_{NON\_WORKDAY}}{1,000}$$

---

[383] British Columbia Hydro. *Smart Strip Electrical Savings and Usability.* October 2008.

[384] Research Into Action, Inc. *Electronics and Energy Efficiency: A Plug Load Characterization Study.* Prepared for Southern California Edison. 2010. (This reflects the incremental costs over a standard power strip with surge protection with average market price of $35 for controlled power strip and $20 for baseline plug strip with surge protection.)

Where:

WORKDAYS = Average number of workdays, or business days, in a year (= 240)[385]

$\Delta Wh_{WORKDAY}$ = Energy savings from devices plugged into the strip on work days (= 62.7 Wh; see table below)

Standby Power Consumption from Devices Using Smart Strip Plug Outlets*

Plug Load	Watts in Standby	Hours in Standby	Watts When Off	Hours Off, Workday	Hours Off, Non-Workday	% of Strips	Weighted ΔWh, Workday	Weighted ΔWh, Non-Workday
LCD Monitor	1.4	4	1.1	12	24	69%	13.2	18.7
CRT Monitor	12.1	4	0.8	12	24	25%	14.5	4.8
Printer (average of laser and ink)	N/A	0	1.4	20	24	43%	12.2	14.7
Multifunction Printer (average of laser and ink)	N/A	0	4.2	20	24	12%	10.1	12.1
Speakers	1.8	4	1.8	12	24	1%	0.3	0.4
Scanner	N/A	0	2.5	20	24	7%	3.5	4.2
Copier	N/A	0	1.5	20	24	5%	1.5	1.8
Modem	3.9	16	3.8	0	24	8%	4.9	7.4
Charger	2.2	0	0.3	20	24	50%	2.6	3.1
Total							**62.7**	**67.1**

* Standby and off load values from Lawrence Berkeley National Laboratory. “Standby Power Summary Table.” Last updated 2015. http://standby.lbl.gov/summary-table.html. Hours of operation based on engineering estimates.

$\Delta Wh_{NON\text{-}WORKDAY}$ = Energy savings from devices plugged into the strip on non-work days (= 67.1 Wh)

Summer Peak Coincident Demand Reduction

There is no expected peak demand reduction associated with this measure.[386]

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.

---

[385] This value is assuming two weeks of vacation and two weeks of holidays annually.

[386] This is based on the assumption that most office equipment will be operating during the peak coincident hour.

Plug Load Occupancy Sensor (Retrofit)

	Measure Details
Official Measure Code	CI-Plug-OccSens-1
Measure Unit	Per control
Measure Category	Plug Load
Sector(s)	Commercial
Annual Energy Savings (kWh)	Varies by device
Peak Demand Reduction (kW)	0
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	Varies by device
Lifetime Fossil Fuel Savings (MMBtu)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	8
Incremental Cost	$70.00
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

Plug load occupancy sensors control low wattage office equipment using an occupancy sensor. They typically use an infrared sensor to monitor movement, and use a smart strip to turn off connected devices, or put them in standby mode, when no one is present.

Definition of Efficient Equipment

The installed equipment must be a ‘smart’ power strip with both control and peripheral outlets, and an occupancy sensor.

Definition of Baseline Equipment

The baseline condition assumes a mix of typical document station office equipment (printers, scanners, fax machines, etc.) with uncontrolled standby load.

Deemed Lifetime of Efficient Equipment

The estimated useful life for a smart strip plug outlet is 8 years.[387]

Deemed Measure Cost

The incremental cost for this measure is $70.00.[388]

---

[387] British Columbia Hydro. *Smart Strip Electrical Savings and Usability*. October 2008. Unit can only take one surge, then need to be replaced.

[388] Research Into Action. *Plug Load Characterization Study*. Prepared for Southern California Edison. 2010.

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\Delta \text{kWh} = WORKDAYS * \frac{\Delta Wh_{SLEEP}}{1{,}000}$$

Where:

WORKDAYS = Average number of workdays, or business days, in a year (= 240)[389]

ΔWh_{SLEEP} = Daily energy savings from devices plugged into strip when in sleep mode (= 704 Wh; see table below)

Standby Power Consumption for Devices Using Smart Strip Plug Outlets* (All values in Watts)

Computer Peripherals	Connected Load When On	Connected Load in Sleep	Hours in Sleep Mode	Daily Savings (ΔWh_{SLEEP})
Laser Printer	131	2	4	516
Multi-function device, laser (scanner, fax)	50	3	4	188
Total				**704**

* Standby loads from: Lawrence Berkeley National Laboratory. "Standby Power Summary Table." Last updated 2015. http://standby.lbl.gov/summary-table.html.

Hours of operation based on engineering estimations.

Summer Peak Coincident Demand Reduction

There is no expected peak demand reduction associated with this measure.[390]

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.

---

[389] Assumes two weeks of vacation and two weeks of holidays annually.

[390] Based on the assumption that office equipment will be running during the peak period.

Process

High Efficiency Pumps

	Measure Details
Official Measure Code	CI-Proc-Pump-1
Measure Unit	Per pump motor
Measure Category	Process
Sector(s)	Commercial
Annual Energy Savings (kWh)	Varies by horsepower
Peak Demand Reduction (kW)	Varies by horsepower
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	Varies by horsepower
Lifetime Fossil Fuel Savings (MMBtu)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15
Incremental Cost	Varies by project
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is pump efficiency improvements in commercial and industrial applications.

Definition of Efficient Equipment

The efficient condition is an efficient pump and motor combination, with an EISA-compliant motor.

Definition of Baseline Equipment

The baseline condition is a standard efficiency pump and motor combination.

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 15 years.

Deemed Measure Cost

The incremental cost for this measure is shown below.

Incremental Cost by Motor Size

Motor Size (hp)	Incremental Cost (per hp)
1.5	$233.33
2	$175.00
3	$116.67
5	$68.20
7.5	$66.40
10	$33.20
15	$39.00
20	$42.50

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\Delta kWh = hp * 0.746 * (\frac{1}{\eta Motor_{BASE} * \eta Pump_{BASE}} - \frac{1}{\eta Motor_{Eff} * \eta Pump_{Eff}}) * LF * \frac{Hrs}{year}$$

Where:

hp = Horsepower of motor

$\eta Pump_{BASE}$ = Baseline pump efficiency

$\eta Pump_{EFF}$ = Efficient pump efficiency

$\eta Motor_{BASE}$ = Baseline pump motor efficiency

$\eta Motor_{EFF}$ = Efficient pump motor efficiency

LF = Motor load factor (= 0.66)

Hrs/year = Hours of pump operation per year (= actual; otherwise use 3,680)

Pump and motor efficiency are a function of the motor size, shown in table below.

Pump and Motor Efficiency by Motor Size

Motor Size (hp)	$\eta Pump_{BASE}$	$\eta Pump_{EFF}$	$\eta Motor_{BASE}$	$\eta Motor_{EFF}$
1.5	0.60	0.63	0.80	0.86
2	0.60	0.63	0.80	0.87
3	0.60	0.65	0.81	0.90
5	0.60	0.68	0.82	0.90
7.5	0.64	0.73	0.82	0.91
10	0.66	0.75	0.85	0.92
15	0.69	0.77	0.86	0.93
20	0.72	0.77	0.87	0.93

Some pump replacements may not involve a motor replacement. If the existing motor is retained, use the baseline motor efficiency in the calculations.

For example, the energy savings from upgrading a 10 hp pump and motor would be:

$$\Delta kWh = 10 * 0.746 * \left(\frac{1}{0.85 * 0.66} - \frac{1}{0.92 * 0.75}\right) * 0.66 * 3{,}680 = 6{,}038 \text{ kWh}$$

Summer Peak Coincident Demand Reduction

$$\Delta kW = HP * 0.746 * (\frac{1}{\eta Motor_{BASE} * \eta Pump_{BASE}} - \frac{1}{\eta Motor_{Eff} * \eta Pump_{Eff}}) * LF * CF$$

Where:

CF = Summer peak coincidence factor (= 0.78)

For example, the demand reduction from upgrading a 10 hp pump and motor would be:

$$\Delta kW = 10 * 0.746 * \left(\frac{1}{0.85 * 0.66} - \frac{1}{0.92 * 0.75}\right) * 0.66 * 0.78 = 1.28 \text{ kW}$$

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.

Deemed Savings for this Measure

Deemed values for Annual kWh and Summer Coincident Peak kW Savings as a function of pump motor size are estimated below.

Motor Size (hp)	kWh savings per year	kW savings
1.5	617	0.13
2	900	0.19
3	1,841	0.39
5	3,528	0.75
7.5	5,438	1.15
10	5,952	1.26
15	7,848	1.66
20	7,246	1.54

Engineered Nozzles (Time of Sale, Retrofit - Early Replacement)

	Measure Details
Official Measure Code	CI-Proc-CANozzle-1
Measure Unit	Per nozzle
Measure Category	Process
Sector(s)	Commercial
Annual Energy Savings (kWh)	Varies by size
Peak Demand Reduction (kW)	Varies by size
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	Varies by size
Lifetime Fossil Fuel Savings (MMBtu)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15
Incremental Cost	$14.00
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

Engineered nozzles use compressed air to entrain and amplify atmospheric air into a stream, thus increasing pressure with minimal compressed air use. They are able to induce a large airflow entrainment while still using a smaller volume of air than open jets. The velocity of the resulting airflow is reduced, but the mass flow of the air is increased, thus increasing the cooling and drying effect. Energy savings result due to the decrease in compressor work required to provide the nozzles with compressed air. Engineered nozzles have the added benefits of noise reduction and improved safety in systems with greater than 30 psig.

Definition of Efficient Equipment

The efficient condition is an engineered nozzle equipped to the end of a pneumatic tool.

Definition of Baseline Equipment

The baseline condition is an open copper tube or an air gun with an open end.

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 15 years.[391]

---

[391] PA Consulting Group. *Business Programs: Measure Life Study.* Prepared for State of Wisconsin Public Service Commission. 2009.

Deemed Measure Cost

The deemed cost for this measure is $14.00.

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\Delta\text{kWh} = (FLOW_{BASE} - FLOW_{ENG}) * kW_{SCFM} * \%USE * HOURS$$

Where:

kW_{SCFM} = Average electrical demand needed to produce one cubic foot of air at 100 psi (= 0.29)

$\text{FLOW}_{\text{BASE}}$ = Flow rate of compressed air from an open end in SCFM[392]

FLOW_{ENG} = Flow rate of compressed air from an engineered nozzle in SCFM (= depending on size of nozzle, see table below)

Flow Rate by Nozzle Size

	Open Flow (SCFM)* $\text{FLOW}_{\text{BASELINE}}$	Engineered Nozzle (SCFM)** FLOW_{ENG}	ΔSCFM
1/8" Nozzle	21	6	15
1/4" Nozzle	58	11	47

* Machinery's Handbook 25th Edition.

** Survey of Engineered Nozzle Suppliers.

%USE = Percentage of the compressor total operating hours that nozzle is in use (= 3 seconds of use per minute, or 0.05)[393]

HOURS = Annual operating hours of the compressed air system (= actual; otherwise based on number of facility shifts as shown in table below)

---

[392] SCFM is the flowrate (cfm) at standard conditions of temperature, pressure, and humidity.

[393] This value assumes 50% handheld air guns and 50% stationary air nozzles. Manual air guns tend to be used less than stationary air nozzles, and a conservative estimate of 1 second of blow-off per minute of compressor run time is assumed. Stationary air nozzles are commonly more wasteful, as they are often mounted on machine tools and can be manually operated (resulting in the possibility of a long-term open blow situation).

Annual Operating Hours by Number of Shifts

No. of Shifts	HOURS	Description
Single Shift (8:00 a.m. to 5:00 p.m.)	1,976	7:00 a.m. to 3:00 p.m. weekdays, minus holidays and scheduled downtime
Two Shifts	3,952	7:00 a.m. to 11:00 p.m. weekdays, minus holidays and scheduled downtime
Three Shifts	5,928	24 hours per weekday, minus holidays and scheduled downtime
Four Shifts	8,320	24 hours per day, minus holidays and scheduled downtime

Summer Peak Coincident Demand Reduction

$$\Delta \text{kW} = \frac{\Delta\, kWh}{HOURS} * CF$$

Where:

ΔkWh = Energy savings as calculated above

HOURS = Annual operating hours

CF = Summer peak coincidence factor (= 0.75)[394]

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.

---

[394] *Pacific Gas and Electric, and San Diego Gas and Electric Time of Use Surveys*. 1996. Values based on 4:00 p.m. to 5:00 p.m. as peak hour of use.

Insulated Pellet Dryers (Retrofit)

	Measure Details
Official Measure Code	CI-Proc-InsulPellet-1
Measure Unit	Per heat duct area
Measure Category	Process
Sector(s)	Commercial
Annual Energy Savings (kWh)	Varies by load
Peak Demand Reduction (kW)	Varies by load
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	Varies by load
Lifetime Fossil Fuel Savings (MMBtu)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	5
Incremental Cost	Varies by project
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

Resin pellets used in injection molders and extruders are typically dried using electrically heated and desiccant dried air. Flexible ducts in the 3-inch to 8-inch diameter size range circulate the drying air. Air temperatures usually range from 160°F to 200°F. Un-insulated duct heat loss must be replaced by electric resistance heaters. Most facilities have pellet dryers running constantly to maintain pellet dryness at all times.

Definition of Efficient Equipment

The efficient condition is a pellet dryer with insulation on the heat ducts.

Definition of Baseline Equipment

The baseline condition is a pellet dryer with un-insulated heat ducts.

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 5 years.[395]

Deemed Measure Cost

Incremental costs are based on the linear feet and diameter of heating ducts.

---

[395] This lifetime is based on engineering judgment.

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\Delta\text{kWh} = L * (kW_{BASE} - kW_{EFF}) * HOURS$$

Where:

L = Length of pipe to be insulated in feet

kW_{BASE} = Maximum hourly demand at technology level without insulation (= see table in Reference Table section)

kW_{EFF} = Maximum hourly demand at technology level with pipe insulation (= see table in Reference Table section)

HOURS = Annual operating hours (= 4,962)[396]

Summer Peak Coincident Demand Reduction

$$\Delta\text{kW} = L * (kW_{BASE} - kW_{EFF}) * CF$$

Where:

CF = Summer peak coincident factor (= 0.75)[397]

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.

Reference Table

Electric Demand by Load Temperature and Duct Diameter

Temperature (°F)	Duct Diameter (inches)	kW Baseline	kW Energy Efficient	ΔkW
160	3	0.03/ft	0.01/ft	0.02/ft
	4	0.04/ft	0.01/ft	0.03/ft
	5	0.05/ft	0.01/ft	0.04/ft
	6	0.06/ft	0.01/ft	0.05/ft
	8	0.09/ft	0.01/ft	0.08/ft
170	3	0.03/ft	0.01/ft	0.03/ft
	4	0.05/ft	0.01/ft	0.04/ft

---

[396] PA Consulting Group Inc. *State of Wisconsin Public Service Commission of Wisconsin, Focus on Energy Evaluation, Business Programs: Deemed Savings Parameter Development*. August 2009.

[397] *Pacific Gas and Electric, San Diego Gas and Electric, and Time of Use Surveys*. 1996.

Temperature (°F)	Duct Diameter (inches)	kW Baseline	kW Energy Efficient	ΔkW
	5	0.06/ft	0.01/ft	0.05/ft
	6	0.07/ft	0.01/ft	0.06/ft
	8	0.10/ft	0.01/ft	0.09/ft
180	3	0.04/ft	0.01/ft	0.03/ft
	4	0.05/ft	0.01/ft	0.04/ft
	5	0.07/ft	0.01/ft	0.06/ft
	6	0.08/ft	0.01/ft	0.07/ft
	8	0.11/ft	0.01/ft	0.10/ft
190	3	0.04/ft	0.01/ft	0.04/ft
	4	0.06/ft	0.01/ft	0.05/ft
	5	0.07/ft	0.01/ft	0.06/ft
	6	0.09/ft	0.01/ft	0.08/ft
	8	0.13/ft	0.02/ft	0.11/ft
200	3	0.05/ft	0.01/ft	0.04/ft
	4	0.07/ft	0.01/ft	0.06/ft
	5	0.08/ft	0.01/ft	0.07/ft
	6	0.10/ft	0.01/ft	0.09/ft
	8	0.14/ft	0.02/ft	0.12/ft

Injecting Molding Barrel Wrap (Retrofit – New Equipment)

	Measure Details
Official Measure Code	CI-Proc-IMMWrap-1
Measure Unit	Per blanket or vest
Measure Category	Process
Sector(s)	Commercial
Annual Energy Savings (kWh)	Varies by operating temperature
Peak Demand Reduction (kW)	Varies by operating temperature
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	Varies by operating temperature
Lifetime Fossil Fuel Savings (MMBtu)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	5
Incremental Cost	Varies by project
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

Removable insulated blankets enclose the cylindrical barrels of an injection molding machine. Surface temperatures of the barrels range from 300°F to 600°F, depending on the resins processed. Barrels are heated either with electric resistance band heaters or by friction from the mechanical screw (which shears plastic material in the barrel, generating frictional heat). Insulated blankets minimize the use of resistance heating without affecting the temperature control of the resin. Barrel wraps are held in place by straps. Blankets are available either standard sizes or can be custom manufactured.

Definition of Efficient Equipment

The efficient condition is an injection molding machine with an insulating blanket or vest wrapped around the barrel.

Definition of Baseline Equipment

The baseline condition is an injection molding machine with no added insulation.

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 5 years.

Deemed Measure Cost

The actual measure installation cost should be used (including material and labor).

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\Delta kWh = \frac{\Delta\, E_{LOSS} * LEN_{BARREL} * D_{BARREL} * \pi}{1{,}000} * HOURS$$

Where:

ΔE_{LOSS} = Difference in heat loss (measured in watts per square foot needed to replace lost heat) between an injection molding barrel with insulation and an injection molding barrel without insulation (= dependent on operating temperature and thickness of insulation; see table below)

Difference in Heat Loss (W/sqft) by Operating Temperature and Insulation Thickness

Calculating Barrel Heat Loss*	Amount of Insulation		
Operating Temperature (°F)	No Insulation	1-Inch	1.5-Inches
300	180	18.6	12.4
325	210	20.9	14
350	243	23.4	15.6
375	275	26	17.3
400	313	29	19
425	350	31.5	21
450	387	34.3	22.9
475	425	37.2	24.8
500	465	40.1	25.8
525	505	43.2	26.9
550	550	46.5	28.3
575	605	49.9	29.9
600	660	54.1	32.1

* Industrial Modeling Supplies. *Reference/Conversion Chart*. 2009. Available online: http://www.imscompany.com/pdf/Tech%20Tips%20&%20Conversion%20and%20Reference%20Charts.pdf

LEN_{BARREL} = Length of barrel (= actual)

D_{BARREL} = Diameter of barrel (= actual)

π = Pi is used to calculate the surface area of the insulated barrel

1,000 = Conversion factor from watts to kilowatts

HOURS = Annual operating hours (= actual; otherwise assume 3,952)[398]

---

[398] The default annual operating hours assume that equipment operates continuously on a typical 2-shift operation (7:00 a.m. to 11:00 p.m. weekdays, minus some holidays and scheduled down time).

Summer Peak Coincident Demand Reduction

$$\Delta kW = \frac{\Delta E_{LOSS} * LEN_{BARREL} * D_{BARREL} * \pi}{1,000} * CF$$

Where:

CF = Summer peak coincidence factor (= 0.75)[399]

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.

---

[399] AUTHOR. *Pacific Gas and Electric, RLW Schools, RLW CF, and San Diego Gas and Electric Time of Use Surveys*. 1996. Pending verification based on information to be provided by the utilities.

Efficient Air Compressors (Time of Sale)

	Measure Details
Official Measure Code	CI-Proc-AirComp-1
Measure Unit	Per compressor
Measure Category	Process
Sector(s)	Industrial
Annual Energy Savings (kWh)	Varies by project
Peak Demand Reduction (kW)	Varies by project
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	
Lifetime Fossil Fuel Savings (MMBtu)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15
Incremental Cost	Varies by project
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is installing an air compressor with a variable frequency drive, load/no load controls, or variable displacement controls. Baseline compressors choke off the inlet air to modulate the compressor output, which is not efficient. Efficient compressors use less energy at part load conditions. Demand curves are per U.S. Department of Energy data for a variable speed compressor versus a modulating compressor. This measure could relate to replacing an existing unit at the end of its useful life, or installing a new system in a new building (i.e., time of sale).

Definition of Efficient Equipment

The efficient equipment is an air compressor with a variable frequency drive, load/no load controls,[400] or variable displacement controls.

Definition of Baseline Equipment

The baseline equipment is a modulating air compressor with blow down.

Deemed Lifetime of Efficient Equipment

The expected measure life is 15 years.[401]

---

[400] For analysis purposes, it is assumed that the compressed air system with load/no load controls uses an air receiver with a storage capacity of 5 gallons per cubic foot per minute of compressor capacity.

[401] Based on a review of TRM assumptions from Vermont, New Hampshire, Massachusetts, and Wisconsin. Estimates range from 10 to 15 years.

Deemed Measure Cost

The incremental capital costs for this measure should be determined on a case-by-case basis. For analysis purposes, assume the incremental costs specified in the table below.

Incremental Measure Cost by Compressor Type

Compressor Type	Incremental Cost*
Load/No Load	\$200.00/hp
Variable Displacement	\$250.00/hp
Variable Frequency Drive	\$300.00/hp

* VEIC. *Technical Reference Manual (TRM) for Ohio Senate Bill 221 Energy Efficiency and Conservation Program and 09-512-GE-UNC*. October 15, 2009. Future study of these estimates is recommended, as published estimates of incremental costs for efficient air compressors are scarce. Costs do not include adding a receiver tank; it is assumed that a receiver tank of adequate size is an existing part of the system.

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\Delta \text{kWh} = Bhp * \frac{0.746}{\eta_{MOTOR}} * HOURS * ESF$$

Where:

Bhp = Compressor motor full load brake horsepower (= actual)

0.746 = Conversion factor from horsepower to kilowatts

η_{MOTOR}= Compressor motor nameplate efficiency (= actual; otherwise assume 90%)[402]

HOURS = Total hours of compressor operation (= actual)

ESF = Energy savings factor (= dependent on compressor control type as shown in table below)

---

[402] Improving Compressed Air System Performance: A Sourcebook for Industry, U.S. Department of Energy, November 2003.

Energy Saving Factor by Control Type

Control Type	Energy Savings Factor*
Load/No Load	10%
Variable Displacement	17%
Variable Frequency Drive	26%

* Developed using U.S. Department of Energy part load data for different compressor control types, as well as load profiles from 50 facilities employing air compressors.

Summer Peak Coincident Demand Reduction

$$\Delta\text{kW} = \frac{\Delta kWh}{HOURS} * CF$$

Where:

CF = Summer peak coincidence factor (= 0.38)[403]

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.

---

[403] *Technical Reference Manual (TRM) for Ohio Senate Bill 221 Energy Efficiency and Conservation Program and 09-512-GE-UNC*. October 15, 2009. This is likely a conservative estimate, but is recommended for further study.

Commercial Clothes Washer (Time of Sale)

	Measure Details
Official Measure Code	CI-Proc-CloWash-1
Measure Unit	Per washer
Measure Category	Process
Sector(s)	Commercial
Annual Energy Savings (kWh)	Varies by water heater
Peak Demand Reduction (kW)	Varies by water heater
Annual Fossil Fuel Savings (MMBtu)	Varies by water heater
Lifetime Energy Savings (kWh)	Varies by water heater
Lifetime Fossil Fuel Savings (MMBtu)	Varies by water heater
Water Savings (gal/yr)	15,854 gallons per year
Effective Useful Life (years)	10
Incremental Cost	Varies by CEE Tier
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

High-efficiency commercial washers are intended for purchase and installation in laundromats, multifamily buildings, and institutions. These high-efficiency washers are nearly identical to residential models available in retail outlets, with minor engineering changes, such as the addition of a coin box. High-efficiency commercial washers typically save up to 50% of the energy costs and use 30% less water.

Definition of Efficient Equipment

The efficient equipment is a commercial-grade clothes washer meeting the minimum efficiency standards for ENERGY STAR (MEF ≥ 2.0). Also, the facility where the equipment is installed must have an electric water heater.

Definition of Baseline Equipment

The baseline equipment is a commercial-grade clothes washer that meets federal manufacturing standards (MEF ≥1.26).

Deemed Lifetime of Efficient Equipment

The effective measure life for commercial-grade clothes washers is 10 years.[404]

---

[404] *2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05*. “Effective/Remaining Useful Life Values.”

Deemed Measure Cost

The deemed measure cost is $347.00 per unit ENERGY STAR/CEE Tier1, $475.00 per unit CEE Tier 2, and $604.00 per unit CEE Tier 3.[405]

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\Delta\text{kWh} = \Delta kWh_{LOAD} * Loads_{YEAR}$$

Where:

$\Delta\text{kWh}_{\text{LOAD}}$ = Difference in electricity consumption per load of laundry between baseline equipment and efficient equipment (= dependent on energy source for washer, see table below)[406]

Assumptions for Electricity and Natural Gas Consumption for Commercial Clothes Washers

Fuel Source	ΔkWh per Load	MMBtu per Load
Electric Hot Water, Electric Dryer	0.57	0
Natural Gas Hot Water, Electric Dryer	0.25	0.002

$\text{Load}_{\text{YEAR}}$ = Number of loads per year (= 950)[407]

For example, the energy savings from installing a commercial clothes washer in a facility with electric water heating and electric drying would be:

$$\Delta\text{kWh} = 0.57 * 950 = 541.5\text{ kWh}$$

Summer Peak Coincident Demand Reduction

No demand reduction is claimed for this measure since there is insufficient peak coincident data.

---

[405] *2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05*. "Cost Values and Summary Documentation."

[406] ENERGY STAR. *Calculator for Commercial Clothes Washers.* July 2009. Values based on the difference between the average of all qualified models and the average of all unqualified models.

[407] Multi-Family Laundry Association. *ENERGY STAR Calculator for Commercial Clothes Washers.* 2002.

Fossil Fuel Impact Descriptions and Calculation

Commercial clothes washers will only have fossil fuel impacts when either the washer, dryer, or both are powered by natural gas.

$$\Delta\text{MMBtu} = \Delta MMBtu_{LOAD} * Loads_{YEAR}$$

Where:

$\Delta\text{MMBtu}_{\text{LOAD}}$ = Difference in natural gas consumption per load of laundry between baseline equipment and efficient equipment (= dependent on energy source for washer and dryer, see table above)

$\text{Loads}_{\text{YEAR}}$ = Number of loads per year (= 950)

Water Impact Descriptions and Calculation

The water savings from a commercial clothes washer is 15,854 gallons per year.[408]

---

[408] ENERGY STAR. *Calculator for Commercial Clothes Washers.* July 2009. Average water consumption based on all qualified models.

Refrigeration

LED Case Lighting with/without Motion Sensors (New Construction; Retrofit – Early Replacement

	Measure Details
Official Measure Code	CI-Refrig-LEDCase-1
Measure Unit	Per fixture
Measure Category	Refrigeration
Sector(s)	Commercial
Annual Energy Savings (kWh)	Varies by lamp type
Peak Demand Reduction (kW)	Varies by lamp type
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	Varies by lamp type
Lifetime Fossil Fuel Savings (MMBtu)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	8
Incremental Cost	Varies by project
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is installing LED lamps with or without motion sensors in vertical display refrigerators, coolers, and freezers to replace T8 or T12 linear fluorescent lamp technology. LED lamps should be intended for this application. LED lamps not only provide the same light output with lower connected wattages, but produce less waste heat (which decreases the cooling load on the refrigeration system and the amount of energy needed by the refrigerator compressor). Additional savings can be achieved from installing a motion sensor that automatically dims the lighting system when the space is unoccupied. Retrofit projects must completely remove the existing fluorescent fixture end connectors and ballasts to qualify, though wiring may be reused. Eligible fixtures include new, replacement, and retrofit. Savings and assumptions are based on a per-door basis.

Definition of Efficient Equipment

The efficient equipment is LED case lighting with or without motion sensors on refrigerators, coolers, and freezers (specifically on vertical displays).

Definition of Baseline Equipment

The baseline equipment is T8 or T12 linear fluorescent lamps.

Deemed Lifetime of Efficient Equipment

The expected measure life is 8 years.[409]

Deemed Measure Cost

The incremental capital cost for this measure is $250.00 per door retrofit, or $150.00 for time of sale, new construction.[410]

If a motion sensor is installed, there is an additional cost of $130.00 per every 25 feet of case.[411]

Deemed O&M Cost Adjustments

The stream of baseline lamp replacement costs over the lifetime of the measure results in a net present value of $22.96.[412] This computes to a levelized annual baseline replacement cost assumption of $4.07.

Baseline Lamp Cost:	$4.00
Baseline Lamp Life:	12,000 hours
Baseline Lamp Labor Cost:	$5.00 (15 min @ $20 per hour labor)

Savings Algorithm

Energy Savings

$$\Delta \text{kWh} = \frac{WATTS_{BASE} - WATTS_{EE}}{1{,}000} * (\text{N} + 1) * HOURS * (1 + WHF_E) * ESF_{MC}$$

Where:

$WATTS_{BASE}$ = Connected wattage per door of baseline fixtures (= see table below)

$WATTS_{EE}$ = Connected wattage per door of high-efficiency fixtures (= actual; otherwise see table below)

---

[409] Theobald, M. A., Pacific Gas and Electric Company. *Emerging Technologies Program: Application Assessment Report #0608, LED Supermarket Case Lighting Grocery Store, Northern California*. January 2006. Available online: http://www.etcc-ca.com/images/stories/pdf/ETCC_Report_204.pdf. Assumes 6,205 annual operating hours, and that the lifetime of the motion sensors is equal to the lifetime of the LED lighting.

[410] Based on a review of TRM incremental cost assumptions from Oregon and Vermont, supplemented with completed project information from New York.

[411] Michele Friedrich, Portland Energy Conservation. "LED Case Lighting With and Without Motion Sensors." Presentation. January 2010.

[412] This value is based on using a discount rate of 5.7% (as is used for Efficiency Vermont), and assumes the baseline ballast life exceeds the life of the LED assembly.

Baseline and Efficient Wattage by Measure Type*

Type of Measure	Efficient Lamp	Efficient Fixture Wattage ($WATTS_{EE}$)	Baseline Fixture Wattage ($WATTS_{BASE}$)	Fixture Savings (Watts)
Refrigerated Case Lighting (per door)	5’ LED Case Lighting System	30	55	25
	6’ LED Case Lighting System	36	66	20

* Based on Wisconsin TRM V4.0 (2015) assumption of 11 W/ft of baseline fluorescent case lighting and 6 W/ft of LED case lighting.

1,000 = Conversion factor from watts to kilowatts

N = Number of doors (= actual; note: N+1 accounts for the additional fixture that is present in a row of case lighting doors)

HOURS = Annual operating hours (= actual; otherwise assume 6,205)[413]

ESF_{MC} = Energy savings factor; additional savings percentage achieved with a motion sensor (= 1.0 if no motion sensor is installed; = 1.43 if motion sensor installed)[414]

WHF_E= Waste heat factor for energy to account for cooling savings from efficient lighting (= 0.41 for refrigerated space; = 0.52 for freezer space)[415]

Summer Peak Coincident Demand Reduction

$$\Delta kW = \frac{WATTS_{BASE} - WATTS_{EE}}{1{,}000} * (N+1) * CF * (1 + WHF_D) * DSF_{MC}$$

---

[413] Theobald, M. A., Pacific Gas and Electric Company. *Emerging Technologies Program: Application Assessment Report #0608, LED Supermarket Case Lighting Grocery Store, Northern California*. January 2006. Available online: http://www.etcc-ca.com/images/stories/pdf/ETCC_Report_204.pdf. Assumes refrigerated case lighting typically operates 17 hours per day, 365 days per year.

[414] D. Bisbee, Sacramento Municipal Utility District. *Customer Advanced Technologies Program Technology Evaluation Report: LED Freezer Case Lighting Systems.* July 2008.

[415] Hall, N. et al., TecMarket Works. *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Measures in Commercial and Industrial Programs.* September 1, 2009. This factor is a candidate for future adjustments due to climatic differences between Indiana and New York.

Where:

WHF_D = Waste heat factor for energy to account for cooling savings from efficient lighting (= 0.41 for prescriptive refrigerated lighting measures; = 0.52 for freezer space)[416]

DSF_{MC} = Demand savings factor; additional savings percentage achieved with a motion sensor (= 1.0 if no motion sensor is installed; = 1.43 if motion sensor installed)[417]

CF = Summer peak coincidence factor (= 0.92)[418]

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts associated with this measure.

---

[416] Ibid.

[417] D. Bisbee, Sacramento Municipal Utility District. *Customer Advanced Technologies Program Technology Evaluation Report: LED Freezer Case Lighting Systems.* July 2008.

[418] Kuiken et al., KEMA. *State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Deemed Savings Parameter Development.* November 13, 2009. Summer peak coincident period is defined as June through August on weekdays between 3:00 p.m. and 6:00 p.m., unless otherwise noted.

Refrigerated Case Covers (Time of Sale, New Construction, Retrofit – New Equipment)

	Measure Details
Official Measure Code	CI-Refrig-CaseCover-1
Measure Unit	Per cover
Measure Category	Refrigeration
Sector(s)	Commercial
Annual Energy Savings (kWh)	Varies by linear foot
Peak Demand Reduction (kW)	Varies by linear foot
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	Varies by linear foot
Lifetime Fossil Fuel Savings (MMBtu)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	5
Incremental Cost	$42.00 per linear foot
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

By covering refrigerated cases, the heat gain from spilling refrigerated air and convective mixing with room air is reduced at the case opening. Continuous curtains can be pulled down overnight while the store is closed, yielding significant energy savings.

Definition of Efficient Equipment

The efficient equipment is a refrigerated case with a continuous cover deployed during overnight periods. The savings are based on covers being deployed for six hours daily.

Definition of Baseline Equipment

The baseline equipment is a refrigerated case without a cover.

Deemed Lifetime of Efficient Equipment

The expected measure life is 5 years.[419]

---

[419] California Public Utilities Commission. *2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05*. "Effective/Remaining Useful Life Values." December 16, 2008.

Deemed Measure Cost

The incremental capital cost is $42.00 per linear foot of cover installed, including material and labor.[420]

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\Delta \text{kWh} = \frac{LOAD}{12{,}000} * FEET * \frac{3.516}{COP} * ESF * 8{,}760$$

Where:

LOAD = Average refrigeration load per linear foot of refrigerated case without night covers deployed (= 1,500 Btu/hr)[421]

12,000 = Conversion factor of Btu per ton of cooling

FEET = Linear (horizontal) feet of covered refrigerated case (= actual)

3.516 = Conversion factor from coefficient of performance to kilowatts per ton

COP = Coefficient of performance for refrigerated case (= actual; otherwise assume 2.2)[422]

ESF = Energy savings factor; reflects the percentage reduction in refrigeration load due to the deployment of night covers (= 9%)[423]

8,760 = Assumed annual operating hours of refrigerated case

Summer Peak Coincident Demand Reduction

There is no expected peak demand reduction associated with this measure.[424]

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.

---

[420] California Public Utilities Commission. *2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05.* "Cost Values and Summary Documentation." December 16, 2008.

[421] Davis Energy Group. *Analysis of Standard Options for Open Case Refrigerators and Freezers.* May 11, 2004.

[422] Kuiken et al., KEMA. *Focus on Energy Evaluation, Business Programs: Deemed Savings Manual V1.0.* March 22, 2010.

[423] Southern California Edison. *Effects of the Low Emissivity Shields on Performance and Power Use of a Refrigerated Display Case*. August 8, 1997. Available online: http://www.sce.com/NR/rdonlyres/2AAEFF0B-4CE5-49A5-8E2C-3CE23B81F266/0/AluminumShield_Report.pdf

[424] Because continuous covers are deployed at night, no demand reduction occurs during the peak period.

Door Heater Controls for Cooler or Freezer (Time of Sale)

	Measure Details
Official Measure Code	CI-Refrig-ASHCtrl-1
Measure Unit	Per heater
Measure Category	Refrigeration
Sector(s)	Commercial
Annual Energy Savings (kWh)	Varies by connected load
Peak Demand Reduction (kW)	Varies by connected load
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	Varies by connected load
Lifetime Fossil Fuel Savings (MMBtu)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	12
Incremental Cost	$200.00
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

Significant energy savings can be realized by installing a control device to turn off door heaters when there is little or no risk of condensation. There are two commercially available "on-off" control strategies for door heaters:

1. The first is based on the relative humidity of the air in the store. The system activates door heaters when the relative humidity in the store rises above a specific setpoint, and turns them off when the relative humidity falls below that setpoint.
2. The second is based on the conductivity of the door (which drops when condensation appears). The sensor activates door heaters when the door conductivity falls below a certain setpoint, and turns them off when the conductivity rises above that setpoint.

Definition of Efficient Equipment

The efficient equipment is a door heater control on a commercial glass door cooler or refrigerator with humidity or conductivity control.

Definition of Baseline Equipment

The baseline condition is a commercial glass door cooler or refrigerator with a standard heated door with no controls installed.

Deemed Lifetime of Efficient Equipment

The expected measure life is 12 years.[425]

Deemed Measure Cost

The incremental capital cost for a humidity based control is $300.00 per circuit, regardless of the number of doors controlled. The incremental cost for conductivity based controls is $200.00.[426]

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\Delta \text{kWh} = kW_{BASE} * NUM_{DOORS} * ESF * BF * 8{,}760$$

Where:

kW_{BASE} = Connected load kilowatts for typical reach-in refrigerator or freezer door and frame with a heater (= actual; otherwise assume 0.195 kW for freezers and 0.092 kW for coolers)[427]

NUM_{DOORS} = Number of reach-in refrigerator or freezer doors controlled by sensor (= actual)

ESF = Energy savings factor; represents the percentage of hours annually that the door heater is powered off due to the controls (= 55% for humidity based controls, = 70% for conductivity based controls)[428]

BF = Bonus factor; represents the increased savings due to the reduced cooling load inside the cases (=1.36 for low-temperature applications, =

---

[425] California Public Utilities Commission. *2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05.* "Effective/Remaining Useful Life Values." December 16, 2008.

[426] Efficiency Vermont. *Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions.* February, 19, 2010.

[427] A review of TRM methodologies from Connecticut, New York, Vermont, and Wisconsin reveals several different sources for this factor. Connecticut requires site-specific information, whereas New York's characterization does not explicitly identify the kW_{BASE}. Connecticut and Vermont provide very consistent values, and the simple average of these two values was used.

[428] A review of TRM methodologies from Connecticut, New York, Vermont, and Wisconsin reveals several different estimates of the energy savings factor. Vermont has the only TRM that provides savings estimates dependent on the control type, and these estimates are the most conservative of all TRMs reviewed. The Vermont TRM values were adopted.

1.22 for medium-temperature applications, = 1.15 for high-temperature applications)[429]

Summer Peak Coincident Demand Reduction

There is no expected peak demand reduction associated with this measure.[430]

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.

---

[429] Efficiency Vermont. *Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions*. February, 19, 2010.

[430] This is based on the assumption that humidity levels will most likely be relatively high during the peak period, reducing the likelihood of demand reduction from door heater controls.

ENERGY STAR Ice Machine (Time of Sale, New Construction)

	Measure Details
Official Measure Code	CI-Refrig-IceMach-1
Measure Unit	Per machine
Measure Category	Refrigeration
Sector(s)	Commercial
Annual Energy Savings (kWh)	Varies by project
Peak Demand Reduction (kW)	Varies by project
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	
Lifetime Fossil Fuel Savings (MMBtu)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	9
Incremental Cost	Varies by project
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is installing a new ENERGY STAR-qualified, air-cooled, cube-type commercial ice machine, including ice-making head, self-contained, and remote-condensing units. This measure could relate to replacing an existing unit at the end of its useful life, or installing a new system in a new or existing building.

Definition of Efficient Equipment

The efficient equipment is a commercial ice machine meeting the minimum ENERGY STAR efficiency standards.

Definition of Baseline Equipment

The baseline equipment is a commercial ice machine meeting the federal equipment standards established January 1, 2010.

Deemed Lifetime of Efficient Equipment

The expected measure life is 9 years.[431]

Deemed Measure Cost

The incremental capital cost for this measure is provided in the table below.

---

[431] The following report estimates the life of a commercial ice-maker at 7-10 years: Arthur D. Little, Inc. *Energy Savings Potential for Commercial Refrigeration Equipment*. 1996.

Incremental Capital Cost by Size of Machine

Harvest Rate (H)	Incremental Cost*
100-200 lb. ice machine	$296.00
201-300 lb. ice machine	$312.00
301-400 lb. ice machine	$559.00
401-500 lb. ice machine	$981.00
501-1,000 lb. ice machine	$1,485.00
1,001-1,500 lb. ice machine	$1,821.00
>1,500 lb. ice machine	$2,194.00

* These values are from electronic work papers prepared in support of the following report: San Diego Gas & Electric. *Application for Approval of Electric and Gas Energy Efficiency Programs and Budgets for Years 2009-2011*. March 2, 2009.

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\Delta kWh = \frac{kWh_{BASE} - kWh_{EE}}{100} * DC * H * 365$$

Where:

kWh_{BASE} = Maximum kilowatt-hour consumption per 100 pounds of ice for the baseline equipment (= dependent on machine type; see table below using the actual harvest rate (H) of efficient equipment)

kWh_{EE} = Maximum kilowatt-hour consumption per 100 pounds of ice for the efficient equipment (=dependent on machine type; see table below using the actual harvest rate (H) of efficient equipment)

Ice Machine Type	kWh_{BASE}*	kWh_{EE}**
Ice Making Head (H < 450)	10.26 - 0.0086*H	9.23 - 0.0077*H
Ice Making Head (H ≥ 450)	6.89 – 0.0011*H	6.20 - 0.0010*H
Remote Condensing Unit, without remote compressor (H < 1,000)	8.85 – 0.0038*H	8.05 - 0.0035*H
Remote Condensing Unit, without remote compressor (H ≥ 1,000)	5.1	4.64
Remote Condensing Unit, with remote compressor (H < 934)	8.85 – 0.0038*H	8.05 - 0.0035*H
Remote Condensing Unit, with remote compressor (H ≥ 934)	5.3	4.82
Self-Contained Unit (H < 175)	18 - 0.0469*H	16.7 - 0.0436*H
Self-Contained Unit (H ≥ 175)	9.8	9.11

* Baseline reflects federal standards that apply to units manufactured on or after January 1, 2010 (http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&rgn=div6&view=text&node=10:3.0.1.4.17.8&idno=10).
** U.S. Environmental Protection Agency. *ENERGY STAR Program Requirements for Commercial Ice Machines, Partner Commitments*.

100 = Conversion factor from kWh_{BASE} and kWh_{EE} into maximum kilowatt-hour consumption per pound of ice

DC = Duty cycle of ice machine (= 0.57)[432]

H = Harvest rate of pounds of ice made per day (= actual)

365 = Days per year

Summer Peak Coincident Demand Reduction

$$\Delta kW = \frac{\Delta kWh}{HOURS * DC} * CF$$

---

[432] The duty cycle varies considerably from one installation to the next. TRM assumptions from New York Vermont, and Wisconsin vary from 40% to 57%, while the ENERGY STAR *Commercial Ice Machine Savings Calculator* assumes a value of 75% (http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_Ice_Machines.xls). A field study of eight ice machines in California revealed an average duty cycle of 57% (Food Service Technology Center. *A Field Study to Characterize Water and Energy Use of Commercial Ice-Cube Machines and Quantify Saving Potential*. December 2007.). Furthermore, another report assumed a value of 40% (Nadel, S., American Council for an Energy-Efficient Economy. *Packaged Commercial Refrigeration Equipment: A Briefing Report for Program Planners and Implementers*. December 2002.). These savings are based on the average value of 57% from the California study.

Where:

HOURS = Annual operating hours (= 8,760)[433]

CF = Summer peak coincidence factor (= 0.772)[434]

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.

Water Impact Descriptions and Calculation

While the ENERGY STAR labeling criteria have certain “maximum potable water use per 100 pounds of ice made” requirements for certified commercial ice machines, such requirements are intended to prevent equipment manufacturers from gaining energy efficiency at the cost of water consumptions. The AHRI *Certification Directory*[435] indicates that approximately 81% of air-cooled, cube-type machines meet the ENERGY STAR potable water use requirement. Therefore, there are no assumed water impacts for this measure.

---

[433] A unit is assumed to be connected to power 24 hours per day, 365 days per year.

[434] This value is based on the summer peak coincidence factor for commercial ice machines being consistent with that of general commercial refrigeration equipment. The savings use a value of 77.2% from: Efficiency Vermont. *Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions*. February 19, 2010.

[435] Available online: http://www.ahridirectory.org/ahridirectory/pages/home.aspx

Commercial Solid Door Refrigerators & Freezers (Time of Sale, New Construction)

	Measure Details
Official Measure Code	CI-Refrig-Ref/Freez-1
Measure Unit	Per door
Measure Category	Refrigeration
Sector(s)	Commercial
Annual Energy Savings (kWh)	Varies by equipment type
Peak Demand Reduction (kW)	Varies by equipment type
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	Varies by equipment type
Lifetime Fossil Fuel Savings (MMBtu)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	12
Incremental Cost	Varies by project
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This measure is installing a reach-in commercial refrigerator or freezer meeting ENERGY STAR efficiency standards. ENERGY STAR-labeled commercial refrigerators and freezers are more energy efficient because they are designed with components such as ECM evaporator and condenser fan motors, hot natural gas anti-sweat heaters, or high-efficiency compressors, which significantly reduce energy consumption. This measure could relate to replacing an existing unit at the end of its useful life, or installing a new system in a new or existing building.

Definition of Efficient Equipment

The efficient equipment is a solid or glass door refrigerator or freezer meeting the minimum ENERGY STAR efficiency standards.

Definition of Baseline Equipment

The baseline equipment is a solid or glass door refrigerator or freezer meeting the minimum federal manufacturing standards as specified by the Energy Policy Act of 2005.

Deemed Lifetime of Efficient Equipment

The expected measure life is 12 years.[436]

Deemed Measure Cost

The incremental capital cost for this measure is provided in the table below.

Incremental Cost by Refrigerator or Freezer Volume

Type	Refrigerator Incremental Cost*	Freezer Incremental Cost*
Solid or Glass Door		
Volume ≤ 15	$143.00	$142.00
15 ≤ Volume < 30	$164.00	$166.00
30 ≤ Volume < 50	$164.00	$166.00
Volume ≥ 50	$249.00	$407.00

* Estimates of the incremental cost for commercial refrigerators and freezers varies widely by source. One report indicates that the incremental cost is approximately $0.00 (Nadel, S., American Council for an Energy-Efficient Economy. *Packaged Commercial Refrigeration Equipment: A Briefing Report for Program Planners and Implementers*. December 2002.). Another report assumes incremental cost range from $75.00 to $125.00 depending on equipment volume (Efficiency Vermont. *Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions.* February 19, 2010.). The American Council for an Energy-Efficient Economy notes that incremental cost ranges from 0% to 10% of the baseline unit cost (http://www.aceee.org/ogeece/ch5_reach.htm). These values use a 5% incremental cost adder on the full unit costs (as presented in: Goldberg et al., KEMA. *State of Wisconsin Public Service Commission of Wisconsin, Focus on Energy Evaluation, Business Programs: Incremental Cost Study*. October 28, 2009.

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\Delta \text{kWh} = (kWh_{BASE} - kWh_{EE}) * 365$$

Where:

kWh_{BASE} = Baseline maximum daily energy consumption in kilowatt hours (= dependent on chilled or frozen compartment volume (V) of efficient unit, see table below)

---

[436] California Public Utilities Commission. *2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05*. “Effective/Remaining Useful Life Values.” December 16, 2008. Available online: http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf

Baseline Daily Energy Consumption by Refrigerator or Freezer Volume

Type	kWh_{BASE}*
Solid Door Refrigerator	0.10 * V + 2.04
Glass Door Refrigerator	0.12 * V + 3.34
Solid Door Freezer	0.40 * V + 1.38
Glass Door Freezer	0.75 * V + 4.10

* U.S. Environmental Protection Agency. Energy Policy Act of 2005.

kWh_{EE} = Efficient maximum daily energy consumption in kilowatt hours (= dependent on chilled or frozen compartment volume of efficient unit, see table below)[437]

Efficient Daily Energy Consumption by Refrigerator or Freezer Volume

Type	Refrigerator kWh_{EE}	Freezer kWh_{EE}
Solid Door		
Volume ≤ 15	≤ 0.089V + 1.411	≤ 0.250V + 1.250
15 ≤ Volume < 30	≤ 0.037V + 2.200	≤ 0.400V – 1.000
30 ≤ Volume < 50	≤ 0.056V + 1.635	≤ 0.163V + 6.125
Volume ≥ 50	≤ 0.060V + 1.416	≤ 0.158V + 6.333
Glass Door		
Volume ≤ 15	≤ 0.118V + 1.382	≤ 0.607V + 0.893
15 ≤ Volume < 30	≤ 0.140V + 1.050	≤ 0.733V – 1.000
30 ≤ Volume < 50	≤ 0.088V + 2.625	≤ 0.250V + 13.500
Volume ≥ 50	≤ 0.110V + 1.500	≤ 0.450V + 3.500

V = Chilled or frozen compartment volume in square feet as defined in the Association of Home Appliance Manufacturers Standard HRF1–1979 (= actual)

365 = Days per year

Summer Peak Coincident Demand Reduction

$$\Delta kW = \frac{\Delta kWh}{HOURS} * CF$$

Where:

HOURS = Number of hours equipment is operating (= 8,760)

CF = Summer peak coincidence factor (= 1.0)

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.

---

[437] U.S. Environmental Protection Agency. *ENERGY STAR Program Requirements for Commercial Refrigerators and Freezers Partner Commitments Version 2.0*.

Strip Curtain for Walk-in Coolers and Freezers (New Construction, Retrofit – New Equipment, Retrofit –Early Replacement)

	Measure Details
Official Measure Code	CI-Refrig-StripCurt-1
Measure Unit	Per curtain
Measure Category	Refrigeration
Sector(s)	Commercial
Annual Energy Savings (kWh)	2,974 (freezer), 422 (refrigerator)
Peak Demand Reduction (kW)	0.34 (freezer), 0.05 (refrigerator)
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	
Lifetime Fossil Fuel Savings (MMBtu)	
Water Savings (gal/yr)	0
Effective Useful Life (years)	6
Incremental Cost	$10.22 per square foot
Important Comments	
Effective Date	January 10, 2013
End Date	TBD

Description

This commercial measure is installing infiltration barriers (strip curtains) on walk-in coolers or freezers. Strip curtains impede heat transfer from adjacent warm and humid spaces into walk-ins when the main door is opened, thereby reducing the cooling load. As a result, the compressor run time and energy consumption are reduced. The savings values are based on the walk-in door being open 2.5 hours per day every day, and the strip curtain covering the entire door frame. Eligible applications include new construction and retrofit.

Definition of Efficient Equipment

The efficient equipment is a polyethylene strip curtain added to a walk-in cooler or freezer.

Definition of Baseline Equipment

The baseline assumption is a walk-in cooler or freezer with either no strip curtain installed or an old, ineffective strip curtain installed.

Deemed Lifetime of Efficient Equipment

The expected measure life is 6 years.[438]

---

[438] M. Goldberg, J.R. Barry, B. Dunn, M. Ackley, J. Robinson, and D. Deangelo-Woolsey, KEMA. *Focus on Energy: Business Programs – Measure Life Study*. August 2009.

Deemed Measure Cost

The incremental capital cost for this measure is $10.22 per square foot of door opening (includes material and labor).[439]

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

ΔkWh[440] = 2,974 for freezers

= 422 for coolers

Summer Peak Coincident Demand Reduction

$$\Delta kW = \frac{\Delta kWh}{8{,}760} * CF$$

Where:

8,760 = Hours per year

CF = Summer peak coincidence factor (= 1.0)

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.

---

[439] California Public Utilities Commission. *2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05*. "Cost Values and Summary Documentation." December 16, 2008.

[440] Values based on analysis prepared by ADM for FirstEnergy utilities in Pennsylvania, provided via personal communication with Diane Rapp of FirstEnergy on June 4, 2010. Based on a review of deemed savings assumptions and methodologies from Oregon and California, the values from Pennsylvania appear reasonable and are the most applicable to the Indiana climate.

Door Gaskets for Refrigerated Cases

	Measure Details
Official Measure Code	CI-Refrig-Gasket-1
Measure Unit	Per installation
Measure Category	Refrigeration
Sector(s)	Commercial
Annual Energy Savings (kWh)	Varies by project
Peak Demand Reduction (kW)	Varies by project
Annual Fossil Fuel Savings (MMBtu)	0
Lifetime Energy Savings (kWh)	
Lifetime Fossil Fuel Savings (MMBtu)	
Water Savings (gal/yr)	0
Effective Useful Life (years)	4
Incremental Cost	$2.25 per linear foot
Important Comments	
Effective Date	January 2013
End Date	TBD

Description

This measure is replacing worn-out gaskets with new, better fitting gaskets on glass or solid door reach-in coolers and freezers. Tight-fitting gaskets inhibit the infiltration of warm and moist air from the surrounding environment into the cold refrigerated space, thereby reducing the cooling load. They also prevent moisture from entering the refrigerated space and becoming frost on the cooling coils, reducing heat transfer effectiveness. As a result of these two factors, the compressor run time and energy consumption are reduced.

Definition of Efficient Equipment

The efficient condition is replacement door gaskets being applied to a reach-in cooler or freezer.

Definition of Baseline Equipment

The baseline condition is a reach-in cooler or freezer with worn gaskets.

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 4 years.

Deemed Measure Cost

The incremental cost for this measure is $2.25 per linear foot.

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Savings Algorithm

Energy Savings

$$\Delta kWh = \frac{\Delta kWh}{LF} * LF$$

Where:

ΔkWh/LF = Kilowatt-hour savings per linear foot of gasket installed (= 3.3 for reach-in freezers; = 0.5 for reach-in coolers)[441]

LF = Linear feet of installed gasket (= actual)

Summer Peak Coincident Demand Reduction

$$\Delta \text{kW} = \frac{\Delta kWh}{8{,}760} * CF$$

Where:

ΔkWh = Annual kilowatt-hour savings from gasket replacement

CF = Summer peak coincidence factor (= 0.9)

Fossil Fuel Impact Descriptions and Calculation

There are no fossil fuel impacts from this measure.

---

[441] ADM Associates. *Commercial Facilities Contract Group 2006-2008 Direct Impact Evaluation*. Study ID PUC0016.01. Prepared for California Public Utilities Commission. 2010.

Appendices

Appendix A – Prototypical Building Energy Simulation Model Development

Many of the savings values from the TRM are derived from DOE-2.2 simulations of typical commercial buildings. They are based on building prototypes originally developed to calculate savings for the California DEER, with certain parameters adjusted to Indiana building practice based on a review of the U.S. Energy Information Administration's *Commercial Buildings Energy Consumption Survey*. The following sections describe prototypical buildings and summarize key modeling assumptions.

Residential Building Prototypes

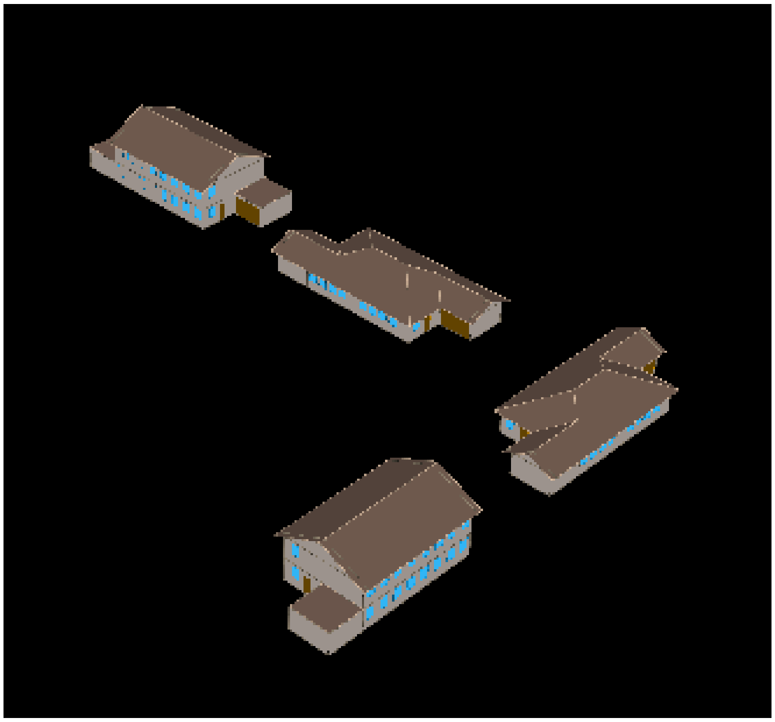
The analysis used to develop parameters for the energy savings and demand savings calculations are based on DOE-2.2 simulations of a set of prototypical residential buildings. The prototypical simulation models were derived from the residential building prototypes used in the California DEER[442] study, with adjustments made for local building practices and climate. The single family model contains four residential buildings: two are one-story and two are two-story. Both versions of the one-story and 2-story buildings are identical except for the orientation, which is shifted by 90 degrees. The selection of four buildings provides a reasonable average of the impacts from energy efficiency measures for buildings of different design and orientation.

A sketch of the single-family residential prototype buildings is shown below.

---

[442] Itron, Inc. *2004-2005 Database for Energy Efficiency Resources (DEER) Update Study, Final Report.* December 2005. Available online: http://www.calmac.org/publications/2004-05_DEER_Update_Final_Report-Wo.pdf

Computer Rendering of Single-Family Residential Building Prototypical DOE-2 Model



The general characteristics of the single-family residential building prototype model are summarized below.

Single Family Residential Building Prototype Description

Characteristic	Value
Conditioned floor area	1-story house: 1,465 square feet (not including basement) 2-story house: 2,930 square feet (not including basement)
Wall construction	Wood frame with siding
Roof construction	Wood frame with asphalt shingles
Glazing type	Double pane clear
Lighting and appliance power density	0.51 watts per square foot average
HVAC system type	Packaged single zone air conditioner or heat pump
HVAC system size	Based on peak load with 20% over-sizing
HVAC system efficiency	Baseline SEER = 13
Thermostat setpoints	Heating: 70°F with setback to 67°F Cooling: 75°F with setup to 78°F
Duct location	Buildings without basement: attic Buildings with basement: basement
Duct surface area	Single-story house: 390 square foot supply, 72 square foot return Two-story house: 505 square foot supply, 290 square foot return

Characteristic	Value
Duct insulation	Uninsulated
Duct leakage	20% of fan flow total leakage, evenly split between supply and return
Natural ventilation	Allowed during cooling season when cooling setpoint exceeded and outdoor temperature < 65°F, with three air changes per hour

Commercial Building Prototype Model Development

Commercial sector prototype building models were developed for a series of small commercial buildings with packaged rooftop HVAC systems, including assembly, big-box retail, fast food restaurant, full service restaurant, grocery, light industrial, primary school, small office, and small retail buildings. Large office, hotel, and hospital prototypes were also included to analyze measures associated with built-up HVAC systems. The following sections describe the prototypical simulation models used in this analysis.

Assembly

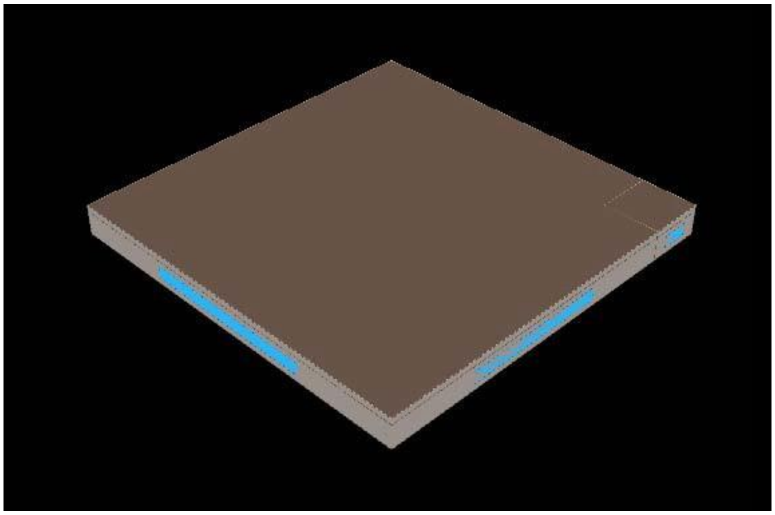
A prototypical building energy simulation model for an assembly building was developed using the DOE-2.2 building energy simulation program. The characteristics of the prototype are summarized in the table below.

Assembly Prototype Building Description

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	34,000 square feet Auditorium: 33,240 square feet Office: 760 square feet
Number of floors	1
Wall construction and R-value	Concrete block, R-5
Roof construction and R-value	Wood frame with built-up roof, R-12
Glazing type	Multipane shading coefficient = 0.84 U-value = 0.72
Lighting power density	Auditorium: 1.9 watts per square foot Office: 1.55 watts per square foot
Plug load density	Auditorium: 1.2 watts per square foot Office: 1.7 watts per square foot
Operating hours	Monday through Sunday, 8:00 a.m. to 9:00 p.m.
HVAC system type	Packaged single zone, no economizer
HVAC system size	Based on ASHRAE design day conditions, 10% over-sizing assumed
Thermostat setpoints	Occupied hours: 75°F cooling, 70°F heating Unoccupied hours: 80°F cooling, 65°F heating

A computer-generated sketch of the prototype is shown below.

Assembly Building Rendering



Big-Box Retail

A prototypical building energy simulation model for a big-box retail building was developed using the DOE-2.2 building energy simulation program. The characteristics of the prototype are summarized in the table below.

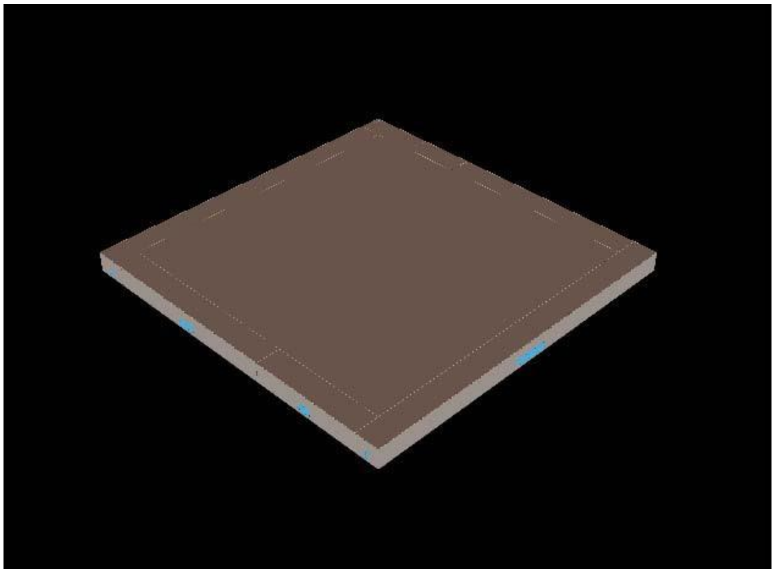
Big-Box Retail Prototype Building Description

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	130,500 square feet Sales: 107,339 square feet Storage: 11,870 square feet Office: 4,683 square feet Auto repair: 5,151 square feet Kitchen: 1,459 square feet
Number of floors	1
Wall construction and R-value	Concrete block with insulation, R-7.5
Roof construction and R-value	Metal frame with built-up roof, R-13.5
Glazing type	Multipane shading coefficient = 0.84 U-value = 0.72
Lighting power density	Sales: 2.15 watts per square foot Storage: 0.85 watts per square foot (active), 0.45 watts per square foot (inactive) Office: 1.55 watts per square foot Auto repair: 1.7 watts per square foot Kitchen: 2.2 watts per square foot
Plug load density	Sales: 1.15 watts per square foot Storage: 0.23 watts per square foot

Characteristic	Value
	Office: 1.73 watts per square foot Auto repair: 1.15 watts per square foot Kitchen: 3.23 watts per square foot
Operating hours	Monday through Sunday, 10:00 a.m. to 9:00 p.m.
HVAC system type	Packaged single zone, no economizer
HVAC system size	Based on ASHRAE design day conditions, 10% over-sizing assumed
Thermostat setpoints	Occupied hours: 75°F cooling, 70°F heating Unoccupied hours: 80°F cooling, 65°F heating

A computer-generated sketch of the prototype is shown below.

Big-Box Retail Building Rendering



Fast Food Restaurant

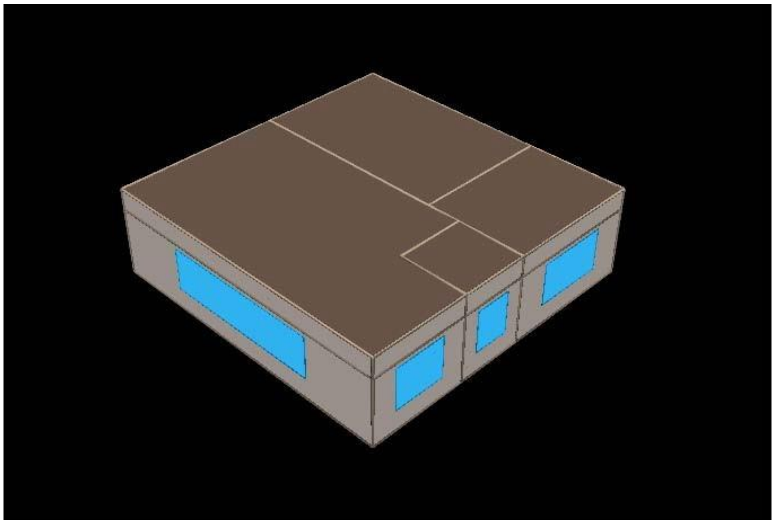
A prototypical building energy simulation model for a fast food restaurant was developed using the DOE-2.2 building energy simulation program. The characteristics of the prototype are summarized in the table below.

Fast Food Restaurant Prototype Building Description

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	2,000 square feet Dining: 1,000 square feet Entry/lobby: 600 square feet Kitchen: 300 square feet Restroom: 100 square feet
Number of floors	1
Wall construction and R-value	Concrete block with brick veneer, R-7.5
Roof construction and R-value	Concrete deck with built-up roof, R-13.5
Glazing type	Multipane shading coefficient = 0.84 U-value = 0.72
Lighting power density	Dining: 1.7 watts per square foot Entry area: 1.7 watts per square foot Kitchen: 2.2 watts per square foot Restroom: 0.9 watts per square foot
Plug load density	Dining: 0.6 watts per square foot Entry/lobby: 0.6 watts per square foot Kitchen: 4.3 watts per square foot Restroom: 0.2 watts per square foot
Operating hours	Monday through Sunday, 6:00 a.m. to 11:00 p.m.
HVAC system type	Packaged single zone, no economizer
HVAC system size	Based on ASHRAE design day conditions, 10% over-sizing assumed
Thermostat setpoints	Occupied hours: 75°F cooling, 70°F heating Unoccupied hours: 80°F cooling, 65°F heating

A computer-generated sketch of the prototype is shown below.

Fast Food Restaurant Building Rendering



Full-Service Restaurant

A prototypical building energy simulation model for a full-service restaurant was developed using the DOE-2.2 building energy simulation program. The characteristics of the full service restaurant prototype are summarized in the table below.

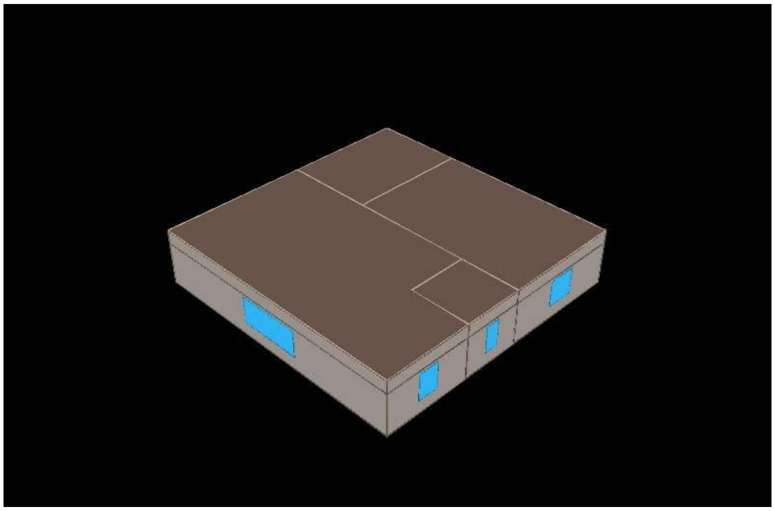
Full Service Restaurant Prototype Description

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	Dining: 2,000 square feet Entry/reception: 600 square feet Kitchen: 1,200 square feet Restrooms: 200 square feet
Number of floors	1
Wall construction and R-value	Concrete block with brick veneer, R-7.5
Roof construction and R-value	Wood frame with built-up roof, R-13.5
Glazing type	Multipane shading coefficient = 0.84 U-value = 0.72
Lighting power density	Dining: 1.7 watts per square foot Entry: 1.7 watts per square foot Kitchen: 2.2 watts per square foot Restrooms: 1.5 watts per square foot
Plug load density	Dining: 0.6 watts per square foot Entry: 0.6 watts per square foot Kitchen: 3.1 watts per square foot Restrooms: 0.2 watts per square foot
Operating hours	9:00 a.m. to 12:00 a.m.

Characteristic	Value
HVAC system type	Packaged single zone, no economizer
HVAC system size	Based on ASHRAE design day conditions, 10% over-sizing assumed
Thermostat setpoints	Occupied hours: 75°F cooling, 70°F heating Unoccupied hours: 80°F cooling, 65°F heating

A computer-generated sketch of the full-service restaurant prototype is shown in **Error! Reference ource not found.**.

Full Service Restaurant Prototype Rendering



Grocery

A prototypical building energy simulation model for a grocery building was developed using the DOE-2.2 building energy simulation program. The characteristics of the prototype are summarized in the table below.

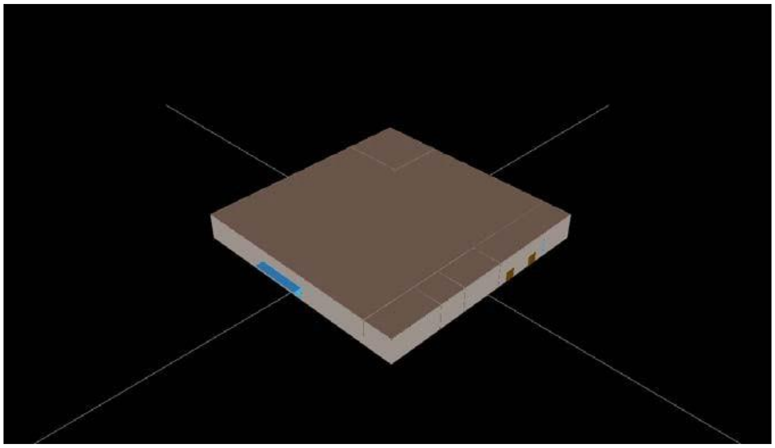
Grocery Prototype Building Description

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	50,000 square feet Sales: 40,000 square feet Office and employee lounge: 3,500 square feet Dry storage: 2,860 square feet 50°F prep area: 1,268 square feet 35°F walk-in cooler: 1,560 square feet - 5°F walk-in freezer: 812 square feet
Number of floors	1
Wall construction and R-value	Concrete block with insulation, R-5
Roof construction and R-value	Metal frame with built-up roof, R-12

Characteristic	Value
Glazing type	Single pane clear
Lighting power density	Sales: 3.36 watts per square foot Office: 2.2 watts per square foot Storage: 1.82 watts per square foot 50°F prep area: 4.3 watts per square foot 35°F walk-in cooler: 0.9 watts per square foot - 5°F walk-in freezer: 0.9 watts per square foot
Equipment power density	Sales: 1.15 watts per square foot Office: 1.73 watts per square foot Storage: 0.23 watts per square foot 50°F prep area: 0.23 watts per square foot+ 36 kBtu/hr process load 35°F walk-in cooler: 0.23 watts per square foot+ 17 kBtu/hr process load - 5°F walk-in freezer: 0.23 watts per square foot+ 29 kBtu/hr process load
Operating hours	Monday through Sunday, 6:00 a.m. to 10:00 p.m.
HVAC system type	Packaged single zone, no economizer
Refrigeration system type	Air cooled multiplex
Refrigeration system size	-20°F suction temperature: 23 compressor ton 18°F suction temperature: 45 compressor ton
Refrigeration condenser size	-20°F suction temperature: 535 kBtu/hr THR 18°F suction temperature: 756 kBtu/hr THR
Thermostat setpoints	Occupied hours: 74°F cooling, 70°F heating Unoccupied hours: 79°F cooling, 65°F heating

A computer-generated sketch of the prototype is shown in the figure below.

Grocery Building Rendering



Hospital

A prototypical building energy simulation model for a large hospital building was developed using the DOE-2.2 building energy simulation program and TMY3 long-term average weather data. The characteristics of the prototype are summarized in the table below.

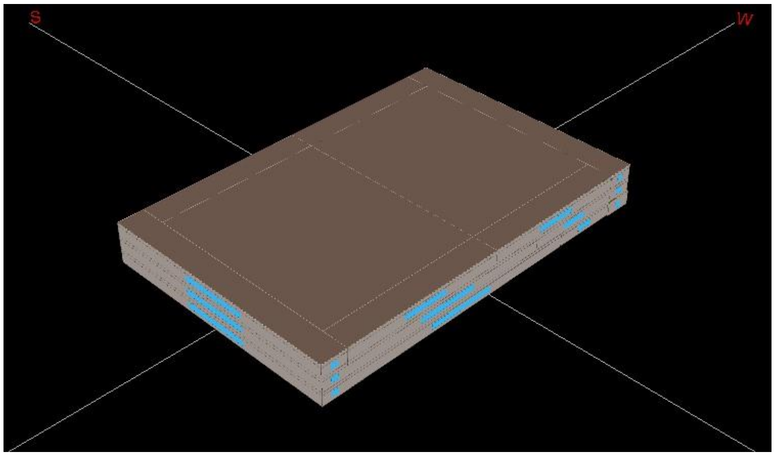
Large Hospital Prototype Building Description

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	250,000 square feet
Number of floors	3
Wall construction and R-value	Brick and CMU, R=7.5
Roof construction and R-value	Built-up roof, R=13.5
Glazing type	Multipane shading coefficient = 0.84 U-value = 0.72
Lighting power density	Patient rooms: 2.3 watts per square foot Office: 2.2 watts per square foot Lab: 4.4 watts per square foot Dining: 1.7 watts per square foot Kitchen and food prep: 4.3 watts per square foot
Plug load density	Patient rooms: 1.7 watts per square foot Office: 1.7 watts per square foot Lab: 1.7 watts per square foot Dining: 0.6 watts per square foot Kitchen and food prep: 4.6 watts per square foot
Operating hours	24/7, 365
HVAC system types	Patient Rooms: 4 pipe fan coil Kitchen: Rooftop DX Remaining space: 1. Central constant volume system with hydronic reheat, without economizer 2. Central constant volume system with hydronic reheat, with economizer 3. Central VAV system with hydronic reheat, with economizer
HVAC system size	Based on ASHRAE design day conditions, 10% over-sizing assumed
Chiller type	Water cooled and air cooled
Chilled water system type	Constant volume with 3-way control valves
Chilled water system control	Constant CHW temperature, 45°F setpoint
Boiler type	Hot water, 80% efficiency
Hot water system type	Constant volume with 3-way control valves
Hot water system control	Constant hot water temperature, 180°F setpoint
Thermostat setpoints	Occupied hours: 76°F cooling, 72°F heating Unoccupied hours: 79°F cooling, 69°F heating

Each set of measures was run with three different HVAC system configurations: (1) a constant volume reheat system without economizer, (2) a constant volume reheat system with economizer, and (3) a VAV system with economizer. The constant volume reheat system without economizer represents a system with the most heating and cooling operating hours, while the VAV system with economizer represents a system with the least heating and cooling hours. This presents a range of system loads and energy savings for each measure analyzed.

A computer-generated sketch of the prototype is shown below.

Hospital Building Rendering



Hotel

A prototypical building energy simulation model for a hotel building was developed using the DOE-2.2 building energy simulation program. The characteristics of the prototype are summarized in the table below.

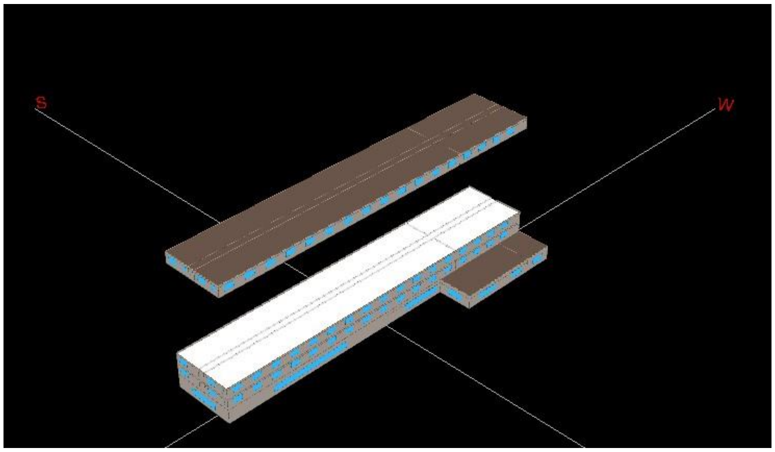
Hotel Prototype Building Description

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	200,000 square feet total Bar/cocktail lounge: 800 square feet Corridor: 20,100 square feet Dining: 1,250 square feet Guest rooms: 160,680 square feet Kitchen: 750 square feet Laundry: 4,100 square feet Lobby: 8,220 square feet Office: 4,100 square feet
Number of floors	11
Wall construction and R-value	Block construction, R-7.5
Roof construction and R-value	Wood deck with built-up roof, R-13.5

Characteristic	Value
Glazing type	Multipane shading coefficient = 0.84 U-value = 0.72
Lighting power density	Bar/cocktail lounge: 1.7 watts per square foot Corridor: 1.0 watts per square foot Dining: 1.7 watts per square foot Guest: 0.6 watts per square foot Kitchen: 4.3 watts per square foot Laundry: 1.8 watts per square foot Lobby: 3.1 watts per square foot Office: 2.2 watts per square foot
Plug load density	Bar/cocktail lounge: 1.2 watts per square foot Corridor: 0.2 watts per square foot Dining: 0.6 watts per square foot Guest rooms: 0.6 watts per square foot Kitchen: 3.0 watts per square foot Laundry: 3.5 watts per square foot Lobby: 0.6 watts per square foot Office: 1.7 watts per square foot
Operating hours	Rooms: 60% occupied 40% unoccupied All others: 24 hr/day
HVAC system type	Guest rooms: PTAC Corridors: PSZ Everywhere else: central built-up system: 1. Central constant volume system with perimeter hydronic reheat, without economizer 2. Central constant volume system with perimeter hydronic reheat, with economizer 3. Central VAV system with perimeter hydronic reheat, with economizer
HVAC system size	Based on ASHRAE design day conditions, 10% over-sizing assumed
Chiller type	Water cooled and air cooled
Chilled water system type	Constant volume with 3-way control valves
Chilled water system control	Constant CHW temperature, 45°F setpoint
Boiler type	Hot water, 80% efficiency
Hot water system type	Constant volume with 3-way control valves
Hot water system control	Constant hot water temperature, 180°F setpoint
Thermostat setpoints	Occupied hours: 76°F cooling, 72°F heating Unoccupied hours: 81°F cooling, 67°F heating

A computer-generated sketch of the prototype is shown below.

Hotel Building Rendering



Large Office

A prototypical building energy simulation model for a large office building was developed using the DOE-2.2 building energy simulation program. The characteristics of the prototype are summarized in the table below.

Large Office Prototype Building Description

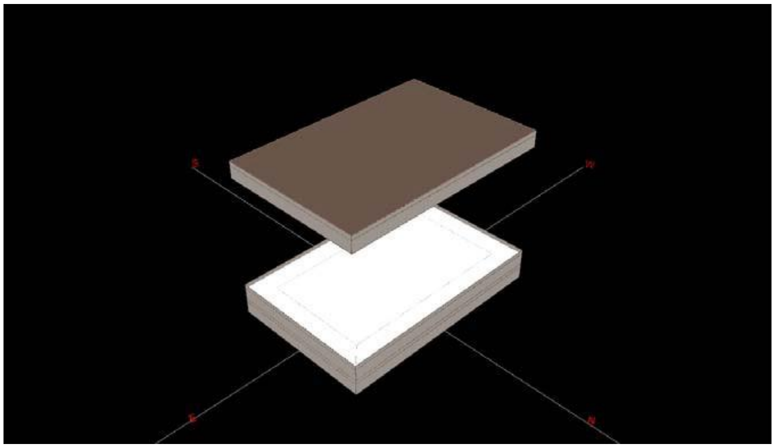
Characteristic	Value
Vintage	Existing (1970s) vintage
Size	350,000 square feet
Number of floors	10
Wall construction and R-value	Glass curtain wall, R-7.5
Roof construction and R-value	Built-up roof, R-13.5
Glazing type	Multipane shading coefficient = 0.84 U-value = 0.72
Lighting power density	Perimeter offices: 1.55 watts per square foot Core offices: 1.45 watts per square foot
Plug load density	Perimeter offices: 1.6 watts per square foot Core offices: 0.7 watts per square foot
Operating hours	Monday through Saturday, 9:00 a.m. to 6:00 p.m. Sunday unoccupied
HVAC system types	1. Central constant volume system with perimeter hydronic reheat, without economizer 2. Central constant volume system with perimeter hydronic reheat, with economizer 3. Central VAV system with perimeter hydronic reheat, with economizer
HVAC system size	Based on ASHRAE design day conditions, 10% over-sizing assumed
Chiller type	Water cooled and air cooled
Chilled water system type	Constant volume with 3-way control valves

Chilled water system control	Constant CHW temperature, 45°F setpoint
Boiler type	Hot water, 80% efficiency
Hot water system type	Constant volume with 3-way control valves
Hot water system control	Constant hot water temperature, 180°F setpoint
Thermostat setpoints	Occupied hours: 75°F cooling, 70°F heating Unoccupied hours: 80°F cooling, 65°F heating

Each set of measures was run using three different HVAC system configurations: (1) a constant volume reheat system without economizer, (2) a constant volume reheat system with economizer, and (3) a VAV system with economizer. The constant volume reheat system without economizer represents the system with the most heating and cooling operating hours, while the VAV system with economizer represents a system with the least heating and cooling hours. This presents a range of system loads and energy savings for each measure analyzed.

A computer-generated sketch of the prototype is shown below. Note that middle floors are thermally equivalent, therefore were simulated as a single floor with the results multiplied by the number of floors.

Large Office Building Rendering



Light Industrial

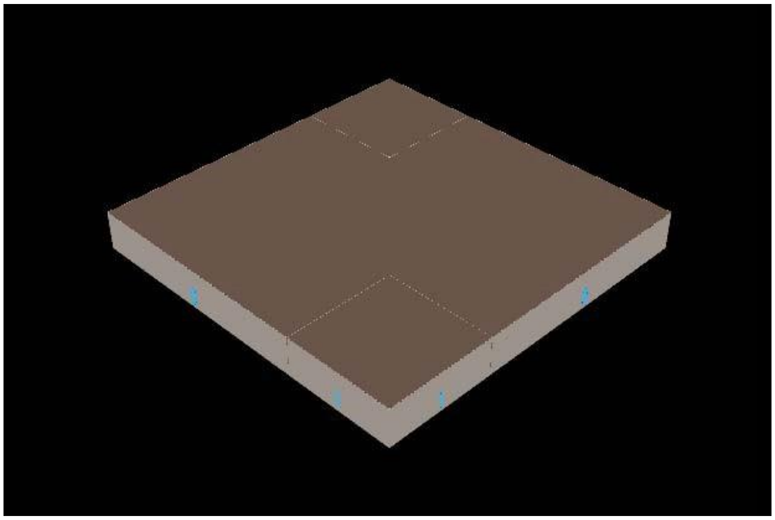
A prototypical building energy simulation model for a light industrial building was developed using the DOE-2.2 building energy simulation program. The characteristics of the prototype are summarized in the table below.

Light Industrial Prototype Building Description

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	100,000 square feet total Factory: 80,000 square feet Warehouse: 20,000 square feet
Number of floors	1
Wall construction and R-value	Concrete block with brick, no insulation, R-5
Roof construction and R-value	Concrete deck with built-up roof, R-12
Glazing type	Multipane shading coefficient = 0.84 U-value = 0.72
Lighting power density	Factory: 2.25 watts per square foot Warehouse: 0.7 watts per square foot
Plug load density	Factory: 1.2 watts per square foot Warehouse: 0.2 watts per square foot
Operating hours	Monday through Friday, 6:00 a.m. to 6:00 p.m. Saturday and Sunday, u noccupied
HVAC system type	Packaged single zone, no economizer
HVAC system size	Based on ASHRAE design day conditions, 10% over-sizing assumed
Thermostat setpoints	Occupied hours: 75°F cooling, 70°F heating Unoccupied hours: 80°F cooling, 65°F heating

A computer-generated sketch of the prototype is shown below.

Light Industrial Building Rendering



Primary School

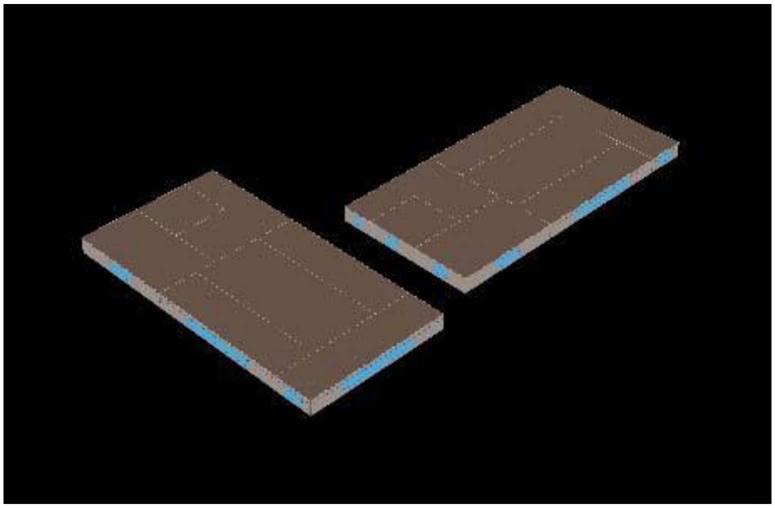
A prototypical building energy simulation model for an elementary school was developed using the DOE-2.2 building energy simulation program. The model is of two identical buildings oriented in different directions. The characteristics of the prototype are summarized in the table below.

Elementary School Prototype Building Description

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	2 buildings, 25,000 square feet each, oriented 90 degrees from each other Classroom: 15,750 square feet Cafeteria: 3,750 square feet Gymnasium: 3,750 square feet Kitchen: 1,750 square feet
Number of floors	1
Wall construction and R-value	Concrete with brick veneer, R-7.5
Roof construction and R-value	Wood frame with built-up roof, R-13.5
Glazing type	Multipane shading coefficient = 0.84 U-value = 0.72
Lighting power density	Classroom: 1.8 watts per square foot Cafeteria: 1.3 watts per square foot Gymnasium: 1.7 watts per square foot Kitchen: 2.2 watts per square foot
Plug load density	Classroom: 1.2 watts per square foot Cafeteria: 0.6 watts per square foot Gymnasium: 0.6 watts per square foot Kitchen: 4.2 watts per square foot
Operating hours	Monday through Friday, 8:00 a.m. to 6:00 p.m. Sunday, 8:00 a.m. to 4:00 p.m. Saturday, unoccupied
HVAC system type	Packaged single zone, no economizer
HVAC system size	Based on ASHRAE design day conditions, 10% over-sizing assumed
Thermostat setpoints	Occupied hours: 75°F cooling, 70°F heating Unoccupied hours: 80°F cooling, 65°F heating

A computer-generated sketch of the prototype is shown below.

School Building Rendering



Small Office

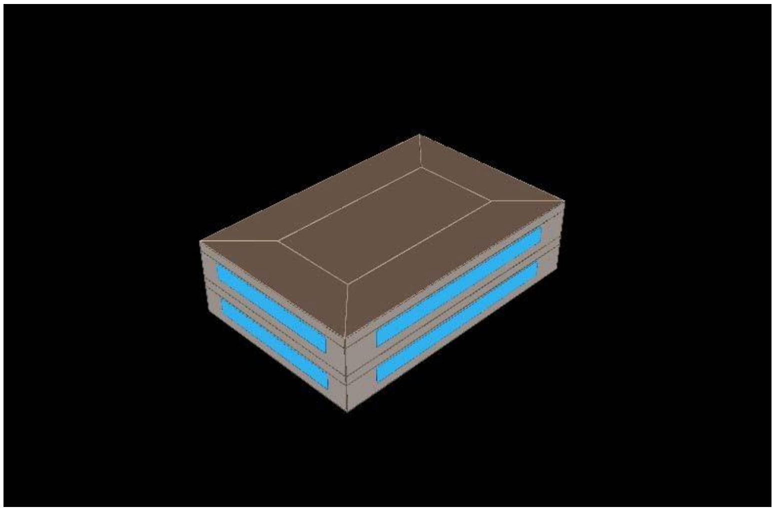
A prototypical building energy simulation model for a small office was developed using the DOE-2.2 building energy simulation program. The characteristics of the small office prototype are summarized in the table below.

Small Office Prototype Building Description

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	10,000 square feet
Number of floors	2
Wall construction and R-value	Wood frame with brick veneer, R-7.5
Roof construction and R-value	Wood frame with built-up roof, R-13.5
Glazing type	Multipane shading coefficient = 0.84 U-value = 0.72
Lighting power density	Perimeter offices: 1.55 watts per square foot Core offices: 1.45 watts per square foot
Plug load density	Perimeter offices: 1.6 watts per square foot Core offices: 0.7 watts per square foot
Operating hours	Monday through Saturday, 9:00 a.m. to 6:00 p.m. Sunday, unoccupied
HVAC system type	Packaged single zone, no economizer
HVAC system size	Based on ASHRAE design day conditions, 10% over-sizing assumed
Thermostat setpoints	Occupied hours: 75°F cooling, 70°F heating Unoccupied hours: 80°F cooling, 65°F heating

A computer-generated sketch of the small office prototype is shown below.

Small Office Prototype Building Rendering



Small Retail

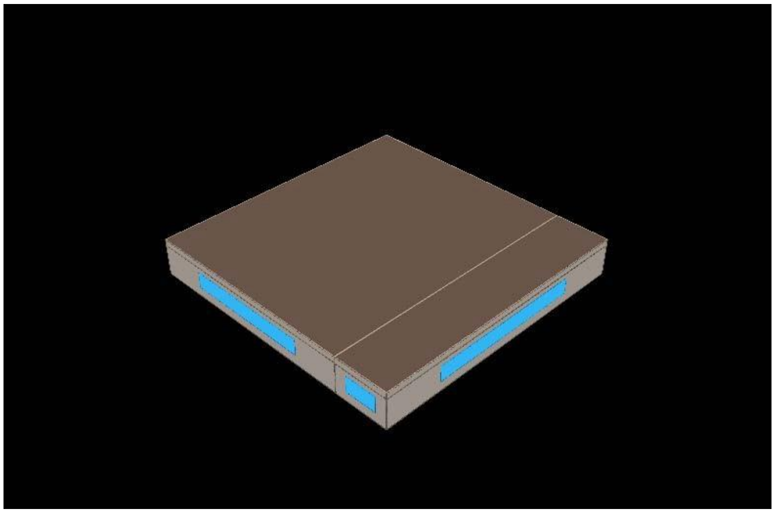
A prototypical building energy simulation model for a small retail building was developed using the DOE-2.2 building energy simulation program. The characteristics of the small retail building prototype are summarized in the table below.

Table 1. Small Retail Prototype Description

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	8,000 square feet total Sales area: 6,400 square feet Storage: 1,600 square feet
Number of floors	1
Wall construction and R-value	Concrete block with brick veneer, R-7.5
Roof construction and R-value	Wood frame with built-up roof, R-13.5
Glazing type	Multipane shading coefficient = 0.84 U-value = 0.72
Lighting power density	Sales area: 2.15 watts per square foot Storage: 0.85 watts per square foot (active); 0.45 watts per square foot (inactive)
Plug load density	Sales area: 1.2 watts per square foot Storage: 0.2 watts per square foot
Operating hours	Monday through Saturday, 10:00 a.m. to 10:00 p.m. Sunday, 10:00 a.m. to 8:00 p.m.
HVAC system type	Packaged single zone, no economizer
HVAC system size	Based on ASHRAE design day conditions, 10% over-sizing assumed
Thermostat setpoints	Occupied hours: 75°F cooling, 70°F heating Unoccupied hours: 80°F cooling, 65°F heating

A computer-generated sketch of the small retail building prototype is shown below.

Small Retail Prototype Building Rendering



Appendix B – HVAC Interactive Effects Multipliers

Residential Buildings

HVAC Interactive Effects Multipliers for Residential Buildings

City	AC with Natural Gas Heat			Heat Pump			AC with Electric Heat			Electric Heat Only			Natural Gas Heat Only		
	WHF_E	WHF_D	WHF_G	WHF_E	WHF_D	WHF_G	WHF_E	WHF_D	WHF_G	WHF_E	WHF_D	WHF_G	WHF_E	WHF_D	WHF_G
Indianapolis	0.06	0.07	-0.0024	-0.17	0.03	0.00	-0.45	0.07	0.00	-0.52	0.00	0.00	0.00	0.00	-0.0024
South Bend	0.05	0.05	-0.0025	-0.18	0.00	0.00	-0.47	0.05	0.00	-0.54	0.00	0.00	0.00	0.00	-0.0025
Evansville	0.07	0.11	-0.0022	-0.11	0.10	0.00	-0.37	0.11	0.00	-0.45	0.00	0.00	0.00	0.00	-0.0022
Ft Wayne	0.05	0.05	-0.0026	-0.22	0.00	1.00	-0.50	0.05	1.00	-0.56	0.00	0.00	0.00	0.00	-0.0026
Terre Haute	0.07	0.08	-0.0024	-0.15	0.00	2.00	-0.42	0.08	2.00	-0.50	0.00	0.00	0.00	0.00	-0.0024

Data to calculated weights for each HVAC system type in residential buildings were obtained from the *Residential Energy Consumption Survey* for the East North Central census region (including Indiana and Ohio). These data are summarized in the table below.

Waste Heat Factor Weights by HVAC System Type

HVAC System Type	Number of Homes (millions)	Weight
AC Natural Gas Heat	4.22	0.63
Heat Pump	0.30	0.04
AC Electric Heat	1.18	0.18
Electric Heat Only	0.15	0.02
Natural Gas Heat Only	0.85	0.13

Applying these weights to the waste heat factor from the table above gives the following weighted averages by city, along with a statewide value assuming equal weights across cities.

Weighted Average Waste Heat Factors by City

City	Weighted		
	WHF_E	WHF_D	WHF_G
Indianapolis	-0.061	0.055	-0.0018
South Bend	-0.070	0.038	-0.0019
Evansville	-0.034	0.092	-0.0017
Ft Wayne	-0.082	0.038	-0.0019
Terre Haute	-0.048	0.061	-0.0018
Statewide	**-0.059**	**0.057**	**-0.0018**

Commercial Buildings

HVAC Interactive Effects Multipliers for Commercial Buildings

Building	City	AC with Natural Gas Heat			Heat Pump			AC with Electric Heat			Electric Heat Only			Natural Gas Heat Only		
		WHF_E	WHF_D	WHF_G	WHF_E	WHF_D	WHF_G	WHF_E	WHF_D	WHF_G	WHF_E	WHF_D	WHF_G	WHF_E	WHF_D	WHF_G
Assembly	Indianapolis	0.155	0.2	-0.0029	-0.174	0.2	0	-0.434	0.2	0	-0.591	0	0	0	0	-0.0029
	South Bend	0.133	0.2	-0.0023	-0.221	0.2	0	-0.349	0.2	0	-0.483	0	0	0	0	-0.0024
	Evansville	0.2	0.2	-0.0017	-0.042	0.2	0	-0.143	0.2	0	-0.318	0	0	0	0	-0.0017
	Ft Wayne	0.123	0.2	-0.003	-0.571	0.2	0	-0.485	0.2	0	-0.607	0	0	0	0	-0.0029
	Terre Haute	0.165	0.2	-0.0031	-0.184	0.2	0	-0.459	0.2	0	-0.604	0	0	0	0	-0.003
Big Box	Indianapolis	0.146	0.2	-0.0017	-0.086	0.2	0	-0.193	0.2	0	-0.318	0	0	0	0	-0.0017
	South Bend	0.133	0.2	-0.0019	-0.099	0.2	0	-0.242	0.2	0	-0.365	0	0	0	0	-0.0019
	Evansville	0.177	0.2	-0.0012	0.049	0.2	0	-0.043	0.2	0	-0.186	0	0	0	0	-0.0011
	Ft Wayne	0.126	0.2	-0.002	-0.16	0.2	0	-0.266	0.2	0	-0.371	0	0	0	0	-0.002
	Terre Haute	0.17	0.2	-0.0015	-0.028	0.2	0	-0.116	0.2	0	-0.28	0	0	0	0	-0.0015
Elementary School	Indianapolis	0.096	0.2	-0.0033	-0.278	0.2	0	-0.605	0.2	0	-0.743	0	0	0	0	-0.0033
	South Bend	0.073	0.2	-0.0036	-0.318	0.2	0	-0.701	0.2	0	-0.839	0	0	0	0	-0.0036
	Evansville	0.126	0.2	-0.0029	-0.148	0.2	0	-0.465	0.2	0	-0.606	0	0	0	0	-0.0029
	Ft Wayne	0.069	0.2	-0.0037	-0.356	0.2	0	-0.736	0.2	0	-0.869	0	0	0	0	-0.0037
	Terre Haute	0.101	0.2	-0.0034	-0.274	0.2	0	-0.605	0.2	0	-0.784	0	0	0	0	-0.0034

Building	City	AC with Natural Gas Heat			Heat Pump			AC with Electric Heat			Electric Heat Only			Natural Gas Heat Only		
		WHF_E	WHF_D	WHF_G	WHF_E	WHF_D	WHF_G	WHF_E	WHF_D	WHF_G	WHF_E	WHF_D	WHF_G	WHF_E	WHF_D	WHF_G
Fast Food	Indianapolis	0.109	0.2	-0.0029	-0.023	0.2	0	-0.53	0.2	0	-0.661	0	0	0	0	-0.0032
	South Bend	0.09	0.2	-0.0032	-0.024	0.2	0	-0.586	0.2	0	-0.664	0	0	0	0	-0.0032
	Evansville	0.131	0.2	-0.0025	-0.016	0.2	0	-0.404	0.2	0	-0.677	0	0	0	0	-0.0033
	Ft Wayne	0.088	0.2	-0.0032	-0.026	0.2	0	-0.618	0.2	0	-0.66	0	0	0	0	-0.0032
	Terre Haute	0.112	0.2	-0.0029	-0.02	0.2	0	-0.505	0.2	0	-0.689	0	0	0	0	-0.0034
Full Service Restaurant	Indianapolis	0.108	0.2	-0.0033	-0.023	0.2	0	-0.556	0	0	-0.872	0	0	0	0	-0.0042
	South Bend	0.091	0.2	-0.0034	-0.024	0.2	0	-0.602	0	0	-0.746	0	0	0	0	-0.0036
	Evansville	0.135	0.2	-0.0026	-0.016	0.2	0	-0.372	0	0	-0.546	0	0	0	0	-0.0028
	Ft Wayne	0.088	0.2	-0.0036	-0.026	0.2	0	-0.638	0	0	-0.758	0	0	0	0	-0.0036
	Terre Haute	0.124	0.2	-0.0029	-0.02	0.2	0	-0.458	0	0	-0.628	0	0	0	0	-0.0031
Grocery	Indianapolis	0.146	0.2	-0.0017	-0.086	0.2	0	-0.193	0.2	0	-0.318	0	0	0	0	-0.0017
	South Bend	0.133	0.2	-0.0019	-0.099	0.2	0	-0.242	0.2	0	-0.365	0	0	0	0	-0.0019
	Evansville	0.177	0.2	-0.0012	0.049	0.2	0	-0.043	0.2	0	-0.186	0	0	0	0	-0.0011
	Ft Wayne	0.126	0.2	-0.002	-0.16	0.2	0	-0.266	0.2	0	-0.371	0	0	0	0	-0.002
	Terre Haute	0.17	0.2	-0.0015	-0.028	0.2	0	-0.116	0.2	0	-0.28	0	0	0	0	-0.0015
Light Industrial	Indianapolis	0.096	0.2	-0.0022	-0.145	0.2	0	-0.332	0.2	0	-0.433	0	0	0	0	-0.0021
	South Bend	0.08	0.2	-0.0024	-0.173	0.2	0	-0.397	0.2	0	-0.496	0	0	0	0	-0.0024
	Evansville	0.123	0.2	-0.0018	-0.048	0.2	0	-0.217	0.2	0	-0.308	0	0	0	0	-0.0017
	Ft Wayne	0.074	0.2	-0.0025	-0.188	0.2	0	-0.407	0.2	0	-0.499	0	0	0	0	-0.0024
	Terre Haute	0.103	0.2	-0.0021	-0.099	0.2	0	-0.306	0.2	0	-0.394	0	0	0	0	-0.0021
Small Office	Indianapolis	0.119	0.2	-0.0016	-0.027	0.2	0	-0.182	0.2	0	-0.182	0	0	0	0	-0.0015
	South Bend	0.122	0.2	-0.0015	-0.015	0.2	0	-0.169	0.2	0	-0.169	0	0	0	0	-0.0014
	Evansville	0.144	0.2	-0.0012	0.051	0.2	0	-0.072	0.2	0	-0.072	0	0	0	0	-0.009
	Ft Wayne	0.102	0.2	-0.0019	-0.112	0.2	0	-0.271	0.2	0	-0.271	0	0	0	0	-0.0018
	Terre Haute	0.124	0.2	-0.0016	-0.036	0.2	0	-0.184	0.2	0	-0.184	0	0	0	0	-0.0014
Small Retail	Indianapolis	0.124	0.2	-0.0023	-0.083	0.2	0	-0.315	0.2	0	-0.437	0	0	0	0	-0.0022
	South Bend	0.121	0.2	-0.0024	-0.088	0.2	0	-0.324	0.2	0	-0.445	0	0	0	0	-0.0022
	Evansville	0.157	0.2	-0.0016	0.023	0.2	0	-0.128	0.2	0	-0.264	0	0	0	0	-0.0015
	Ft Wayne	0.101	0.2	-0.0026	-0.168	0.2	0	-0.41	0.2	0	-0.51	0	0	0	0	-0.0025

Building	City	AC with Natural Gas Heat			Heat Pump			AC with Electric Heat			Electric Heat Only			Natural Gas Heat Only		
		WHF_E	WHF_D	WHF_G	WHF_E	WHF_D	WHF_G	WHF_E	WHF_D	WHF_G	WHF_E	WHF_D	WHF_G	WHF_E	WHF_D	WHF_G
	Terre Haute	0.145	0.2	-0.002	-0.076	0.2	0	-0.247	0.2	0	-0.381	0	0	0	0	-0.002
Warehouse	Indianapolis	0.096	0.2	-0.0022	-0.145	0.2	0	-0.332	0.2	0	-0.433	0	0	0	0	-0.0021
	South Bend	0.08	0.2	-0.0024	-0.173	0.2	0	-0.397	0.2	0	-0.496	0	0	0	0	-0.0024
	Evansville	0.123	0.2	-0.0018	-0.048	0.2	0	-0.217	0.2	0	-0.308	0	0	0	0	-0.0017
	Ft Wayne	0.074	0.2	-0.0025	-0.188	0.2	0	-0.407	0.2	0	-0.499	0	0	0	0	-0.0024
	Terre Haute	0.103	0.2	-0.0021	-0.099	0.2	0	-0.306	0.2	0	-0.394	0	0	0	0	-0.0021
Other	Indianapolis	0.115	0.2	-0.0023	-0.15	0.2	0	-0.357	0.185	0	-0.487	0	0	0	0	-0.0022
	South Bend	0.103	0.2	-0.0024	-0.159	0.2	0	-0.38	0.185	0	-0.488	0	0	0	0	-0.0021
	Evansville	0.142	0.2	-0.0019	-0.047	0.2	0	-0.24	0.185	0	-0.375	0	0	0	0	-0.0017
	Ft Wayne	0.095	0.2	-0.0026	-0.247	0.2	0	-0.448	0.185	0	-0.544	0	0	0	0	-0.0023
	Terre Haute	0.126	0.2	-0.0023	-0.129	0.2	0	-0.345	0.185	0	-0.476	0	0	0	0	-0.0021

Appendix C – Insulation Measures in Single Family Buildings

Roof Insulation Measure Tables by City and HVAC Type

City: Indianapolis
HVAC: AC with Natural Gas Heat

Measure R-Value	Base														
	0			11			19			30			38		
	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	416.2	0.154	30.2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
19	467.6	0.205	33.8	51.4	0.051	3.7	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
30	496.6	0.222	36.0	80.4	0.068	5.8	29.0	0.017	2.2	N/A	N/A	N/A	N/A	N/A	N/A
38	505.3	0.239	36.8	89.1	0.085	6.6	37.7	0.034	3.0	8.7	0.017	0.8	N/A	N/A	N/A
49	514.3	0.239	37.5	98.1	0.085	7.4	46.8	0.034	3.7	17.7	0.017	1.6	9.0	0.00	0.7
60	522.9	0.239	38.0	106.7	0.085	7.8	55.3	0.034	4.2	26.3	0.017	2.0	17.6	0.00	1.2

City: Indianapolis
HVAC: Heat Pump

Measure R-Value	Base									
	0		11		19		30		38	
	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF
11	5,043.2	0.410	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
19	5,588.4	0.495	545.2	0.085	N/A	N/A	N/A	N/A	N/A	N/A
30	5,902.4	0.546	859.2	0.137	314.0	0.051	N/A	N/A	N/A	N/A
38	6,022.0	0.563	978.8	0.154	433.6	0.068	119.6	0.017	N/A	N/A
49	6,128.3	0.580	1,085.2	0.171	539.9	0.085	225.9	0.034	106.3	0.017
60	6,194.0	0.580	1,150.9	0.171	605.6	0.085	291.6	0.034	172.0	0.017

City: Indianapolis
HVAC: AC with Electric Heat

Measure R-Value	Base									
	0		11		19		30		38	
	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF
11	7,280.0	0.375	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
19	8,141.3	0.444	861.3	0.068	N/A	N/A	N/A	N/A	N/A	N/A
30	8,644.2	0.495	1,364.2	0.119	502.9	0.051	N/A	N/A	N/A	N/A
38	8,837.4	0.512	1,557.3	0.137	696.1	0.068	193.2	0.017	N/A	N/A
49	9,011.4	0.529	1,731.4	0.154	870.1	0.085	367.2	0.034	174.1	0.017
60	9,118.9	0.529	1,838.9	0.154	977.6	0.085	474.7	0.034	281.6	0.017

City: Indianapolis
HVAC: Electric Heat Only

Measure R-Value	Base									
	0		11		19		30		38	
	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF
11	6942.2	0.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
19	7766.6	0.00	824.4	0.00	N/A	N/A	N/A	N/A	N/A	N/A
30	8247.6	0.00	1305.5	0.00	481.1	0.00	N/A	N/A	N/A	N/A
38	8434.0	0.00	1491.8	0.00	667.4	0.00	186.3	0.00	N/A	N/A
49	8596.1	0.00	1653.9	0.00	829.5	0.00	348.5	0.00	162.1	0.00
60	8701.9	0.00	1759.7	0.00	935.3	0.00	454.3	0.00	267.9	0.00

City: Indianapolis
HVAC: Natural Gas Heat Only

Measure	Base														
	0			11			19			30			38		
	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	149.1	0.00	30.6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
19	166.7	0.00	34.4	17.6	0.00	3.7	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
30	177.0	0.00	36.5	27.8	0.00	5.9	10.2	0.00	2.2	N/A	N/A	N/A	N/A	N/A	N/A
38	180.9	0.00	37.4	31.7	0.00	6.7	14.2	0.00	3.0	3.9	0.00	0.9	N/A	N/A	N/A
49	184.1	0.00	38.1	35.0	0.00	7.5	17.4	0.00	3.8	7.2	0.00	1.6	3.2	0.00	0.7
60	186.3	0.00	38.6	37.2	0.00	8.0	19.6	0.00	4.2	9.4	0.00	2.1	5.5	0.00	1.2

City: South Bend
HVAC: AC with Natural Gas Heat

Measure	Base														
	0			11			19			30			38		
	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	351.2	0.137	30.4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
19	394.5	0.171	34.1	43.3	0.034	3.7	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
30	417.2	0.188	36.2	66.0	0.051	5.9	22.7	0.017	2.2	N/A	N/A	N/A	N/A	N/A	N/A
38	424.4	0.188	37.1	73.2	0.051	6.7	29.9	0.017	3.0	7.2	0.00	0.8	N/A	N/A	N/A
49	433.1	0.188	37.8	81.9	0.051	7.4	38.6	0.017	3.7	15.9	0.00	1.6	8.7	0.00	0.8
60	437.9	0.188	38.3	86.7	0.051	7.9	43.3	0.017	4.2	20.6	0.00	2.1	13.5	0.00	1.2

City: South Bend
HVAC: Heat Pump

Measure R-Value	Base									
	0		11		19		30		38	
	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF
11	5,171.8	0.119	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
19	5,730.0	0.154	558.2	0.034	N/A	N/A	N/A	N/A	N/A	N/A
30	6,044.9	0.171	873.0	0.051	314.8	0.017	N/A	N/A	N/A	N/A
38	6,166.4	0.188	994.5	0.068	436.3	0.034	121.5	0.017	N/A	N/A
49	6,271.7	0.188	1,099.8	0.068	541.6	0.034	226.8	0.017	105.3	0.00
60	6,343.0	0.188	1,171.2	0.068	613.0	0.034	298.1	0.017	176.6	0.00

City: South Bend
HVAC: AC with Electric Heat

Measure R-Value	Base									
	0		11		19		30		38	
	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF
11	7,316.2	0.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
19	8,190.4	0.034	874.2	0.034	N/A	N/A	N/A	N/A	N/A	N/A
30	8,694.2	0.068	1,378.0	0.068	503.8	0.034	N/A	N/A	N/A	N/A
38	8,892.2	0.068	1,575.9	0.068	701.7	0.034	198.0	0.00	N/A	N/A
49	9,063.7	0.085	1,747.4	0.085	873.2	0.051	369.5	0.017	171.5	0.017
60	9,177.8	0.085	1,861.6	0.085	987.4	0.051	483.6	0.017	285.7	0.017

City: South Bend
HVAC: Electric Heat Only

Measure	Base									
	0		11		19		30		38	
	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF
11	7,061.6	0.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
19	7,905.5	0.00	843.9	0.00	N/A	N/A	N/A	N/A	N/A	N/A
30	8,393.2	0.00	1,331.6	0.00	487.7	0.00	N/A	N/A	N/A	N/A
38	8,584.3	0.00	1,522.7	0.00	678.8	0.00	191.1	0.00	N/A	N/A
49	8,750.3	0.00	1,688.7	0.00	844.9	0.00	357.2	0.00	166.0	0.00
60	8,859.0	0.00	1,797.4	0.00	953.6	0.00	465.9	0.00	274.7	0.00

City: South Bend
HVAC: Natural Gas Heat Only

Measure	Base														
	0			11			19			30			38		
	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	151.9	0.00	30.8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
19	170.0	0.00	34.6	18.1	0.00	3.8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
30	180.2	0.00	36.8	28.3	0.00	6.0	10.2	0.00	2.2	N/A	N/A	N/A	N/A	N/A	N/A
38	184.1	0.00	37.6	32.3	0.00	6.8	14.2	0.00	3.1	3.9	0.00	0.9	N/A	N/A	N/A
49	187.7	0.00	38.4	35.8	0.00	7.6	17.7	0.00	3.8	7.5	0.00	1.6	3.6	0.00	0.8
60	189.9	0.00	38.9	38.1	0.00	8.0	20.0	0.00	4.3	9.7	0.00	2.1	5.8	0.00	1.2

City: Evansville
HVAC: AC with Natural Gas Heat

Measure	Base														
	0			11			19			30			38		
	kWh/kSF	kW/kSF	MMBtu/kSF	kWh/kSF	kW/kSF	MMBtu/kSF	kWh/kSF	kW/kSF	MMBtu/kSF	kWh/kSF	kW/kSF	MMBtu/kSF	kWh/kSF	kW/kSF	MMBtu/kSF
11	475.3	0.392	24.2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
19	530.7	0.461	27.3	55.5	0.068	3.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
30	562.1	0.512	29.0	86.9	0.119	4.8	31.4	0.051	1.8	N/A	N/A	N/A	N/A	N/A	N/A
38	573.5	0.529	29.7	98.3	0.137	5.5	42.8	0.068	2.5	11.4	0.017	0.7	N/A	N/A	N/A
49	582.4	0.546	30.3	107.2	0.154	6.1	51.7	0.085	3.1	20.3	0.034	1.3	8.9	0.017	0.6
60	588.6	0.563	30.7	113.3	0.171	6.5	57.8	0.102	3.5	26.5	0.051	1.7	15.0	0.034	1.0

City: Evansville
HVAC: Heat Pump

Measure R-Value	Base									
	0		11		19		30		38	
	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF
11	3,299.0	0.631	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
19	3,673.2	0.717	374.2	0.085	N/A	N/A	N/A	N/A	N/A	N/A
30	3,886.9	0.751	587.9	0.119	213.7	0.034	N/A	N/A	N/A	N/A
38	3,968.4	0.768	669.5	0.137	295.2	0.051	81.6	0.017	N/A	N/A
49	4,042.0	0.785	743.0	0.154	368.8	0.068	155.1	0.034	73.5	0.017
60	4,089.2	0.785	790.3	0.154	416.0	0.068	202.4	0.034	120.8	0.017

City: Evansville
HVAC: AC with Electric Heat

Measure R-Value	Base									
	0		11		19		30		38	
	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF
11	5,831.6	0.580	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
19	6,547.1	0.648	715.5	0.068	N/A	N/A	N/A	N/A	N/A	N/A
30	6,959.0	0.683	1,127.5	0.102	411.9	0.034	N/A	N/A	N/A	N/A
38	7,118.8	0.700	1,287.2	0.119	571.7	0.051	159.7	0.017	N/A	N/A
49	7,260.1	0.700	1,428.5	0.119	713.0	0.051	301.0	0.017	141.3	0.00
60	7,351.2	0.717	1,519.6	0.137	804.1	0.068	392.2	0.034	232.4	0.017

City: Evansville
HVAC: Electric Heat Only

Measure R-Value	Base									
	0		11		19		30		38	
	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF
11	5,398.6	0.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
19	6,057.8	0.00	659.2	0.00	N/A	N/A	N/A	N/A	N/A	N/A
30	6,441.1	0.00	1,042.5	0.00	383.3	0.00	N/A	N/A	N/A	N/A
38	6,591.1	0.00	1,192.5	0.00	533.3	0.00	150.0	0.00	N/A	N/A
49	6,721.3	0.00	1,322.7	0.00	663.5	0.00	280.2	0.00	130.2	0.00
60	6,806.8	0.00	1,408.2	0.00	749.0	0.00	365.7	0.00	215.7	0.00

City: Evansville
HVAC: Natural Gas Heat Only

Measure	Base														
	0			11			19			30			38		
	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	115.5	0.00	24.6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
19	129.7	0.00	27.7	14.2	0.00	3.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
30	137.7	0.00	29.5	22.2	0.00	4.9	8.0	0.00	1.8	N/A	N/A	N/A	N/A	N/A	N/A
38	141.0	0.00	30.2	25.4	0.00	5.6	11.3	0.00	2.5	3.2	0.00	0.7	N/A	N/A	N/A
49	143.7	0.00	30.8	28.2	0.00	6.2	14.0	0.00	3.1	6.0	0.00	1.3	2.7	0.00	0.6
60	145.4	0.00	31.2	29.9	0.00	6.6	15.7	0.00	3.5	7.7	0.00	1.7	4.4	0.00	1.0

City: Ft Wayne
HVAC: AC with Natural Gas Heat

Measure	Base														
	0			11			19			30			38		
	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	339.2	0.171	32.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
19	378.7	0.205	35.9	39.4	0.034	3.9	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
30	399.7	0.239	38.1	60.4	0.068	6.1	21.0	0.034	2.3	N/A	N/A	N/A	N/A	N/A	N/A
38	409.2	0.239	39.0	70.0	0.068	7.0	30.5	0.034	3.2	9.6	0.00	0.9	N/A	N/A	N/A
49	417.4	0.256	39.8	78.2	0.085	7.8	38.7	0.051	3.9	17.7	0.017	1.7	8.2	0.017	0.8
60	421.7	0.256	40.3	82.4	0.085	8.3	43.0	0.051	4.4	22.0	0.017	2.2	12.5	0.017	1.3

City: Ft Wayne
HVAC: Heat Pump

Measure R-Value	Base									
	0		11		19		30		38	
	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF
11	5,507.3	0.051	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
19	6,091.0	0.085	583.6	0.034	N/A	N/A	N/A	N/A	N/A	N/A
30	6,427.1	0.102	919.8	0.051	336.2	0.017	N/A	N/A	N/A	N/A
38	6,555.6	0.102	1,048.3	0.051	464.7	0.017	128.5	0.00	N/A	N/A
49	6,667.2	0.102	1,159.9	0.051	576.3	0.017	240.1	0.00	111.6	0.00
60	6,739.8	0.119	1,232.4	0.068	648.8	0.034	312.6	0.017	184.1	0.017

City: Ft Wayne
HVAC: AC with Electric Heat

Measure R-Value	Base									
	0		11		19		30		38	
	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF
11	7,528.7	0.171	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
19	8,421.0	0.205	892.3	0.034	N/A	N/A	N/A	N/A	N/A	N/A
30	8,941.0	0.239	1,412.3	0.068	520.0	0.034	N/A	N/A	N/A	N/A
38	9,146.8	0.239	1,618.1	0.068	725.8	0.034	205.8	0.00	N/A	N/A
49	9,326.1	0.256	1,797.4	0.085	905.1	0.051	385.2	0.017	179.4	0.017
60	9,441.8	0.256	1,913.1	0.085	1,020.8	0.051	500.9	0.017	295.1	0.017

City: Ft Wayne
HVAC: Electric Heat Only

Measure R-Value	Base									
	0		11		19		30		38	
	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF
11	7,338.6	0.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
19	8,208.0	0.00	869.5	0.00	N/A	N/A	N/A	N/A	N/A	N/A
30	8,718.1	0.00	1,379.5	0.00	510.1	0.00	N/A	N/A	N/A	N/A
38	8,917.9	0.00	1,579.4	0.00	709.9	0.00	199.8	0.00	N/A	N/A
49	9,092.5	0.00	1,753.9	0.00	884.5	0.00	374.4	0.00	174.6	0.00
60	9,206.7	0.00	1,868.1	0.00	998.6	0.00	488.6	0.00	288.7	0.00

City: Ft Wayne
HVAC: Natural Gas Heat Only

Measure	Base														
	0			11			19			30			38		
	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	149.0	0.00	32.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
19	166.4	0.00	35.8	17.4	0.00	3.9	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
30	176.6	0.00	38.1	27.6	0.00	6.1	10.2	0.00	2.3	N/A	N/A	N/A	N/A	N/A	N/A
38	180.5	0.00	39.0	31.6	0.00	7.0	14.2	0.00	3.2	3.9	0.00	0.9	N/A	N/A	N/A
49	184.1	0.00	39.8	35.2	0.00	7.8	17.7	0.00	4.0	7.5	0.00	1.7	3.6	0.00	0.8
60	186.3	0.00	40.3	37.4	0.00	8.3	20.0	0.00	4.5	9.7	0.00	2.2	5.8	0.00	1.3

City: Terre Haute
HVAC: AC with Natural Gas Heat

Measure	Base														
	0			11			19			30			38		
	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	344.0	0.188	31.9	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
19	384.3	0.205	35.8	40.3	0.017	3.9	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
30	406.0	0.222	38.1	61.9	0.034	6.2	21.7	0.017	2.3	N/A	N/A	N/A	N/A	N/A	N/A
38	416.4	0.239	39.0	72.4	0.051	7.1	32.1	0.034	3.2	10.4	0.017	0.9	N/A	N/A	N/A
49	420.6	0.239	39.8	76.6	0.051	7.9	36.3	0.034	4.0	14.7	0.017	1.7	4.3	0.00	0.8
60	426.3	0.239	40.3	82.3	0.051	8.4	42.0	0.034	4.5	20.3	0.017	2.2	9.9	0.00	1.3

City: Terre Haute
HVAC: Heat Pump

Measure	Base									
	0		11		19		30		38	
	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF
11	5,539.8	0.188	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
19	6,144.0	0.205	604.3	0.017	N/A	N/A	N/A	N/A	N/A	N/A
30	6,488.6	0.222	948.8	0.034	344.5	0.017	N/A	N/A	N/A	N/A
38	6,621.2	0.239	1,081.4	0.051	477.1	0.034	132.6	0.017	N/A	N/A
49	6,737.4	0.239	1,197.6	0.051	593.3	0.034	248.8	0.017	116.2	0.00
60	6,813.0	0.256	1,273.2	0.068	668.9	0.051	324.4	0.034	191.8	0.017

City: Terre Haute
HVAC: AC with Electric Heat

Measure R-Value	Base									
	0		11		19		30		38	
	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF
11	7,544.0	0.188	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
19	8,444.2	0.205	900.2	0.017	N/A	N/A	N/A	N/A	N/A	N/A
30	8,970.3	0.222	1,426.3	0.034	526.1	0.017	N/A	N/A	N/A	N/A
38	9,178.5	0.239	1,634.5	0.051	734.3	0.034	208.2	0.017	N/A	N/A
49	9,355.3	0.239	1,811.3	0.051	911.1	0.034	385.0	0.017	176.8	0.00
60	9,473.7	0.239	1,929.7	0.051	1,029.5	0.034	503.4	0.017	295.2	0.00

City: Terre Haute
HVAC: Electric Heat Only

Measure R-Value	Base									
	0		11		19		30		38	
	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF
11	7,354.6	0.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
19	8,232.6	0.00	878.0	0.00	N/A	N/A	N/A	N/A	N/A	N/A
30	8,747.6	0.00	1,393.0	0.00	515.0	0.00	N/A	N/A	N/A	N/A
38	8,949.5	0.00	1,594.9	0.00	716.9	0.00	201.9	0.00	N/A	N/A
49	9,125.8	0.00	1,771.2	0.00	893.2	0.00	378.2	0.00	176.3	0.00
60	9,241.0	0.00	1,886.3	0.00	1,008.4	0.00	493.3	0.00	291.5	0.00

City: Terre Haute
HVAC: Natural Gas Heat Only

Measure	Base														
	0			11			19			30			38		
	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	154.4	0.00	31.9	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
19	172.7	0.00	35.8	18.3	0.00	3.9	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
30	183.3	0.00	38.1	28.8	0.00	6.2	10.6	0.00	2.3	N/A	N/A	N/A	N/A	N/A	N/A
38	187.4	0.00	39.0	32.9	0.00	7.1	14.7	0.00	3.2	4.1	0.00	0.9	N/A	N/A	N/A
49	191.1	0.00	39.8	36.7	0.00	7.9	18.4	0.00	4.0	7.8	0.00	1.7	3.8	0.00	0.8
60	193.5	0.00	40.3	39.1	0.00	8.4	20.8	0.00	4.5	10.2	0.00	2.2	6.1	0.00	1.3

Wall Insulation Measure Tables by City and HVAC Type

City: Indianapolis
HVAC: AC with Natural Gas Heat

Measure	Base														
	0			11			13			17			19		
	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	96.0	0.073	8.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13	108.4	0.073	9.3	12.4	0.00	1.2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
17	128.2	0.091	11.1	32.2	0.018	3.0	19.8	0.018	1.8	N/A	N/A	N/A	N/A	N/A	N/A
19	135.6	0.091	11.8	39.6	0.018	3.7	27.3	0.018	2.5	7.5	0.00	0.7	N/A	N/A	N/A
21	140.5	0.109	12.4	44.5	0.036	4.3	32.2	0.036	3.1	12.4	0.018	1.2	4.9	0.018	0.6
25	152.2	0.109	13.2	56.2	0.036	5.1	43.8	0.036	3.9	24.0	0.018	2.1	16.5	0.018	1.4
27	156.0	0.109	13.6	60.0	0.036	5.5	47.6	0.036	4.3	27.8	0.018	2.5	20.4	0.018	1.8

City: Indianapolis
HVAC: Heat Pump

Measure R-Value	Base									
	0		11		13		17		19	
	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF
11	1,150.4	0.145	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13	1,312.9	0.164	162.5	0.018	N/A	N/A	N/A	N/A	N/A	N/A
17	1,567.1	0.200	416.7	0.055	254.2	0.036	N/A	N/A	N/A	N/A
19	1,658.7	0.218	508.4	0.073	345.8	0.055	91.6	0.018	N/A	N/A
21	1,735.8	0.218	585.5	0.073	422.9	0.055	168.7	0.018	77.1	0.00
25	1,855.1	0.236	704.7	0.091	542.2	0.073	288.0	0.036	196.4	0.018
27	1,902.4	0.255	752.0	0.109	589.5	0.091	335.3	0.055	243.6	0.036

City: Indianapolis
HVAC: AC with Electric Heat

Measure R-Value	Base									
	0		11		13		17		19	
	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF
11	1,866.2	0.127	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13	2,135.5	0.145	269.3	0.018	N/A	N/A	N/A	N/A	N/A	N/A
17	2,556.2	0.182	690.0	0.055	420.7	0.036	N/A	N/A	N/A	N/A
19	2,709.3	0.182	843.1	0.055	573.8	0.036	153.1	0.00	N/A	N/A
21	2,837.8	0.200	971.6	0.073	702.4	0.055	281.6	0.018	128.5	0.018
25	3,036.7	0.200	1,170.5	0.073	901.3	0.055	480.5	0.018	327.5	0.018
27	3,116.5	0.218	1,250.4	0.091	981.1	0.073	560.4	0.036	407.3	0.036

City: Indianapolis
HVAC: Electric Heat Only

Measure R-Value	Base									
	0		11		13		17		19	
	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF
11	1,794.2	0.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13	2,054.2	0.00	260.0	0.00	N/A	N/A	N/A	N/A	N/A	N/A
17	2,458.9	0.00	664.7	0.00	404.7	0.00	N/A	N/A	N/A	N/A
19	2,606.0	0.00	811.8	0.00	551.8	0.00	147.1	0.00	N/A	N/A
21	2,730.0	0.00	935.8	0.00	675.8	0.00	271.1	0.00	124.0	0.00
25	2,920.2	0.00	1,126.0	0.00	866.0	0.00	461.3	0.00	314.2	0.00
27	2,998.4	0.00	1,204.2	0.00	944.2	0.00	539.5	0.00	392.4	0.00

City: Indianapolis
HVAC: Natural Gas Heat Only

Measure	Base														
	0			11			13			17			19		
	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	39.3	0.00	8.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13	44.7	0.00	9.3	5.5	0.00	1.2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
17	53.6	0.00	11.2	14.4	0.00	3.0	8.9	0.00	1.8	N/A	N/A	N/A	N/A	N/A	N/A
19	56.9	0.00	11.9	17.6	0.00	3.7	12.2	0.00	2.5	3.3	0.00	0.7	N/A	N/A	N/A
21	59.6	0.00	12.4	20.4	0.00	4.3	14.9	0.00	3.1	6.0	0.00	1.2	2.7	0.00	0.6
25	63.8	0.00	13.3	24.5	0.00	5.2	19.1	0.00	4.0	10.2	0.00	2.1	6.9	0.00	1.5
27	65.5	0.00	13.7	26.2	0.00	5.5	20.7	0.00	4.3	11.8	0.00	2.5	8.5	0.00	1.8

City: South Bend
HVAC: AC with Natural Gas Heat

Measure	Base														
	0			11			13			17			19		
	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	81.5	0.055	8.2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13	91.6	0.055	9.5	10.2	0.00	1.3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
17	111.8	0.073	11.3	30.4	0.018	3.1	20.2	0.018	1.8	N/A	N/A	N/A	N/A	N/A	N/A
19	117.6	0.073	12.0	36.2	0.018	3.8	26.0	0.018	2.5	5.8	0.00	0.7	N/A	N/A	N/A
21	121.3	0.073	12.5	39.8	0.018	4.4	29.6	0.018	3.1	9.5	0.00	1.2	3.6	0.00	0.6
25	131.1	0.073	13.4	49.6	0.018	5.3	39.5	0.018	3.9	19.3	0.00	2.1	13.5	0.00	1.4
27	135.3	0.073	13.8	53.8	0.018	5.6	43.6	0.018	4.3	23.5	0.00	2.5	17.6	0.00	1.8

City: South Bend
HVAC: Heat Pump

Measure R-Value	Base									
	0		11		13		17		19	
	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF
11	1,160.0	0.055	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13	1,338.5	0.073	178.5	0.018	N/A	N/A	N/A	N/A	N/A	N/A
17	1,591.3	0.091	431.3	0.036	252.7	0.018	N/A	N/A	N/A	N/A
19	1,682.0	0.091	522.0	0.036	343.5	0.018	90.7	0.00	N/A	N/A
21	1,756.2	0.091	596.2	0.036	417.6	0.018	164.9	0.00	74.2	0.00
25	1,876.4	0.091	716.4	0.036	537.8	0.018	285.1	0.00	194.4	0.00
27	1,924.5	0.109	764.5	0.055	586.0	0.036	333.3	0.018	242.5	0.018

City: South Bend
HVAC: AC with Electric Heat

Measure R-Value	Base									
	0		11		13		17		19	
	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF
11	1,885.5	0.073	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13	2,184.2	0.073	298.7	0.00	N/A	N/A	N/A	N/A	N/A	N/A
17	2,606.5	0.091	721.1	0.018	422.4	0.018	N/A	N/A	N/A	N/A
19	2,758.9	0.091	873.5	0.018	574.7	0.018	152.4	0.00	N/A	N/A
21	2,886.5	0.091	1,001.1	0.018	702.4	0.018	280.0	0.00	127.6	0.00
25	3,090.5	0.109	1,205.1	0.036	906.4	0.036	484.0	0.018	331.6	0.018
27	3,171.3	0.109	1,285.8	0.036	987.1	0.036	564.7	0.018	412.4	0.018

City: South Bend
HVAC: Electric Heat Only

Measure R-Value	Base									
	0		11		13		17		19	
	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF
11	1,826.5	0.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13	2,117.6	0.00	291.1	0.00	N/A	N/A	N/A	N/A	N/A	N/A
17	2,526.2	0.00	699.6	0.00	408.5	0.00	N/A	N/A	N/A	N/A
19	2,675.3	0.00	848.7	0.00	557.6	0.00	149.1	0.00	N/A	N/A
21	2,799.6	0.00	973.1	0.00	682.0	0.00	273.5	0.00	124.4	0.00
25	2,995.8	0.00	1,169.3	0.00	878.2	0.00	469.6	0.00	320.5	0.00
27	3,074.2	0.00	1,247.6	0.00	956.5	0.00	548.0	0.00	398.9	0.00

City: South Bend
HVAC: Natural Gas Heat Only

Measure	Base														
	0			11			13			17			19		
	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	40.0	0.00	8.2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13	46.4	0.00	9.5	6.4	0.00	1.3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
17	55.5	0.00	11.4	15.5	0.00	3.2	9.1	0.00	1.9	N/A	N/A	N/A	N/A	N/A	N/A
19	58.7	0.00	12.1	18.7	0.00	3.8	12.4	0.00	2.5	3.3	0.00	0.7	N/A	N/A	N/A
21	61.5	0.00	12.6	21.5	0.00	4.4	15.1	0.00	3.1	6.0	0.00	1.2	2.7	0.00	0.6
25	65.6	0.00	13.5	25.6	0.00	5.3	19.3	0.00	4.0	10.2	0.00	2.1	6.9	0.00	1.5
27	67.5	0.00	13.9	27.5	0.00	5.7	21.1	0.00	4.3	12.0	0.00	2.5	8.7	0.00	1.8

City: Evansville
HVAC: AC with Natural Gas Heat

Measure	Base														
	0			11			13			17			19		
	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	100.5	0.109	6.6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13	118.4	0.127	7.6	17.8	0.018	1.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
17	144.2	0.164	9.1	43.6	0.055	2.6	25.8	0.036	1.5	N/A	N/A	N/A	N/A	N/A	N/A
19	151.8	0.164	9.7	51.3	0.055	3.1	33.5	0.036	2.1	7.6	0.00	0.5	N/A	N/A	N/A
21	158.7	0.182	10.1	58.2	0.073	3.6	40.4	0.055	2.5	14.5	0.018	1.0	6.9	0.018	0.5
25	169.6	0.182	10.9	69.1	0.073	4.3	51.3	0.055	3.2	25.5	0.018	1.7	17.8	0.018	1.2
27	175.1	0.200	11.1	74.5	0.091	4.6	56.7	0.073	3.5	30.9	0.036	2.0	23.3	0.036	1.5

City: Evansville
HVAC: Heat Pump

Measure	Base									
	0		11		13		17		19	
	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF
11	760.9	0.127	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13	882.2	0.145	121.3	0.018	N/A	N/A	N/A	N/A	N/A	N/A
17	1,062.9	0.182	302.0	0.055	180.7	0.036	N/A	N/A	N/A	N/A
19	1,124.2	0.200	363.3	0.073	242.0	0.055	61.3	0.018	N/A	N/A
21	1,174.4	0.200	413.5	0.073	292.2	0.055	111.5	0.018	50.2	0.00
25	1,255.3	0.218	494.4	0.091	373.1	0.073	192.4	0.036	131.1	0.018
27	1,287.6	0.218	526.7	0.091	405.5	0.073	224.7	0.036	163.5	0.018

City: Evansville
HVAC: AC with Electric Heat

Measure	Base									
	0		11		13		17		19	
	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF
11	1,479.6	0.109	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13	1,716.7	0.127	237.1	0.018	N/A	N/A	N/A	N/A	N/A	N/A
17	2,062.5	0.145	582.9	0.036	345.8	0.018	N/A	N/A	N/A	N/A
19	2,184.0	0.164	704.4	0.055	467.3	0.036	121.5	0.018	N/A	N/A
21	2,286.4	0.164	806.7	0.055	569.6	0.036	223.8	0.018	102.4	0.00
25	2,444.4	0.182	964.7	0.073	727.6	0.055	381.8	0.036	260.4	0.018
27	2,507.8	0.182	1,028.2	0.073	791.1	0.055	445.3	0.036	323.8	0.018

City: Evansville
HVAC: Electric Heat Only

Measure R-Value	Base									
	0		11		13		17		19	
	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF
11	1,381.1	0.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13	1,602.4	0.00	221.3	0.00	N/A	N/A	N/A	N/A	N/A	N/A
17	1,925.3	0.00	544.2	0.00	322.9	0.00	N/A	N/A	N/A	N/A
19	2,038.9	0.00	657.8	0.00	436.5	0.00	113.6	0.00	N/A	N/A
21	2,133.8	0.00	752.7	0.00	531.5	0.00	208.5	0.00	94.9	0.00
25	2,282.5	0.00	901.5	0.00	680.2	0.00	357.3	0.00	243.6	0.00
27	2,342.4	0.00	961.3	0.00	740.0	0.00	417.1	0.00	303.5	0.00

City: Evansville
HVAC: Natural Gas Heat Only

Measure	Base														
	0			11			13			17			19		
	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	30.0	0.00	6.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13	34.9	0.00	7.6	4.9	0.00	1.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
17	42.0	0.00	9.1	12.0	0.00	2.6	7.1	0.00	1.5	N/A	N/A	N/A	N/A	N/A	N/A
19	44.4	0.00	9.7	14.4	0.00	3.1	9.5	0.00	2.1	2.4	0.00	0.5	N/A	N/A	N/A
21	46.5	0.00	10.1	16.5	0.00	3.6	11.6	0.00	2.5	4.5	0.00	1.0	2.2	0.00	0.5
25	49.6	0.00	10.8	19.6	0.00	4.3	14.7	0.00	3.2	7.6	0.00	1.7	5.3	0.00	1.2
27	51.1	0.00	11.1	21.1	0.00	4.6	16.2	0.00	3.5	9.1	0.00	2.0	6.7	0.00	1.5

City: Ft. Wayne
HVAC: AC with Natural Gas Heat

Measure	Base														
	0			11			13			17			19		
	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	50.8	0.033	5.3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13	58.5	0.043	6.1	7.7	0.011	0.8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
17	69.4	0.054	7.3	18.5	0.022	2.0	10.8	0.011	1.2	N/A	N/A	N/A	N/A	N/A	N/A
19	73.4	0.054	7.8	22.5	0.022	2.4	14.8	0.011	1.6	4.0	0.00	0.4	N/A	N/A	N/A
21	76.5	0.054	8.1	25.7	0.022	2.8	18.0	0.011	2.0	7.2	0.00	0.8	3.1	0.00	0.4
25	82.9	0.054	8.7	32.1	0.022	3.4	24.4	0.011	2.5	13.5	0.00	1.4	9.5	0.00	0.9
27	84.5	0.054	8.9	33.7	0.022	3.6	26.0	0.011	2.8	15.2	0.00	1.6	11.2	0.00	1.1

City: Ft Wayne
HVAC: Heat Pump

Measure R-Value	Base									
	0		11		13		17		19	
	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF
11	778.7	0.022	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13	897.9	0.022	119.2	0.00	N/A	N/A	N/A	N/A	N/A	N/A
17	1,062.4	0.033	283.8	0.011	164.5	0.011	N/A	N/A	N/A	N/A
19	1,122.6	0.033	343.9	0.011	224.7	0.011	60.2	0.00	N/A	N/A
21	1,172.0	0.033	393.3	0.011	274.1	0.011	109.6	0.00	49.4	0.00
25	1,251.8	0.033	473.1	0.011	353.9	0.011	189.4	0.00	129.2	0.00
27	1,282.0	0.043	503.4	0.022	384.1	0.022	219.6	0.011	159.4	0.011

City: Ft Wayne
HVAC: AC with Electric Heat

Measure R-Value	Base									
	0		11		13		17		19	
	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF
11	1,218.4	0.033	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13	1,409.0	0.043	190.5	0.011	N/A	N/A	N/A	N/A	N/A	N/A
17	1,677.1	0.054	458.7	0.022	268.2	0.011	N/A	N/A	N/A	N/A
19	1,775.1	0.054	556.7	0.022	366.1	0.011	98.0	0.00	N/A	N/A
21	1,856.7	0.054	638.3	0.022	447.8	0.011	179.6	0.00	81.6	0.00
25	1,986.3	0.054	767.9	0.022	577.4	0.011	309.2	0.00	211.3	0.00
27	2,037.4	0.054	819.0	0.022	628.4	0.011	360.3	0.00	262.3	0.00

City: Ft Wayne
HVAC: Electric Heat Only

Measure R-Value	Base									
	0		11		13		17		19	
	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF
11	1,193.0	0.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13	1,380.2	0.00	187.2	0.00	N/A	N/A	N/A	N/A	N/A	N/A
17	1,643.4	0.00	450.4	0.00	263.2	0.00	N/A	N/A	N/A	N/A
19	1,739.4	0.00	546.4	0.00	359.2	0.00	96.0	0.00	N/A	N/A
21	1,819.4	0.00	626.4	0.00	439.2	0.00	176.0	0.00	80.0	0.00
25	1,945.5	0.00	752.4	0.00	565.3	0.00	302.1	0.00	206.0	0.00
27	1,996.0	0.00	802.9	0.00	615.8	0.00	352.6	0.00	256.6	0.00

City: Ft. Wayne
HVAC: Natural Gas Heat Only

Measure	Base														
	0			11			13			17			19		
	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	25.9	0.00	5.3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13	29.9	0.00	6.1	4.0	0.00	0.8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
17	35.7	0.00	7.3	9.8	0.00	2.0	5.7	0.00	1.2	N/A	N/A	N/A	N/A	N/A	N/A
19	37.7	0.00	7.8	11.8	0.00	2.4	7.8	0.00	1.6	2.1	0.00	0.4	N/A	N/A	N/A
21	39.5	0.00	8.1	13.5	0.00	2.8	9.5	0.00	2.0	3.8	0.00	0.8	1.7	0.00	0.4
25	42.2	0.00	8.7	16.3	0.00	3.4	12.2	0.00	2.5	6.5	0.00	1.4	4.4	0.00	0.9
27	43.2	0.00	8.9	17.3	0.00	3.6	13.3	0.00	2.8	7.6	0.00	1.6	5.5	0.00	1.2

City: Terre Haute
HVAC: AC with Natural Gas Heat

Measure	Base														
	0			11			13			17			19		
	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	49.2	0.033	5.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13	57.2	0.033	6.0	8.0	0.00	0.8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
17	72.6	0.043	7.1	23.4	0.011	2.0	15.4	0.011	1.2	N/A	N/A	N/A	N/A	N/A	N/A
19	74.9	0.043	7.5	25.7	0.011	2.4	17.7	0.011	1.6	2.3	0.00	0.4	N/A	N/A	N/A
21	79.4	0.043	7.9	30.2	0.011	2.8	22.2	0.011	1.9	6.8	0.00	0.8	4.6	0.00	0.4
25	84.5	0.054	8.5	35.3	0.022	3.3	27.3	0.022	2.5	11.9	0.011	1.3	9.6	0.011	0.9
27	88.0	0.054	8.7	38.8	0.022	3.5	30.8	0.022	2.7	15.4	0.011	1.6	13.1	0.011	1.1

City: Terre Haute
HVAC: Heat Pump

Measure R-Value	Base									
	0		11		13		17		19	
	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF
11	760.8	0.033	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13	878.8	0.033	118.0	0.00	N/A	N/A	N/A	N/A	N/A	N/A
17	1,046.2	0.043	285.4	0.011	167.4	0.011	N/A	N/A	N/A	N/A
19	1,105.9	0.043	345.1	0.011	227.1	0.011	59.7	0.00	N/A	N/A
21	1,154.8	0.043	394.0	0.011	276.0	0.011	108.6	0.00	48.9	0.00
25	1,233.0	0.054	472.3	0.022	354.2	0.022	186.9	0.011	127.1	0.011
27	1,265.8	0.054	505.0	0.022	386.9	0.022	219.6	0.011	159.9	0.011

City: Terre Haute
HVAC: AC with Electric Heat

Measure R-Value	Base									
	0		11		13		17		19	
	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF
11	1,175.9	0.033	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13	1,363.4	0.033	187.5	0.00	N/A	N/A	N/A	N/A	N/A	N/A
17	1,631.7	0.043	455.8	0.011	268.3	0.011	N/A	N/A	N/A	N/A
19	1,726.3	0.043	550.4	0.011	362.9	0.011	94.6	0.00	N/A	N/A
21	1,807.7	0.043	631.8	0.011	444.3	0.011	176.0	0.00	81.4	0.00
25	1,933.8	0.054	757.9	0.022	570.3	0.022	302.1	0.011	207.5	0.011
27	1,985.6	0.054	809.7	0.022	622.2	0.022	353.9	0.011	259.3	0.011

City: Terre Haute
HVAC: Electric Heat Only

Measure R-Value	Base									
	0		11		13		17		19	
	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF	kWh/kSF	kW/kSF
11	1,151.6	0.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13	1,335.1	0.00	183.5	0.00	N/A	N/A	N/A	N/A	N/A	N/A
17	1,593.5	0.00	441.9	0.00	258.4	0.00	N/A	N/A	N/A	N/A
19	1,688.1	0.00	536.4	0.00	352.9	0.00	94.5	0.00	N/A	N/A
21	1,766.6	0.00	615.0	0.00	431.5	0.00	173.1	0.00	78.6	0.00
25	1,890.3	0.00	738.7	0.00	555.2	0.00	296.8	0.00	202.3	0.00
27	1,939.7	0.00	788.1	0.00	604.6	0.00	346.2	0.00	251.7	0.00

City: Terre Haute
HVAC: Natural Gas Heat Only

Measure	Base														
	0			11			13			17			19		
	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	25.0	0.00	5.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13	29.0	0.00	6.0	4.0	0.00	0.8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
17	34.7	0.00	7.1	9.6	0.00	2.0	5.6	0.00	1.2	N/A	N/A	N/A	N/A	N/A	N/A
19	36.7	0.00	7.6	11.7	0.00	2.4	7.7	0.00	1.6	2.1	0.00	0.4	N/A	N/A	N/A
21	38.4	0.00	7.9	13.3	0.00	2.8	9.3	0.00	2.0	3.7	0.00	0.8	1.6	0.00	0.4
25	41.1	0.00	8.5	16.0	0.00	3.3	12.0	0.00	2.5	6.4	0.00	1.3	4.3	0.00	0.9
27	42.2	0.00	8.7	17.1	0.00	3.5	13.1	0.00	2.7	7.5	0.00	1.5	5.4	0.00	1.1

Appendix D – Standard Wattage Tables

High Bay Fixture Baseline and Efficient Wattages

Efficient Lamp	Efficient Fixture Ballast Type	Baseline Lamp	Baseline Fixture Ballast Type	Efficient Fixture Wattage ($WATTS_{EE}$)	Efficient Fixture Wattage Source	Baseline Fixture Wattage ($WATTS_{BASE}$)	Baseline Fixture Wattage Source	Fixture Savings (Watts)
High Bay Fixtures								
T-5 46" Two Lamp High Output	Electronic - PRS	150 Watt Pulse Start Metal Halide	Magnetic-CWA	117	4	183	4	66
T-5 46" Three Lamp High Output	Electronic - PRS	200 Watt Pulse Start Metal Halide	Magnetic-CWA	181	4	232	3	51
T-5 46" Four Lamp High Output	Electronic – IS	320 Watt Pulse Start Metal Halide	Magnetic-CWA	234	3	365	3	131
T-5 46" Six Lamp High Output	Electronic – IS	350 Watt Pulse Start Metal Halide	Magnetic-CWA	351	3	400	3	49
T-5 46" Eight Lamp High Output	Electronic – IS	1,000 Watt Pulse Start Metal Halide	Magnetic-CWA	468	3	1,080	3	612
T-5 46” Six Lamp High Output (2 Fixtures)	Electronic – IS	1,000 Watt Pulse Start Metal Halide	Magnetic-CWA	702	3	1,080	3	378
T-8 48” Two Lamp Very High Output	Electronic – IS	150 Watt Pulse Start Metal Halide	Magnetic-CWA	77	4	183	4	106
T-8 48" Three Lamp Very High Output	Electronic – IS	150 Watt Pulse Start Metal Halide	Magnetic-CWA	112	3	183	4	71
T-8 48" Four Lamp Very High Output	Electronic – IS	200 Watt Pulse Start Metal Halide	Magnetic-CWA	151	3	232	3	81
T-8 48" Six Lamp Very High Output	Electronic – IS	320 Watt Pulse Start Metal Halide	Magnetic-CWA	226	3	365	3	139
T-8 48” Eight Lamp Very High Output	Electronic - PRS	350 Watt Pulse Start Metal Halide	Magnetic-CWA	288	4	400	3	112

Efficient Lamp	Efficient Fixture Ballast Type	Baseline Lamp	Baseline Fixture Ballast Type	Efficient Fixture Wattage (WATTS$_{EE}$)	Efficient Fixture Wattage Source	Baseline Fixture Wattage (WATTS$_{BASE}$)	Baseline Fixture Wattage Source	Fixture Savings (Watts)
T-8 48” Eight Lamp Very High Output (2 Fixtures)	Electronic – PRS	1,000 Watt Pulse Start Metal Halide	Magnetic-CWA	576	4	1,080	3	504
High Efficiency Fluorescent (HEF) Fixtures								
T-8 24" One Lamp	Electronic	T-12 24" One Lamp	Magnetic-STD	18	3	24	3	6
T-8 24" Two Lamp	Electronic	T-12 24" Two Lamp	Magnetic-STD	32	3	56	3	24
T-8 24" Three Lamp	Electronic	T-12 24" Three Lamp	Magnetic-STD	50	3	62	3	12
T-8 24" Four Lamp	Electronic	T-12 24" Four Lamp	Magnetic-STD	65	3	112	3	47
T-8 36" One Lamp	Electronic	T-12 36" One Lamp	Magnetic-STD	25	3	46	3	21
T-8 36" Two Lamp	Electronic	T-12 36" Two Lamp	Magnetic-STD	46	3	81	3	35
T-8 36" Three Lamp	Electronic	T-12 36" Three Lamp	Magnetic-STD	70	3	127	3	57
T-8 36" Four Lamp	Electronic	T-12 36" Four Lamp	Magnetic-STD	88	3	162	3	74
Reduced Wattage T-8 48" One Lamp-28 Watts	Electronic – IS	T-8 48" One Lamp	Electronic - IS	23	2	31	3	7.7
Reduced Wattage T-8 48" Two Lamp-28 Watts	Electronic – IS	T-8 48" Two Lamp	Electronic - IS	47	2	59	3	12
Reduced Wattage T-8 48" Three Lamp-28 Watts	Electronic – IS	T-8 48" Three Lamp	Electronic - IS	69.9	2	89	3	19.1
Reduced Wattage T-8 48" Four Lamp-28 Watts	Electronic – IS	T-8 48" Four Lamp	Electronic - IS	92.6	2	112	3	19.4
Reduced Wattage T-8 48" One Lamp-25 Watts	Electronic – IS	T-8 48" One Lamp	Electronic - IS	22	2	31	3	9
Reduced Wattage T-8 48" Two Lamp-25 Watts	Electronic – IS	T-8 48" Two Lamp	Electronic - IS	41	2	59	3	18
Reduced Wattage T-8 48" Three Lamp-25 Watts	Electronic – IS	T-8 48" Three Lamp	Electronic - IS	61.3	2	89	3	27.7
Reduced Wattage T-8 48" Four Lamp-25 Watts	Electronic – IS	T-8 48" Four Lamp	Electronic - IS	80.5	2	112	3	31.5

Efficient Lamp	Efficient Fixture Ballast Type	Baseline Lamp	Baseline Fixture Ballast Type	Efficient Fixture Wattage (WATTS$_{EE}$)	Efficient Fixture Wattage Source	Baseline Fixture Wattage (WATTS$_{BASE}$)	Baseline Fixture Wattage Source	Fixture Savings (Watts)
T-8 96" One Lamp	Electronic – IS	T-12 96" One Lamp-ES	Magnetic-STD	58	3	75	3	17
T-8 96" Two Lamp	Electronic – IS	T-12 96" Two Lamp-ES	Magnetic-ES	109	3	123	3	14
T-8 96" Four Lamp	Electronic – IS	T-12 96" Four Lamp-ES	Magnetic-ES	219	3	246	3	27
High Performance T-8 48" One Lamp	Electronic	T-8 48" One Lamp	Electronic - IS	25	6	31	3	6
High Performance T-8 48" Two Lamp	Electronic	T-8 48" Two Lamp	Electronic - IS	48	6	59	3	10
High Performance T-8 48" Three Lamp	Electronic	T-8 48" Three Lamp	Electronic - IS	73	6	89	3	17
High Performance T-8 48" Four Lamp	Electronic	T-8 48" Four Lamp	Electronic - IS	96	6	112	3	18
Metal Halide Track (MHT) Fixtures								
Metal Halide 20 Watts		Two 50 Watt Halogen		23	1	100	1	77
Metal Halide 39 Watts		Two 75 Watt Halogen		43	1	150	1	107
Metal Halide 70 Watts		Three 75 Watt Halogen		77	1	225	1	148
Ceramic Metal Halide (CMH) Fixtures								
Ceramic Metal Halide 20 Watts		Two 50 Watt Halogen		26	1	100	1	74
Ceramic Metal Halide 39 Watts		Two 75 Watt Halogen		45	1	150	1	105
Ceramic Metal Halide 50 Watts		Three 65 Watt Halogen		55	1	195	1	140
Ceramic Metal Halide 70 Watts		Three 75 Watt Halogen		79	1	225	1	146
Ceramic Metal Halide 100 Watts		Three 90 Watt Halogen		110	1	270	1	160
Ceramic Metal Halide 150		Three 120 Watt Halogen		163	1	360	1	197

Efficient Lamp	Efficient Fixture Ballast Type	Baseline Lamp	Baseline Fixture Ballast Type	Efficient Fixture Wattage (WATTS$_{EE}$)	Efficient Fixture Wattage Source	Baseline Fixture Wattage (WATTS$_{BASE}$)	Baseline Fixture Wattage Source	Fixture Savings (Watts)
Watts								
Low and High Bay Fixtures								
Low Bay LED 85 Watts 3		Metal Halide 250 Watts		85		295		210
Low Bay LED 85 Watts 3		T-8 96" Two Lamp High Output	Electronic	85		160		75
High Bay LED 139 Watts		Metal Halide 200 Watts		139		232		93
High Bay LED 175 Watts		Metal Halide 250 Watts		175		295		120

Sources

1. Efficiency Vermont. *Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions*. February 19, 2010.
2. Kuiken et al., KEMA. *Focus on Energy Evaluation, Business Programs: Deemed Savings Manual V1.0*. March 22, 2010.
3. Southern California Edison. *2010 Standard Performance Contract Procedures Manual.* “Appendix B: 2010 Table of Standard Fixture Wattages. Ver. 1.1.” February 25, 2010. Available online: http://www.aesc-inc.com/download/SPC/2010SPCDocs/UnifiedManual/App%20B%20Standard%20Fixture%20Watts.pdf
4. El Paso Electric. “2009 EPE Program Downloads. Wattage Table 2009.” Accessed September 26, 2009. http://www.epelectricefficiency.com/downloads.asp?section=ci
5. *New Jersey Clean Energy Program: Protocols to Measure Resource Savings.* December 2007.
6. Thorne and Nadel. *Commercial Lighting Retrofits: A Briefing Report for Program Implementers.* Paper presented at the annual meeting for the American Council for an Energy-Efficient Economy, April 2003.

Appendix E – TRM Updates and Changes

Measure	Edit #	Major Edit Description	Date
Residential Sector			
Residential ENERGY STAR Compact Fluorescent Lamp (CFL) Lighting (CFL and LED)	1	Combined with LED lamps	June 2015
	2	Fully accepted EISA baselines (no more language about future changes)	June 2015
	3	Included annual hours-of-use for school programs	June 2015
	4	Included annual hours-of-use for multifamily and specialty bulbs (from Illinois TRM)	June 2015
	5	Changed algorithm from delta watts multiplier to base watts multiplier	June 2015
	6	Updated incremental cost for CFLs	June 2015
	7	Updated incremental cost for LEDs	June 2015
Residential Direct Install - ENERGY STAR Compact Fluorescent Lamp (CFL) (Early Replacement)	1	Removed from TRM (combined with CFL/LED section)	June 2015
Residential LED Lamps	1	Removed from TRM (combined with CFL/LED section)	June 2015
	2	Created baseline watt multiplier from ENERGY STAR-qualified list	June 2015
LED Night Lights	1	No edits made	June 2015
Refrigerator and/or Freezer Retirement (Early Retirement)	1	Corrected math in example equation	June 2015
Residential HVAC Maintenance/Tune Up (Retrofit)	1	Included typical existing cooling capacity in accordance with 2012 Baseline Study	June 2015
	2	Included typical existing SEER in accordance with 2012 Baseline Study	June 2015
Residential Boiler Tune-Up	1	Included typical existing heating input in accordance with 2012 Baseline Study	June 2015

Measure	Edit #	Major Edit Description	Date
Attic/Roof/Ceiling Insulation (Retrofit)	1	Removed from TRM (combined with Wall Insulation)	June 2015
	2	Corrected math in example equation	June 2015
ENERGY STAR Torchiere (Time of Sale)	1	Updated baseline watts to reflect EISA	June 2015
Dedicated Pin Based Compact Fluorescent Lamp (CFL) Table Lamp	1	Updated baseline watts to reflect EISA	June 2015
Ceiling Fan with ENERGY STAR Light Fixture (Time of Sale)	1	Updated baseline watts to reflect EISA	June 2015
Efficient Refrigerator – ENERGY STAR and CEE TIER 2 (Time of Sale)	1	Updated baseline UEC from ENERGY STAR website	June 2015
Refrigerator Replacement (Low Income, Early Replacement)	1	Updated baseline and efficient UEC from ENERGY STAR website	June 2015
Clothes Washer – ENERGY STAR and CEE TIER 3 (Time of Sale)	1	No edits made (could not follow methodology); future edits should update RECs data	June 2015
	2	Updated incremental cost	June 2015
ENERGY STAR Room Air Conditioner (Time of Sale)	1	Updated average size of rebated unit according to ENERGY STAR list	June 2015
	2	Updated baseline efficiency based on 2015 e-CFR (federal standard)	June 2015
	3	Updated ENERGY STAR efficiency to comply with standards	June 2015
ENERGY STAR Room Air Conditioner Replacement (Low Income, Early Replacement)	1	Updated average size of rebated unit according to ENERGY STAR list	June 2015
	2	Updated the baseline efficiency based on 2015 e-CFR (fed standard)	June 2015
	3	Updated ENERGY STAR efficiency to comply with standards	June 2015
ENERGY STAR Room Air Conditioner Recycling (Early Retirement)	1	Updated average size of rebated unit according to ENERGY STAR list	June 2015
Central Air Conditioning (Early Replacement)	1	Included typical existing cooling capacity in accordance with 2012 Baseline Study	June 2015

Measure	Edit #	Major Edit Description	Date
	2	Included typical existing SEER in accordance with 2012 Baseline Study	June 2015
Central Air Conditioning (Time of Sale	1	Included typical existing cooling capacity in accordance with 2012 Baseline Study	June 2015
Central Air Source Heat Pump (Early Replacement)	1	Corrected algorithm to distinguish between heating and cooling capacities	June 2015
Central Air-Source Heat Pump (Time of Sale)	1	Corrected algorithm to distinguish between heating and cooling capacities	June 2015
Ground-Source Heat Pumps (Time of Sale)	1	Corrected algorithm to distinguish between heating and cooling capacities	June 2015
Low-Flow Faucet Aerator (Time of Sale or Early Replacement)	1	Overhauled measure and algorithm to comply with Cadmus Michigan water study and Interstate Power & Light multifamily direct install study	June 2015
	2	Updated groundwater temperature table to comply with *DHW Event Generator* developed by NREL	June 2015
Low-Flow Showerhead (Time of Sale or Early Replacement)	1	Overhauled measure and algorithm to comply with Cadmus Michigan water study and Interstate Power & Light multifamily direct install study	June 2015
	2	Updated incremental cost	June 2015
	2	Updated groundwater temperature table to comply with *DHW Event Generator* developed by NREL	June 2015
Domestic Hot Water Pipe Insulation (Retrofit)	1	Updated incremental cost	June 2015
Wall Insulation (Retrofit)	1	Removed from TRM (combined with Attic/Roof/Ceiling Insulation)	June 2015
Air Sealing - Reduce Infiltration (Retrofit)	1	Updated N-factors in table to align properly with *Residential Energy Book*	June 2015

Measure	Edit #	Major Edit Description	Date
	2	Updated reference tables to incorporate the adjustment proxy for new modeling	June 2015
Duct Sealing and Insulation (Retrofit)	1	Included typical existing cooling capacity in accordance with 2012 Baseline Study	June 2015
	2	Included typical existing SEER in accordance with 2012 Baseline Study	June 2015
	3	Updated incremental cost	June 2015
ENERGY STAR Windows (Time of Sale)	1	Updated reference tables to incorporate the adjustment proxy for new modeling	June 2015
Natural Gas Water Heaters (Time of Sale)	1	Updated groundwater temperature table to comply with *DHW Event Generator* developed by NREL	June 2015
	2	Updated ENERGY STAR criteria table	June 2015
Programmable Thermostats (Time of Sale, Direct Install)	1	Updated ESFs based on NIPSCO smart Wi-Fi t-stat study	June 2015
	2	Updated heating algorithm (no efficiency term needed since FF equipment rating is already in input)	June 2015
Added Smart Thermostats	1	Based on published studies in Indiana.	July 2015
Condensing Furnaces-Residential (Time of Sale)	1	Updated incremental cost	June 2015
Residential New Construction	1	Updated based on IECC 2009 specifications	June 2015
Other Software	1	Removed	June 2015
Commercial Sector			
Chiller Tune-Up	1	Corrected math in example equation	June 2015
C&I Lighting Controls (Time of Sale, Retrofit)	1	Removed redundant ESF from demand reduction algorithm	June 2015
Lighting Systems (Non-Controls) (Time of Sale, New Construction	1	Reformatted to condense	June 2015

Measure	Edit #	Major Edit Description	Date
Lighting Systems (Non-Controls) (Early Replacement, Retrofit)	1	Reduced Delta Watts multiplier due to EISA	June 2015
LED Case Lighting with/without Motion Sensors (New Construction; Retrofit – Early Replacement	1	Updated wattage tables to align with Wisconsin TRM	June 2015
	1	Corrected algorithm to account for additional freezer fixture	June 2015
June 2015Traffic Signals (Retrofit)	1	Updated wattage tables and CFs to align with Pennsylvania TRM	June 2015
ENERGY STAR Room Air Conditioner (Time of Sale)	1	Updated baseline efficiency standards	June 2015
	2	Updated Tier 1 and ENERGY STAR efficiency standards	June 2015
ENERGY STAR Hot Food Holding Cabinet (Time of Sale)	1	Updated baseline and efficient wattage per cubic foot based on ENERGY STAR requirements and fishnick.com	June 2015
ENERGY STAR Griddle (Time of Sale)	1	Updated efficient model parameters based on fishnick.com	June 2015
Spray Nozzles for Food Service (Retrofit)	1	Updated groundwater temperature table to comply with *DHW Event Generator* developed by NREL	June 2015
Heat Pump Water Heaters (New Construction, Retrofit)	1	Updated groundwater temperature table to comply with *DHW Event Generator* developed by NREL	June 2015
	2	Updated EF algorithms based on federal baseline	June 2015
Commercial Clothes Washer (Time of Sale)	1	No edits made	June 2015
Commercial Plug Load – Smart Strip Plug Outlets (Time of Use, Retrofit – New Equipment)	1	Expanded standby power consumption table to include weighted values	June 2015
Energy Efficient Furnace (Time of Sale, Retrofit – Early Replacement)	1	Corrected algorithm to conform with citation	June 2015

Measure	Edit #	Major Edit Description	Date
High Efficiency Storage Tank Water Heater (Time of Sale, Retrofit – Early Replacement)	1	Updated groundwater temperature table to comply with *DHW Event Generator* developed by NREL	June 2015
	2	Updated EF algorithms based on federal baseline	June 2015
Tankless Water Heaters (Time of Sale, Retrofit – Early Replacement)	1	Updated groundwater temperature table to comply with *DHW Event Generator* developed by NREL	June 2015
	2	Updated EF algorithms based on federal baseline	June 2015