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October 16, 2015

Via Hand Delivery And Electronic Mail
Honorable Irene Kim Asbury, Secretary
New Jersey Board of Public Utilities
44 South Clinton Avenue, 9th Floor
P.O. Box 350
Trenton, New Jersey 08625

Re: Comments of the New Jersey Division of Rate Counsel
CEP Proposed Revisions to NJCEP Protocols
BPU Dkt. No.: EO09120975

Dear Secretary Asbury:

The Division of Rate Counsel ("Rate Counsel") would like to thank the Board of Public Utilities ("BPU" or "Board") for the opportunity to present the within comments on the proposed revisions ("Draft Protocols") to the Clean Energy Program ("CEP") Protocols ("Protocols") submitted in red-line form by the BPU's Office of Clean Energy ("OCE") on September 21, 2015 to stakeholders for comment.[1]

Enclosed please find original and ten copies of comments submitted on behalf of Rate Counsel in connection with the above-captioned matter. We are enclosing one additional copy of

[1] The Draft Protocols circulated for comment was entitled: "New Jersey Board of Public Utilities, New Jersey Clean Energy Program, Protocols to Measure Resource Savings, Revisions to FY 2015 Protocols, Release Date TBD"

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the comments. **Please stamp and date the extra copy as 'filed" and return it in our self-addressed stamped envelope**.

I. Introduction and Summary

Presently, the Office of Clean Energy ("OCE") and the Market Managers for CEP's energy efficiency ("EE") and renewable energy ("RE") programs use the current version of the Protocols to Measure Resource Savings to track the energy and demand savings (and RE generation) resulting from participation in CEP programs. Energy and demand savings data submitted by the CEP Market Managers – calculated using the Protocols – is compiled by the OCE's CEP Program Coordinator, who then prepares quarterly and annual reports on CEP activity and results to the Board. In addition, the Protocols have been used by several utilities to estimate prospective energy savings associated with the EE measures and programs found in their energy efficiency economic stimulus ("E3") programs initially approved by the Board in 2009. For the above reasons, the Protocols are an important component of the CEP.

Rate Counsel notes that Draft Protocols incorporate the revisions to the March 2014 Protocols approved by the Board.[2] Generally, except as noted below, Rate Counsel does not object to those proposed revisions to the March 2014 Protocols and concurs with the proposed revisions which address new federal standards, industry norms, and technological advancements.

The Draft Protocols incorporate approximately 30 modifications. Rate Counsel found that while the majority of the proposed modifications are reasonable, there are several minor issues with some of the proposed changes. Such issues include calculation errors, typographical

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[2] I/M/O Revisions to New Jersey's Clean Energy Program March 2014 Protocols to Measure Resource Savings, BPU Dkt. No. EO09120975 (Order, 5/19/15) ("2015 Protocols Order").

errors, and unclear variable definitions and data sources. Rate Counsel's comments on specific issues are found below.

II. Specific Issues

A. Lost Revenue Recovery (pp. 1-2)

Previous versions of the Protocols have listed calculation of lost margin revenue recovery as one of the Protocols' main uses. Rate Counsel has consistently objected to the inclusion of calculation of lost margin revenue recovery as a use of the Protocols, because its inclusion presumptively considers Board approval of consideration of lost margin revenue. While the proposed revisions to the Protocols no longer include calculations of lost margin revenue recovery as a use of the document on page 5, Rate Counsel recommends an additional step: the document should include an affirmative statement that the Protocols should not be used for lost revenue calculations.

B. Free Riders and Free Drivers

The savings calculations in the Protocols do not reflect the impacts of free ridership and spillover (also known as effects of "free drivers"). These values help assess the effectiveness of EE measures. The Draft Protocols indicates that "[f]ree riders and free drivers are not addressed in these Protocols."(p. 2) Rate Counsel is aware of many savings protocols in other jurisdictions that include these values, primarily because they are essential for determining the effectiveness of the current program designs. Thus, Rate Counsel recommends that the OCE initiate studies for free riders and free drivers soon after the new Program Administrator starts to deliver programs at the end of this year or early next year. The results from these studies should be included in future versions of the Protocols.

C. Ground Source Heat Pump (p. 13)

There appears to be a typographical error in the formula for calculating heating energy savings from ground source heat pumps ("GSHP"). The proposed revised formula for GSHP heating energy savings is as follows:

> Heating Energy (kWh) Savings = CAPY/1000 X (1/*(COPg,b X GSER)* ~~HSPFb~~ – (1/ (COPg X GSOP)) X EFLHh

Rate Counsel believes the revision in italics above should use "GSOP" rather than "GSER." While this is a technical detail, it is an important distinction which affects the accuracy of the energy savings calculation for heating, in contrast to that for cooling. GSER is defined as the factor to determine the Seasonal Energy Efficiency Ratio ("SEER") (expressed in Btu per watt-hour) of a GSHP based on its energy efficiency ratio (p. 14). However, SEER is an efficiency factor for cooling energy consumption, rather than heating energy consumption. Thus, GSER is tied to energy savings for cooling. In contrast, GSOP is tied to heating savings since it is a factor to determine the Heating Seasonal Performance Factor ("HSPF") (expressed in Btu per watt-hour) of a GSHP-based on its Coefficient of Performance ("COP").[3]

D. Residential Gas HVAC Boiler Circulatory Pumps (pp. 20 - 22)

The Draft Protocols propose to remove the formula for estimating savings from a qualifying boiler control and replace it with a formula for circulator pumps savings. Boiler control and circulator pumps are two different energy efficiency measures. Thus, it is unclear why the proposed formula for circulator pumps replaces the formula for a boiler control. Rate Counsel recommends that the authors provide an additional explanation for this change.

[3] COP represents the ratio of total heating capacity to electrical energy input. It is a unit-less measure of efficiency typically used for the heating mode of geothermal heat pumps.

Another issue identified by Rate Counsel is the data source used for estimating savings for circular pumps. The Draft Protocols propose to use Source Number 8 "Efficiency Vermont Technical Reference Manual." The Draft Protocols should provide more information for the data source "Efficiency Vermont Technical Reference Manual," such as the version, date of the publication, and URL so that reviewers could review the original data source, calculations, and any studies that support the key assumptions.

E. Residential Low Income Combo Space and Water Heating (pp. 25 – 29)

Within Table IV-1 on page 29, the Draft Protocols provide fixed values for both annual domestic water heating load and annual domestic home water usage. These values appear to be based on the water usage and water heating load for a typical Connecticut home. While New Jersey and Connecticut are located in the same region and have broadly similar housing profiles, the great variety of housing stock within New Jersey means that these fixed values are only rough estimates of savings. Where possible, water heating savings estimates should be better tailored to the characteristics of the building in question, as is the case with the space heating saving estimates.

In addition, Rate Counsel found some omissions and typographical errors in this section, as described below:

- In the calculations for both $ABTU_H$ and $ABTU_W$ provided on page 29, there appears to be a typographical error: "AFEUI" should be written as "AFUEI."
- No definition is given for $ABTU_W$ in Table IV-1 or elsewhere in this section.
- Tables IV-2 and IV-3 for HF and $AFUE_E$ values, referenced on page 29, are missing from the Draft Protocols Update document.

F. Residential Low Income LED Nightlight (pp. 31 – 36)

Values for Light Emitting Diode ("LED") lighting measures, such as energy savings, operating hours, and capacity savings are based on the Apprise Memorandum referenced on page 34. Rate Counsel was unable to locate this document. The Draft Protocols' authors should provide the URL for this document to allow reviewers to assess the reasonableness of the approach and key assumptions used to estimate energy savings from LEDs.

G. Residential New Construction (p. 35 – 40)

The Draft Protocols propose to add detailed calculations and assumptions for building shells, lighting and appliances, and multi-family high-rise new construction. The majority of the proposed changes appear reasonable. A requirement for the use of REM/Rate™ is reasonable as REM/Rate is the most widely used software to estimate energy consumption from residential new construction, often for code compliance purposes.[4] The use of US EPA's Performance Path Calculator ("PPC") for multi-family high-rise buildings also appears reasonable because this tool is built upon outputs from a widely-used building simulation software called eQuest.

However, Rate Counsel identified two minor issues related to residential new construction. First, Rate Counsel recommends that the phrase "Baseline Home Peak Demand" (at the bottom of page 35) be revised to read "Baseline Home Electric Peak Demand" because the calculation pertains to only electricity peak load, not gas peak load.

Second, Rate Counsel was unable to locate the reference numbers 4 and 6 for CFL-related energy savings, both of which refer to a single source called "ENERGY STAR CFL Bulb

[4] More specifically, REM/Rate™ estimates annual energy load, consumption and costs as well as Home Energy Rating Systems (HERS) scores for new homes including ENERGY STAR homes. HERS is an industry standard developed by RESNET (Residential Energy Services Network) by which a home's energy efficiency is measured against the performance of a standard new home. More information on REM/Rate™ is available at http://www.remrate.com/.

protocol" (pp. 39 – 40). Rate Counsel recommends that the Draft Protocols' authors provide more information about this data source, including the full source title and URL.

H. Energy Star Products Clothes Washers (p. 45 - 50)

It is unclear how the source named in reference number 5 on page 49 (the reference for ENERGY STAR refrigerator savings) was used to estimate energy savings from ENERGY STAR and CEE Tier 2 refrigerators. The spreadsheet linked to this reference does not clearly indicate which refrigerators fall in CEE Tier 1, and which fall in CEE Tier 2. The Draft Protocols should provide the exact formula the authors used or explain an approach used to calculate electricity, natural gas, and water savings from the eligible clothes washer types. Alternatively, Rate Counsel suggests that the NJCEP use a different data source such as Consortium for Energy Efficiency's ("CEE") database for refrigerators, since it provides savings for the qualified Tier 2 refrigerators.[5]

I. Appliance Recycling (p. 59)

The Draft Protocols also include estimates of annual energy savings from appliance recycling. However, Rate Counsel believes that the annual energy savings estimates of 761 kWh for refrigerator recycling (or $ESav_{RetFridge}$) and 639 kWh for freezer recycling (or $ESav_{RetFreezer}$) are not appropriate for New Jersey. These values were obtained from the source named in reference number 1 as the "Mid-Atlantic Technical Reference Manual" prepared by the Northeast Energy Efficiency Partnership ("NEEP"), published in June 2014. This NEEP document indicates that these values are derived using two regression models based on

[5] CEE database is available at http://library.cee1.org/content/qualifying-product-lists-residential-refrigerators

Maryland-specific values (NEEP 2014, pp. 96 – 97).[6] The NEEP document also indicates that the regression models include location-specific factors such as heating degree days ("HDD") and cooling degree days ("CDD"). Relative to Maryland's climate, New Jersey tends to have higher HDD, and lower CDD, suggesting that the predicated annual savings for New Jersey should be different from those average values for Maryland. Thus, Rate Counsel recommends that the Protocols include New Jersey-specific energy savings for refrigerators and freezers. Further, the peak savings values for both refrigerators and freezers (or $DSav_{RetFridge}$ and $DSav_{RetFreezer}$) need to be modified as well, because peak savings are derived from another formula that accounts for annual energy savings estimated based on the two regression models discussed above.

J. Commercial and Industrial EE Construction Electric Chillers (p. 89)

The Draft Protocols propose to modify a majority of measure types and the associated load values, while maintaining the original data source of ASHRAE 90.1-2007. However, it is difficult to assess the validity of these proposed modifications, mainly because the Draft Protocols do not provide the reasons for the proposed modifications. Further, it is not clear exactly which parts of the ASHRAE 90.1-2007 document the authors used to revise the assumptions. Rate Counsel recommends that the Draft Protocols' authors explain the reasons for the modifications and provide detailed data sources including page numbers and table names from the cited ASHRAE document.

K. Renewable Energy SREC Registration Program (p. 143)

The Draft Protocols should provide the data source for the estimated annual production factor of 1,200 KWh per kW. Otherwise, it is difficult to assess the reasonableness of this assumption.

[6] The NEEP study is available at http://www.neep.org/mid-atlantic-technical-reference-manual-v4.

This is important because, unlike typical energy efficiency measures, actual production data is available when the solar systems start producing electricity. Thus, the solar energy production forecast should be updated with actual data soon after the solar systems commence operation.

Finally, in addition to the above recommendations, Rate Counsel respectfully submits that future versions of the Protocols should reflect the anticipated findings of the now pending CEP's Data and Evaluation working group proceeding as well as any measurement and verification methodologies required for participation in PJM Interconnection, LLC's EE and Demand Response programs.

Thank you for your consideration of the within comments.

Respectfully submitted,

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November 6, 2015

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Re: Supplemental Comments of the New Jersey Division of Rate Counsel
CEP Proposed Revisions to NJCEP Protocols
BPU Dkt. No.: EO09120975

Dear Secretary Asbury:

On October 16, 2015, the Division of Rate Counsel ("Rate Counsel") submitted its initial comments to the Board of Public Utilities ("BPU" or "Board") on the proposed revisions ("Draft Protocols") to the Clean Energy Program ("CEP") Protocols ("Protocols") which were submitted in red-line form by the BPU's Office of Clean Energy ("OCE") on September 21, 2015 to stakeholders for comment.[1] The within supplemental comments address the comments submitted on October 16, 2015 by South Jersey Gas Company ("SJG") with respect to the

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[1] The Draft Protocols circulated for comment was entitled: "New Jersey Board of Public Utilities, New Jersey Clean Energy Program, Protocols to Measure Resource Savings, Revisions to FY 2015 Protocols, Release Date TBD"

protocols applicable to low-income programs.[2] In addition, the within supplemental comments clarify Rate Counsel's earlier comments on the protocols applicable to home appliances.[3]

Enclosed please find original and ten copies of comments submitted on behalf of Rate Counsel in connection with the above-captioned matter. We are enclosing one additional copy of the comments. **Please stamp and date the extra copy as 'filed" and return it in our self-addressed stamped envelope**.

I. Specific Issues Relating to SJG's Low-Income Program Proposals

A. Hot Water Conservation Measures – Showerheads

Low flow showerheads are a new measure introduced in the SJG October 16 Comments.[4] SJG proposes an algorithm to estimate energy savings based on a 2010 technical reference manual ("TRM") from the state of Ohio ("Ohio TRM") as follows:

$$\Delta kWh = ISR \times (GPM_{base} - GPM_{low}) \times \left(\frac{kWh}{GPM_{reduced}}\right)$$

$$\Delta MMBtu = ISR \times (GPM_{base} - GPM_{low}) \times \left(\frac{MMBtu}{GPM_{reduced}}\right)$$

[2] SJG's comments ("SJG October 16 Comments") are available at the CEP website at http://www.njcleanenergy.com/files/file/public_comments/Revised%20Protocols%20comments%281%29.pdf.
[3] See Rate Counsel October 16 Comments, Section II. H., p. 7.
[4] See SJG October 16 Comments, pp. 25-26.

Table IV-19

Definitions and Values for Showerheads

Term	Definition	Value
ISR	In Service Rate – Fraction of Units Installed	1.0
GPM_{base}	Gallons Per Minute of baseline showerhead	2.87
GPM_{low}	Gallons Per Minute of low flow showerhead	1.75
$kWh/GPM_{reduced}$	Assumed kWh savings per GPM reduction	149
MMBtu/GPM Reduced	Assumed MMBtu savings per GPM of reduction	0.66

Rate Counsel has several comments regarding SJG's proposal. The algorithm proposed by SJG contains assumed energy savings values relative to gallons per minute ("GPM") of shower water use for electricity and gas (i.e., 149 kWh for electricity and 0.66 MMBtu for gas). However, at face value the proposed algorithm does not recognize that occupancy differs by housing type.[5] Water and energy consumption differ widely depending on the number of occupants in a household. The latest TRM for Pennsylvania uses an algorithm that recognizes this difference by using two sets of numbers for occupancy: 2.4 persons per household for single-family homes, and 1.9 persons per household for multi-family houses.[6] Using the formula found in the Pennsylvania TRM results in a difference of about 26% in electricity savings between the two types of buildings. Because of the potentially significant difference in energy consumption by residence type, and because it is relatively easy to identify the type of building by asking

[5] Rate Counsel was unable to obtain the original data source, the Ohio TRM, online and, therefore, was unable to evaluate the assumptions underlying the proposed values.

[6] Pennsylvania Public Utility Commission (2015). 2016 Technical Reference Manual, p. 120 to 122, available at http://www.puc.pa.gov/pcdocs/1370278.docx.

participants, we recommend that the OCE consider reviewing and adopting the algorithm provided in the Pennsylvania TRM.

Furthermore, the SJG October 16 Comments do not contain any algorithm or assumption for peak kW load reduction. The above-cited Pennsylvania TRM offers a formula to estimate peak kW savings from this measure. Rate Counsel recommends that the OCE review the Pennsylvania TRM and consider adopting it.

B. Hot Water Conservation Measures – Aerators

Aerators are another new measure introduced in the SJG October 16 Comments.[7] SJG proposes an algorithm to estimate energy savings from aerators based on a 2010 TRM from the State of New York.

Similar to the algorithm for showerheads discussed above, the proposed algorithm does not recognize the differences in occupancy by housing type. The algorithm used in the Pennsylvania TRM for aerators takes into account differences in the number of occupants for single family and multi-family residences.[8] Therefore, Rate Counsel recommends that the OCE consider reviewing and adopting the algorithm provided in the Pennsylvania TRM.

Further, Rate Counsel notes that New York updated its TRM in December 2014 ("2014 New York TRM"). New York's updated TRM uses a slightly different value and formula for aerators.[9] For example, the 2010 New York TRM (on which SJG's proposed aerator value is

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[7] See SJG October 16 Comments, pp. 23-26.

[8] Pennsylvania Public Utility Commission (2015), p. 114 – 117.

[9] New York State Department of Public Service (2014). New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs – Residential, Multi-Family, and Commercial/Industrial Measures. Version 2, available at

based) uses 0.75 for the efficiency of existing gas water heaters whereas 2014 New York TRM uses 0.67. Further, the calculation of water savings in the 2014 New York TRM includes a variable called "flow rate restricted." Rate Counsel recommends that the OCE adopt the algorithm in the Pennsylvania TRM. If, however, the OCE decides to follow New York's approach, Rate Counsel recommends that the OCE use the updated figures found in the updated 2014 New York TRM.

In addition, the SJG October 16 Comments do not contain any algorithm or assumption for peak kW load reduction. The above-cited Pennsylvania TRM offers a formula to estimate peak kW savings from this measure. Rate Counsel recommends that the OCE review the Pennsylvania TRM and consider adopting it.

Finally, Rate Counsel notes that the SJG October 16 Comments bases its assumption for water intake temperature for <u>aerators</u> on New York, yet bases the water intake temperature for <u>combined space and water heaters</u> on a value from Connecticut.[10] Rate Counsel submits that the assumptions for water intake temperature should be consistent across measures and programs.

C. Residential Low-Income Combo Space and Water Heating

Combined space and water heating is another new measure introduced in the SJG October 16 Comments.[11] Rate Counsel identified a few issues with the proposed algorithms and assumptions for combined space and water heating system measures. First, all of the key assumptions—such as heating factor based on home age, boiler AFUE based on boiler age,

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http://www3.dps.ny.gov/W/PSCWeb.nsf/ca7cd46b41e6d01f0525685800545955/06f2fee55575bd8a852576e4006f9af7/$FILE/TRM%20Version%202%20December%2010,%202014.pdf.

[10] <u>See</u> SJG October 16 Comments, p. 30, Table IV-1.

[11] <u>See</u> SJG October 16 Comments, p. 29-30.

annual domestic water heating load (Btu), and annual domestic home water usage (gallons)—should be supported by references to data sources.

Second, the proposed algorithm does not recognize the difference in heating load by housing type. The proposed algorithm uses a heating factor in Btu per square foot per year that differs by the age of the building. However, heating load per square footage is likely to differ between single-family buildings and multi-family buildings, because larger buildings tend to have lower heating load per square foot with all else held equal (e.g., insulation value and shape of the building).[12] A better metric is the installed capacity for heating systems. In fact, the Draft Protocols use algorithms (one for non-low-income residential customers, and another for low-income customers) that take into account installed capacity of heating systems for the Residential Gas HVAC program.[13] Rate Counsel recommends that the OCE adopt a method for the combined space and water heating measure similar to the method used for the Residential Gas HVAC program.

Finally, the proposed formula assumes that a participant will save energy with an efficient heating system relative to the level of consumption based on the existing heating system. This essentially assumes that the participant will use the existing heating system indefinitely if the system is not replaced due to the program. It also implicitly assumes that the system will never break down and will not be replaced in the future. This assumption is not realistic. At some point in the future, any system will be replaced with a new standard efficient unit, even if the owner doesn't receive incentives from the program. Comparing new measures

[12] Building Science Corporation (2012). BSI-061: the Function of Form – Building Shape and Energy, available at http://buildingscience.com/documents/insights/bsi-061-function-form-building-shape-and-energy.

[13] Draft Protocols, p. 20.

to the efficiency of the existing heating system indefinitely will result in an overestimation of actual energy savings.

If the intent is to promote early retirement of aging HVAC equipment, a better approach to estimate energy savings from an energy-efficient system is to construct a baseline using two useful lives: (1) for the remaining useful life of the existing system (e.g., 10 years), use the efficiency of the existing system, and (2) for the period after the expiration of the remaining useful life of the existing system, through the end of the remaining life of the new efficient unit, use the efficiency of a new standard system. An example of the use of this method is Massachusetts' early retirement boiler program, which assumes that the remaining life for the existing unit is 10 years as the first baseline.[14] The Massachusetts TRM notes that this assumption is "a reasonable approximation for the number of years an existing boiler would continue to operate if it had not been replaced early due to the program."[15]

On the other hand, if the intent is to provide rebates for regular replacement of HVAC equipment with high efficiency equipment, the OCE should use the efficiency of a new standard unit as the baseline from the first year.

D. Residential Low-Income LED Nightlight

The SJG October 16 Comments also proposes to include assumptions for LED lighting measures for general service LED lamps and night light LED lamps.[16] The proposed values for wattage savings and daily operating hours are reasonable for general service LED lamps. The

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[14] Massachusetts Technical Reference Manual (TRM) – 2013-2015 Program Years – Plan Version (October 2012), available at http://ma-eeac.org/wordpress/wp-content/uploads/TRM_PLAN_2013-15.pdf.

[15] Massachusetts TRM, page 297, footnote 615.

[16] See SJG October 16 Comments, pp. 33-37.

proposed wattage value for LED night lights appears reasonable. However, the proposed value for operating hours for LED night lights is not reasonable. The Low-Income Supplemental Update proposes an assumption of 24-hour operation for LED night lights. Currently, there are many products available for incandescent and LED night lamps that have integrated light sensors which toggle the nightlight depending on ambient light. Thus, it is more reasonable to assume that night lights operate only at night. The Pennsylvania TRM assumes 12 hours for the operating hours for LED night lights.[17] Rate Counsel recommends that the OCE adopt this value.

II. Clarification for Section II-H of the Rate Counsel October 16 Comments

Section II-H of the Rate Counsel October 16 Comments is titled "Energy Star Products Clothes Washers." However, Rate Counsel intended to discuss issues related to assumptions for refrigerators as well as clothes washers and dryers. Below, Rate Counsel provides its revised comments separately for refrigerators, clothes washers, and clothes dryers. The within supplemental comments further clarify Rate Counsel's recommendations.

A. Refrigerators

It is unclear how the source named in reference number 5 on page 49 of the Draft Protocols (the reference for ENERGY STAR refrigerator savings) was used to estimate energy savings from ENERGY STAR and CEE Tier 1 and 2 refrigerators. The spreadsheet linked to within this reference does not clearly indicate which refrigerators fall in CEE Tier 1, and which

[17] Pennsylvania Public Utility Commission (2015), p. 29.

fall in CEE Tier 2. The Draft Protocols should clearly indicate how energy savings were derived based on reference number 5. Alternatively, Rate Counsel suggests that the OCE use a different data source, such as the Consortium for Energy Efficiency's (CEE) database for refrigerators, which provides savings for the qualified Tier 2 refrigerators.[18]

B. Clothes Washers

The Draft Protocols provide annual electricity and natural gas savings, peak electricity savings, and water savings from ENERGY STAR clothes washers (equivalent of CEE Tier 1) and CEE Tier 2 clothes washers based on the assumptions and the single data source provided in the reference number 2.[19] It is unclear how IMEF (integrated modified energy factor) and IWF (integrated water factors) estimates provided for this reference were used to estimate those energy savings values. Rate Counsel recommends that the Draft Protocols clearly describe how IMEF values and any other key assumptions such as annual washing cycles were used to estimate energy savings. Finally, Rate Counsel recommends that the Draft Protocols provide a direct URL for Itron eShapes, described in the reference number 2 as the source for load shapes to calculate electric demand savings.

C. Clothes Dryers

It is unclear how the source named in reference number 12 on page 50 of the Draft Protocols was used to estimate annual electricity and natural gas savings and peak electricity savings from two types of energy-efficient clothes dryers. The Draft Protocols should clearly

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[18] The CEE database is available at http://library.cee1.org/content/qualifying-product-lists-residential-refrigerators.
[19] Draft Protocols, p. 48-49.

state what key assumptions (e.g., Combined Energy Factor and annual cycles) were used to estimate energy savings for each type of energy-efficient clothes dryer, and where in the spreadsheet cited in this reference such key assumptions are provided.

Thank you for your consideration of the within comments.

Respectfully submitted,

STEFANIE A. BRAND
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Subject:	Comments concerning Low Income Protocols
Date:	Friday, October 16, 2015 5:11:21 PM
Attachments:	NJCEP Protocols to Measure Resource Savings FY2016 Combi and other edits (3).docx Protocol and Engineering Estimate Summary.docx NJCEP Protocols to Measure Resource Savings CLEAN FY2016 Combi and other edits (3).docx
Importance:	High

Hi Sherry

Please see the attached redline and clean version of the NJCEP Protocols to Measure Resource Savings FY 2016. I have also included for reference, the actual memo from the Apprise Evaluation.

Thank you,
Bruce

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New Jersey Board of Public Utilities

New Jersey Clean Energy Program

Protocols to Measure Resource Savings

Revisions to
March 17, 2014 Protocols

Release Date April 27, 2015

New Jersey's Clean Energy Program Protocols

Table of Contents

New Jersey Clean Energy Program
Protocols to Measure Resource Savings

Introduction

These protocols have been developed to measure resource savings, including electric energy capacity, natural gas, and other resource savings, and to measure electric energy and capacity from renewable energy and distributed generation systems. Specific protocols for determination of the resource savings or generation from each program are presented for each eligible measure and technology.

These protocols use measured and customer data as input values in industry-accepted algorithms. The data and input values for the algorithms come from the program application forms or from standard values. The standard input values are based on the recent impact evaluations and best available measured or industry data applicable for the New Jersey programs when impact evaluations are not available.

Purpose

These protocols were developed for the purpose of determining energy and resource savings for technologies and measures supported by New Jersey's Clean Energy Program. The protocols will be updated from time to time to reflect the addition of new programs, modifications to existing programs, and the results of future program evaluations. The protocols will be used consistently statewide to assess program impacts and calculate energy and resource savings to:

1. Report to the Board on program performance
2. Provide inputs for planning and cost-effectiveness calculations
3. Provide information to regulators and program administrators for determining eligibility for administrative performance incentives (to the extent that such incentives are approved by the BPU)
4. Assess the environmental benefits of program implementation

Resource savings to be measured include electric energy (kWh) and capacity (kW) savings, natural gas savings (therms), and savings of other resources (oil, propane, water, and maintenance), where applicable. In turn, these resource savings will be used to determine avoided environmental emissions. The Protocols are also utilized to support preliminary estimates of the electric energy and capacity from renewable energy and distributed generation systems and the associated environmental benefits. Note, however, that renewable energy protocols are different from those required for REC certification in the state of New Jersey.

The protocols in this document focus on the determination of the per unit savings for the energy efficiency measures, and the per unit generation for the renewable energy or distributed generation measures, included in the current programs approved by the Board. The number of adopted units to which these per unit savings or avoided generation apply are captured in the program tracking and reporting process, supported by market assessments for some programs.

The unit count will reflect the direct participation and, through market assessments, the number of units due to market effects in comparison to a baseline level of adoptions. The protocols report gross savings and generation only. Free riders and free drivers are not addressed in these Protocols. Further research in this area is planned.

The outputs of the Protocols are used to support:

- Regulatory Reporting
- Cost Effectiveness Analysis
- Program Evaluation
- Performance Incentives for the Market Managers

These Protocols provide the methods to measure per unit savings for program tracking and reporting. An annual evaluation plan prepared by the Center for Energy, Economic and Environmental Policy (CEEEP) outlines the plans for assessing markets including program progress in transforming markets, and to update key assumptions used in the Protocols to assess program energy impacts. Reporting provides formats and definitions to be used to document program expenditures, participation rates, and program impacts, including energy and resource savings. The program tracking systems, that support program evaluation and reporting, will track and record the number of units adopted due to the program, and assist in documenting the resource savings using the per unit savings values in the Protocols. Cost benefit analyses prepared by CEEEP and other evaluation contractors assesses the impact of programs, including market effects, and their relationship to costs in a multi-year analysis.

Types of Protocols

In general, energy and demand savings will be measured using measured and customer data as input values in algorithms in the protocols, tracking systems, and information from the program application forms, worksheets, and field tools.

The following table summarizes the spectrum of protocols and approaches to be used for measuring energy and resource savings. No one protocol approach will serve all programs and measures.

Summary of Protocols and Approaches

Type of Measure	Type of Protocol	General Approach	Examples
1. Standard prescriptive measures	Standard formula and standard input values	Number of installed units times standard savings/unit	Residential lighting (number of units installed times standard savings/unit)
2. Measures with important variations in one or more input values (e.g., delta watts, efficiency level, capacity, load, etc.)	Standard formula with one or more site-specific input values	Standard formula in the protocols with one or more input values coming from the application form, worksheet, or field tool (e.g., delta watts, efficiency levels, unit capacity, site-specific load)	Some prescriptive lighting measures (delta watts on the application form times standard operating hours in the protocols) Residential Electric HVAC (change in efficiency level times site-specific capacity times standard operating hours) Field screening tools that use site-specific input values Customer On-Site Renewable Energy
3. Custom or site-specific measures, or measures in complex comprehensive jobs	Site-specific analysis	Greater degree of site-specific analysis, either in the number of site-specific input values, or in the use of special engineering algorithms, including building simulation programs	Custom Industrial process Complex comprehensive jobs (P4P) CHP

Three or four systems will work together to ensure accurate data on a given measure:

1. The application form that the customer or customer's agent submits with basic information.
2. Application worksheets and field tools with more detailed site-specific data, input values, and calculations (for some programs).

3. Program tracking systems that compile data and may do some calculations.
4. Protocols that contain algorithms and rely on standard or site-specific input values based on measured data. Parts or all of the protocols may ultimately be implemented within the tracking system, the application forms and worksheets, and the field tools.

Algorithms

The algorithms that have been developed to calculate the energy and or demand savings are driven by a change in efficiency level for the installed measure compared to a baseline level of efficiency. This change in efficiency is reflected in both demand and energy savings for electric measures and energy savings for gas. Following are the basic algorithms.

Electric Demand Savings = $\Delta kW = kW_{baseline} - kW_{energy\ efficient\ measure}$

Electric Energy Savings = ΔkW X EFLH

Electric Peak Coincident Demand Savings = ΔkW X Coincidence Factor

Gas Energy Savings = $\Delta Btuh$ X EFLH

Where:

EFLH = Equivalent Full Load Hours of operation for the installed measure. Total annual energy use (kWh) of an end use over a range of operating conditions divided by the connected full load of the end use in kW.

$\Delta Btuh = Btuh_{baseline\ input} - Btuh_{energy\ efficient\ measure\ input}$

Other resource savings will be calculated as appropriate.

Specific algorithms for each of the program measures may incorporate additional factors to reflect specific conditions associated with a program or measure. This may include factors to account for coincidence of multiple installations, or interaction between different measures.

When building simulation software programs are used to develop savings estimates for several measures in a comprehensive project, as in the Pay for Performance Program, the specific algorithms used are inherent in the software and account for interaction among measures by design. Detailed Simulation Guidelines have been developed for the Pay for Performance Program and are included in the Pay for Performance Program Guidelines. These Guidelines should be followed when building simulation is used to develop savings estimates. As stated in the Guidelines, simulation software must be compliant with ASHRAE 90.1 2004 Section 11 or Appendix G.

Data and Input Values

The input values and algorithms in the protocols and on the program application forms are based on the best available and applicable data for the New Jersey programs. The input values for the algorithms come from the program application forms or from standard values based on measured or industry data.

Many input values, including site-specific data, come directly from the program application forms, worksheets, and field tools. Site-specific data on the application forms are used for measures with important variations in one or more input values (e.g., delta watts, efficiency level, capacity, etc.).

Standard input values are based on the best available measured or industry data, including metered data, measured data from prior evaluations (applied prospectively), field data and program results, and standards from industry associations. The standard values for most commercial and industrial measures are based on recent impact evaluations of New Jersey Programs.

For the standard input assumptions for which metered or measured data were not available, the input values (e.g., delta watts, delta efficiency, equipment capacity, operating hours, coincidence factors) were based on the best available industry data or standards. These input values were based on a review of literature from various industry organizations, equipment manufacturers, and suppliers.

For larger, comprehensive projects, as in the Pay the Performance Program, measurement and verification (M&V) protocols are followed to better estimate site-specific energy use for the pre- and post-retrofit conditions. Guidelines for developing an M&V plan and protocols to follow for conducting M&V are included in the Pay for Performance Program Guidelines, available on the NJ Office of Clean Energy website at www.njcleanenergy.com. These guidelines and protocols should be followed when M&V is conducted to determine energy use for either the pre- or post-retrofit period.

Program evaluation will be used to assess key data and input values to either confirm that current values should continue to be used or update the values going forward.

Baseline Estimates

For most efficiency programs and measures, the Δ kW, Δ kWh, and gas energy savings values are based on the energy use of standard new products vs. the high efficiency products promoted through the programs. The approach used for the new programs encourages residential and business consumers to purchase and install high efficiency equipment vs. new standard efficiency equipment. The baseline estimates used in the protocols are documented in the baseline studies or other market information. Baselines will be updated to reflect changing codes, practices and market transformation effects.

For the Direct Install and Low Income programs, some Δ kW, Δ kWh, and gas energy savings values are based on high efficiency equipment versus existing equipment, where the programs specifically target early retirement or upgrades that would not otherwise occur. Protocols for the Direct Install Program include degradation tables to calculate the efficiency of the replaced unit.

The Pay for Performance Program is a comprehensive program that requires participants to implement energy efficiency improvements that will achieve a minimum of 15% reduction in total source energy consumption. Due to the building simulation and measurement and verification (M&V) requirements associated with this Program, the baseline is the existing energy consumption of the facility, as reported through the U.S. EPA's Portfolio Manager benchmarking software.

Renewable energy and distributed generation program protocols assume that any electric energy or capacity produced by a renewable energy or distributed generation system displaces electric energy and capacity from the PJM grid.

Resource Savings in Current and Future Program Years

The Protocols support tracking and reporting the following categories of energy and resource savings:

1. Savings or generation from installations that were completed in the program year and prior program years due to the program's direct participation and documented market effects.
2. Savings or generation from program participant future adoptions due to program commitments.
3. Savings or generation from future adoptions due to market effects.

Prospective Application of the Protocols

The protocols will be applied prospectively. The input values are from the program application forms and standard input values (based on measured data including metered data and evaluation results). The protocols will be updated periodically based on evaluation results and available data, and then applied prospectively for future program years.

Resource Savings

Electric

Protocols have been developed to determine the electric energy and coincident peak demand savings.

Annual Electric energy savings are calculated and then allocated separately by season (summer and winter) and time of day (on-peak and off-peak). Summer coincident peak demand savings are calculated using a demand savings protocol for each measure that includes a coincidence factor. Application of this coincidence factor converts the demand savings of the measure, which may not occur at time of system peak, to demand savings that is expected to occur during the Summer On-Peak period. These periods for energy savings and coincident peak demand savings are defined as:

	Energy Savings	Coincident Peak Demand Savings
Summer	May through September	June through August
Winter	October through April	NA
On Peak (Monday - Friday)	8:00 a.m. to 8:00 p.m.	12:00 p.m. to 8:00 p.m.
Off Peak (Weekends and Holidays)	8:00 p.m. to 8:00 a.m.	NA

The time periods for energy savings and coincident peak demand savings were chosen to best fit the seasonal avoided cost patterns for electric energy and capacity that were used for the energy efficiency program cost effectiveness purposes. For energy, the summer period May through September was selected based on the pattern of avoided costs for energy at the PJM level. In order to keep the complexity of the process for calculating energy savings benefits to a reasonable level by using two time periods, the knee periods for spring and fall were split approximately evenly between the summer and winter periods.

For capacity, the summer period June through August was selected to match the highest avoided costs time period for capacity. The experience in PJM and New Jersey has been that nearly all system peak events occur during these three months. Coincidence factors are used to calculate energy efficiency factors on peak demand. Renewable energy and distributed generation systems are assumed to be operating coincident with the PJM system peak. This assumption will be assessed in the impact evaluation.

Natural Gas

Protocols have been developed to determine the natural gas energy savings on a seasonal basis. The seasonal periods are defined as:

Summer - April through September
Winter - October through March

The time periods for gas savings were chosen to best fit the seasonal avoided gas cost pattern that was used for calculating energy efficiency program benefits for cost effectiveness purposes. However, given the changing seasonal cost patterns for gas supply, different time periods may be more appropriate to reflect a current outlook for the seasonal pattern, if any, at the time that the avoided cost benefits are calculated. The seasonal factors used in the following protocols that correspond to the above time periods reflect either base load or heating load usage. In the case of base load, one twelfth of the annual use is allocated to each month. In the case of heating load, the usage is prorated to each month based on the number of normal degree-days in each month. This approach makes it relatively easy to calculate new seasonal factors to best match different avoided cost patterns.

Other Resources

Some of the energy savings measures also result in environmental benefits and the saving of other resources. Environmental impacts are quantified based on statewide conversion factors supplied by the NJDEP for electric, gas and oil energy savings. Where identifiable and quantifiable these other key resource savings, such as oil, will be estimated. Oil and propane savings are the major resources that have been identified. If other resources are significantly impacted, they will be included in the resource savings estimates.

Post-Implementation Review

Program administrators will review application forms and tracking systems for all measures and conduct field inspections on a sample of installations. For some programs and jobs (e.g., custom, large process, large and complex comprehensive design), post-installation review and on-site verification of a sample of application forms and installations will be used to ensure the reliability of site-specific savings estimates.

Adjustments to Energy and Resource Savings

Coincidence with Electric System Peak

Coincidence factors are used to reflect the portion of the connected load savings or generation that is coincident with the electric system peak.

Measure Retention and Persistence of Savings

The combined effect of measure retention and persistence is the ability of installed measures to maintain the initial level of energy savings or generation over the measure life. Measure retention and persistence effects were accounted for in the metered data that were based on C&I installations over an eight-year period. As a result, some protocols incorporate retention and persistence effects in the other input values. For other measures, if the measure is subject to a reduction in savings or generation over time, the reduction in retention or persistence is accounted for using factors in the calculation of resource savings (e.g., in-service rates for residential lighting measures, degradation of photovoltaic systems).

Interaction of Energy Savings

Interaction of energy savings is accounted for in certain programs as appropriate. For all other programs and measures, interaction of energy savings is zero.

For the Residential New Construction program, the interaction of energy savings is accounted for in the home energy rating tool that compares the efficient building to the baseline or reference building and calculates savings.

For the Commercial and Industrial Efficient Construction program, the energy savings for lighting is increased by an amount specified in the protocol to account for HVAC interaction. For commercial and industrial custom measures, interaction where relevant is accounted for in the site-specific analysis. In the Pay for Performance Program, interaction is addressed by the building simulation software program.

Calculation of the Value of Resource Savings

The calculation of the value of the resources saved is not part of the protocols. The protocols are limited to the determination of the per unit resource savings in physical terms.

In order to calculate the value of the energy savings for reporting and other purposes, the energy savings are determined at the customer level and then increased by the amount of the transmission and distribution losses to reflect the energy savings at the system level. The energy savings at the system level are then multiplied by the appropriate avoided costs to calculate the value of the benefits.

System Savings = (Savings at Customer) X (T&D Loss Factor)

Value of Resource Savings = (System Savings) X (System Avoided Costs + Environmental Adder) + (Value of Other Resource Savings)

The value of the benefits for a particular measure will also include the value of the water, oil, maintenance and other resource savings where appropriate. Maintenance savings will be estimated in annual dollars levelized over the life of the measure.

Transmission and Distribution System Losses

The protocols calculate the energy savings at the customer level. These savings need to be increased by the amount of transmission and distribution system losses in order to determine the energy savings at the system level. The following loss factors multiplied by the savings calculated from the protocols will result in savings at the supply level.

Electric Loss Factor

The electric loss factor applied to savings at the customer meter is 1.076 for both energy and demand. The electric system loss factor was developed to be applicable to statewide programs. Therefore, average system losses at the margin based on a 10 year (2001 to 2010) average of the New Jersey state electricity supply and disposition dataset from the U.S. Energy Information Administration (EIA).

Gas Loss Factor

The gas loss factor is 1.0. The gas system does not have losses in the same sense that the electric system does. All of the gas gets from the “city gate” (delivery point to the distribution system) to the point of use except for unaccounted for gas (such as theft), gas lost due to system leakage or loss of gas that is purged when necessary to make system repairs. Since none of these types of “losses” is affected by a decrease in gas use due to energy efficiency at the customer, there are no losses for which to make any adjustment. Therefore, a system loss factor of 1.0 is appropriate for gas energy efficiency savings.

These electric and gas loss factors reflect losses at the margin and are a consensus of the electric and gas utilities.

Calculation of Clean Air Impacts

The amount of air emission reductions resulting from the energy savings are calculated using the energy savings at the system level and multiplying them by factors developed by the New Jersey Department of Environmental Protection (NJDEP).

System average air emissions reduction factors provided by the NJDEP are:

Electric Emissions Factors

Emissions Product	Jan 2001-June 2002	July 2003-February 2014	March 2014 - Present
CO_2	1.1 lbs per kWh saved	1,520 lbs per MWh saved	1,111.79 lbs per MWh saved
NO_X	6.42 lbs per metric ton of CO_2 saved	2.8 lbs per MWh saved	0.95 lbs per MWh saved
SO_2	10.26 lbs per metric ton of CO_2 saved	6.5 lbs per MWh saved	2.21 lbs per MWh saved
Hg	0.00005 lbs per metric ton of CO_2 saved	0.0000356 lbs per MWh saved	2.11 mg per MWh saved

Gas Emissions Factors

Emissions Product	Jan 2001-June 2002	July 2003-Present
CO_2	NA	11.7 lbs per therm saved
NO_X	NA	0.0092 lbs per therm saved

All factors are provided by the NJ Department of Environmental Protection and are on an average system basis. They will be updated as new factors become available.

Measure Lives

Measure lives are provided in Appendix A for informational purposes and for use in other applications such as reporting lifetime savings or in benefit cost studies that span more than one year. The Pay for Performance Program uses the measure lives as included in Appendix A to determine measure-level and project-level cost effectiveness.

Protocols for Program Measures

The following pages present measure or project-specific protocols. In those instances where measures are applicable to more than one program, the measures apply to all such programs unless otherwise specified.

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Residential Electric HVAC

Protocols

The measurement plan for residential high efficiency cooling and heating equipment is based on algorithms that determine a central air conditioners or heat pump's cooling/heating energy use and peak demand. Input data is based both on fixed assumptions and data supplied from the high efficiency equipment rebate application form. The algorithms also include the calculation of additional energy and demand savings due to the required proper sizing of high efficiency units.

The savings will be allocated to summer/winter and on-peak/off-peak time periods based on load shapes from measured data and industry sources. The allocation factors are documented below in the input value table.

The protocols applicable for this program measure the energy savings directly related to the more efficient hardware installation. Estimates of energy savings due to the proper sizing of the equipment are also included.

The following is an explanation of the algorithms used and the nature and source of all required input data.

<u>Algorithms</u>

Central Air Conditioner (A/C) & Air Source Heat Pump (ASHP)

Cooling Energy Consumption and Peak Demand Savings – Central A/C & ASHP (High Efficiency Equipment Only)

Energy Impact (kWh) = CAPY/1000 X ($1/SEER_b – 1/SEER_q$) X $EFLH_c$

Peak Demand Impact (kW) = CAPY/1000 X ($1/EER_b – 1/EER_q$) X CF

Heating Energy Savings – ASHP

Energy Impact (kWh) = CAPY/1000 X ($1/HSPF_b$ - $1/HSPF_q$) X $EFLH_h$

Cooling Energy Savings for Proper Sizing and QIV

$kWh_p = kWh_q * ESF$

Cooling Demand Savings for Proper Sizing and QIV

$kW_p = kW_q * DSF$

Cooling Energy Consumption and Demand Savings – Central A/C & ASHP (During Existing System Maintenance)

Energy Impact (kWh) = ((CAPY/(1000 X SEERm)) X $EFLH_c$) X MF

Peak Demand Impact (kW) =((CAPY/(1000 X EERm)) X CF) X MF

Cooling Energy Consumption and Demand Savings– Central A/C & ASHP (Duct Sealing)

Energy Impact (kWh) = (CAPY/ (1000 X SEERq)) X $EFLH_c$ X DuctSF

Peak Demand Impact (kW) = ((CAPY/ (1000 X EERq)) X CF) X DuctSF

Ground Source Heat Pumps (GSHP)

Cooling Energy (kWh) Savings = CAPY/1000 X (1/$SEER_b$ – (1/ (EER_g X GSER))) X $EFLH_c$

Heating Energy (kWh) Savings = CAPY/1000 X (1/$HSPF_b$ – (1/ (COP_g X GSOP))) X $EFLH_h$

Peak Demand Impact (kW) = CAPY/1000 X (1/EER_b – (1/ (EER_g X GSPK))) X CF

GSHP Desuperheater

Energy (kWh) Savings = EDSH

Peak Demand Impact (kW) = PDSH

Furnace High Efficiency Fan

Heating Energy (kWh) Savings = (($CAPY_q$ X $EFLH_{HT}$)/100,000 BTU/therm) X FFS_{HT}

Cooling Energy (kWh) Savings = FFS_{CL}

Solar Domestic Hot Water (augmenting electric resistance DHW)

Heating Energy (kWh) Savings = $ESav_{SDHW}$

Peak Demand Impact (kW) = $DSav_{SDHW}$ x CF_{SDHW}

Heat Pump Hot Water (HPHW)

Heating Energy (kWh) Savings = $ESav_{HPHW}$

Peak Demand Impact (kW) = $DSav_{HPHW}$ x CF_{HPHW}

Drain Water Heat Recovery (DWHR)

Heating Energy (kWh) Savings = $ESav_{DWHR}$

Peak Demand Impact (kW) = $DSav_{DWHR}$ x CF_{DWHR}

Definition of Terms

CAPY = The cooling capacity (output) of the central air conditioner or heat pump being installed. This data is obtained from the Application Form based on the model number.

$SEER_b$ = The Seasonal Energy Efficiency Ratio of the Baseline Unit.

$SEER_q$ = The Seasonal Energy Efficiency Ratio of the qualifying unit being installed. This data is obtained from the Application Form based on the model number.

$SEER_m$ = The Seasonal Energy Efficiency Ratio of the Unit receiving maintenance

EER_b = The Energy Efficiency Ratio of the Baseline Unit.

EER_q = The Energy Efficiency Ratio of the unit being installed. This data is obtained from the Application Form based on the model number.

EER_g = The EER of the ground source heat pump being installed. Note that EERs of GSHPs are measured differently than EERs of air source heat pumps (focusing on entering water temperatures rather than ambient air temperatures). The equivalent SEER of a GSHP can be estimated by multiplying EER_g by 1.02.

GSER = The factor to determine the SEER of a GSHP based on its EER_g.

EFLH = The Equivalent Full Load Hours of operation for the average unit.

ESF = The Energy Savings Factor or the assumed saving due to proper sizing and proper installation.

MF = The Maintenance Factor or assumed savings due to completing recommended maintenance on installed cooling equipment

DuctSF = The Duct Sealing Factor or the assumed savings due to proper sealing of all cooling ducts

CF = The coincidence factor which equates the installed unit’s connected load to its demand at time of system peak.

DSF = The Demand Savings Factor or the assumed peak demand capacity saved due to proper sizing and proper installation.

$HSPF_b$ = The Heating Seasonal Performance Factor of the Baseline Unit.

$HSPF_q$ = The Heating Seasonal Performance Factor of the unit being installed. This data is obtained from the Application Form.

COP_g = Coefficient of Performance. This is a measure of the efficiency of a heat pump.

GSOP = The factor to determine the HSPF of a GSHP based on its COP_g.

GSPK = The factor to convert EER_g to the equivalent EER of an air conditioner to enable comparisons to the baseline unit.

EDSH = Assumed savings per desuperheater.

PDSH = Assumed peak demand savings per desuperheater.

$ESav_{SDHW}$ = Assumed energy savings per installed solar domestic hot water system with electric resistance heater backup.

$DSav_{SDHW}$ = Assumed demand savings per installed solar domestic hot water system with electric resistance heater backup.

$CAPYY_q$ = Output capacity of the qualifying heating unit in BTUs/hour

$EFLH_{HT}$ = The Equivalent Full Load Hours of operation for the average heating unit

FFS_{HT} = Furnace fan savings (heating mode)

FFS_{CL} = Furnace fan savings (cooling mode)

kWh_p = Annual kWh due to proper sizing

kWh_q = Annual kWh usage post-program

kW_p = Annual kW due to proper sizing

kW_q = Annual kW usage post-program

$ESav_{HPHW}$ = Assumed energy savings per installed heat pump water heater.

$DSav_{HPHW}$ = Assumed demand savings per installed heat pump water heater.

$ESav_{DWHR}$ = Assumed energy savings per installed drain water heat recovery unit in a household with an electric water heater.

$DSav_{DWHR}$ = Assumed demand savings per installed drain water heat recovery unit in a household with an electric water heater.

The 1000 used in the denominator is used to convert watts to kilowatts.

A summary of the input values and their data sources follows:

Residential Electric HVAC

Component	Type	Value	Sources
CAPY	Variable		Rebate Application
$SEER_b$	Fixed	Baseline = 13	1
$SEER_q$	Variable		Rebate Application
$SEER_m$	Fixed	10	15
EER_b	Fixed	Baseline = 11.3	2
EER_q	Fixed	= (11.3/13) X $SEER_q$	2
EER_g	Variable		Rebate Application
EER_m	Fixed	8.69	19
GSER	Fixed	1.02	3
EFLH	Fixed	Cooling = 600 Hours Heating = 965Hours	4
ESF	Fixed	9.2%	22
DSF	Fixed	9.2%	22
kWh_q	Variable		Rebate Application
kW_q	Variable		Rebate Application
MF	Fixed	10%	20
DuctSF	Fixed	18%	14
CF	Fixed	70%	6
DSF	Fixed	2.9%	7
$HSPF_b$	Fixed	Baseline = 7.7	8
$HSPF_q$	Variable		Rebate Application
COP_g	Variable		Rebate Application
GSOP	Fixed	3.413	9
GSPK	Fixed	0.8416	10
EDSH	Fixed	1842 kWh	11

Component	Type	Value	Sources
PDSH	Fixed	0.34 kW	12
$ESav_{SDHW}$	Fixed	3100 kWh	21
$DSav_{SDHW}$	Fixed	0.426 kW	21
CF_{SDHW}	Fixed	20%	21
$ESav_{HPHW}$	Fixed	1687 kWh	23
$DSav_{HPHW}$	Fixed	0.37 kW	24
CF_{HPHW}	Fixed	70%	24
$ESav_{DWHR}$	Fixed	1457 kWh	26, 23
$DSav_{DWHR}$	Fixed	0.142 kW	27
CF_{DWHR}	Fixed	20%	27
Cooling - CAC Time Period Allocation Factors	Fixed	Summer/On-Peak 64.9% Summer/Off-Peak 35.1% Winter/On-Peak 0% Winter/Off-Peak 0%	13
Cooling – ASHP Time Period Allocation Factors	Fixed	Summer/On-Peak 59.8% Summer/Off-Peak 40.2% Winter/On-Peak 0% Winter/Off-Peak 0%	13
Cooling – GSHP Time Period Allocation Factors	Fixed	Summer/On-Peak 51.7% Summer/Off-Peak 48.3% Winter/On-Peak 0% Winter/Off-Peak 0%	13
Heating – ASHP & GSHP Time Period Allocation Factors	Fixed	Summer/On-Peak 0.0% Summer/Off-Peak 0.0% Winter/On-Peak 47.9% Winter/Off-Peak 52.1%	13
GSHP Desuperheater Time Period Allocation Factors	Fixed	Summer/On-Peak 4.5% Summer/Off-Peak 4.2% Winter/On-Peak 43.7% Winter/Off-Peak 47.6%	13
SDHW Time Period Allocation Factors	Fixed	Summer/On-Peak 27.0% Summer/Off-Peak 15.0% Winter/On-Peak 42.0% Winter/Off-Peak 17.0%	21
HPWH Time Period Allocation Factors	Fixed	Summer/On-Peak 21% Summer/Off-Peak 22% Winter/On-Peak 28% Winter/Off-Peak 29%	25
DWHR Time Period Allocation Factors	Fixed	Summer/On-Peak 27.0% Summer/Off-Peak 15.0% Winter/On-Peak 42.0% Winter/Off-Peak 17.0%	21
$Capy_q$	Variable		Rebate Application
$EFLH_{HT}$	Fixed	965 hours	16

Component	Type	Value	Sources
FFS_{HT}	Fixed	0.5 kWh	17
FFS_{CL}	Fixed	105 kWh	18

Sources:

1. Federal Register, Vol. 66, No. 14, Monday, January 22, 2001/Rules and Regulations, p. 7170-7200.
2. Average EER for SEER 13 units.
3. VEIC estimate. Extrapolation of manufacturer data.
4. VEIC estimate. Consistent with analysis of PEPCo and LIPA, and conservative relative to ARI.
5. Xenergy, "New Jersey Residential HVAC Baseline Study", (Xenergy, Washington, D.C., November 16, 2001).
6. NEEP, *Mid-Atlantic Technical Reference Manual*, May 2010.
7. Xenergy, "New Jersey Residential HVAC Baseline Study", (Xenergy, Washington, D.C., November 16, 2001)
8. Federal Register, Vol. 66, No. 14, Monday, January 22, 2001/Rules and Regulations, p. 7170-7200.
9. Engineering calculation, HSPF/COP=3.413
10. VEIC Estimate. Extrapolation of manufacturer data.
11. VEIC estimate, based on PEPCo assumptions.
12. VEIC estimate, based on PEPCo assumptions.
13. Time period allocation factors used in cost-effectiveness analysis.
14. Northeast Energy Efficiency Partnerships, Inc., "Benefits of HVAC Contractor Training", (February 2006): Appendix C Benefits of HVAC Contractor Training: Field Research Results 03-STAC-01
15. Minimum Federal Standard for new Central Air Conditioners between 1990 and 2006
16. NJ utility analysis of heating customers, annual gas heating usage
17. Scott Pigg (Energy Center of Wisconsin), "Electricity Use by New Furnaces: A Wisconsin Field Study", Technical Report 230-1, October 2003.
18. Ibid., p. 34. ARI charts suggest there are about 20% more full load cooling hours in NJ than southern WI. Thus, average cooling savings in NJ are estimated at 95 to 115
19. The same EER to SEER ratio used for SEER 13 units applied to SEER 10 units. $EER_m = (11.3/13) * 10$
20. VEIC estimate. Conservatively assumes less savings than for QIV because of the retrofit context
21. Energy savings are estimated based on 2008 SRCC OG300 ratings for a typical 2 panel system with solar storage tank in Newark, NJ with electric DHW backup. Demand savings are estimated based on an estimated electric DHW demand of 2.13kW with 20% CF. Load shape and coincidence factors were developed by VEIC from ASHRAE Standard 90.2 Hot Water Draw Profile and NREL Red Book insulation data for Newark, NJ.
22. KEMA, *NJ Clean Energy Program Energy Impact Evaluation Protocol Review*. 2009.
23. Table 1. (Page 2) From "Heat Pump Water Heaters Evaluation of Field Installed Performance." Steven Winter Associates, Inc. (2012). http://www.ma-eeac.org/Docs/8.1_EMV%20Page/2012/2012%20Residential%20Studies/MA%20RR&L

I%20-
%202011%20HPWH%20Field%20Evaluation%20Report%20FINAL%206_26_2012.pdf

24. VEIC Estimate based upon range derived from FEMP Federal Technology Alert: S9508031.3a (http://www1.eere.energy.gov/femp/pdfs/FTA_res_heat_pump.pdf)
25. "Electrical Use, Efficiency, and Peak Demand of Electric Resistance, Heat Pump, Desuperheater, and Solar Hot Water Systems", http://www.fsec.ucf.edu/en/publications/html/FSEC-PF-215-90/
26. 30% savings (from Zaloum, C. Lafrance, M. Gusdorf, J. "Drain Water Heat Recovery Characterization and Modeling" Natural Resources Canada. 2007. Savings vary due to a number of factors including make, model, installation-type, and household behaviors.) multiplied by standard electric resistance water heating baseline annual usage of 4,857 kWh cited in source #23 above.
27. Demand savings are estimated based on electric DHW demand of 2.13kW and 20% CF as in cited source #21 adjusting for the proportional difference of 30% savings relative to the 70% solar fraction: 0.426*0.3/0.9 = 0.142.

Combined space and water heating (Combo)

Participants installing a qualifying boiler or furnace and a qualifying water heater at the same time earn a special incentive. For savings calculations, there is no special consideration. The heating system savings are calculated according to the appropriate algorithm and the water heating savings are calculated separately according to the system type.

Residential Gas HVAC

Protocols

The following two algorithms detail savings for gas heating and water heating equipment. They are to be used to determine gas energy savings between baseline standard units and the high efficiency units promoted in the program. The input values are based on data on typical customers supplied by the gas utilities, an analysis by the Federal Energy Management Program (FEMP), and customer information on the application form, confirmed with manufacturer data. The energy values are in therms.

Space Heaters

<u>Algorithms</u>

Gas Savings = [($Capy_q$/$AFUE_b$) – ($Capy_q$/ $AFUE_q$)] * EFLH / 100,000 BTUs/therm

Low Income Gas Savings = [($Capy_q$/$AFUE_{LI}$) – ($Capy_q$/ $AFUE_q$)] * EFLH / 100,000 BTUs/therm

Gas Savings due to duct sealing = (CAP_{avg} $AFUE_{avg}$) * EFLH * ($DuctSF_h$/100,000 BTUs/therm)

Average Heating Use (therms) = (Cap_{avg} / $AFUE_{avg}$) * EFLH / 100,000 BTUs/therm

EFLH = Average Heating Use * $AFUE_{avg}$* 100,000 BTUs/therm) / Cap_{avg}

Oil Savings for a qualifying boiler = OsavBOILER

Oil Savings = [($Capy_q$/$AFUE_b$) – ($Capy_q$/ $AFUE_q$)] * EFLH / 100,000 BTUs/therm

Savings for a qualifying boiler control = savBoilerControl * Average Heating Usage

<u>Definition of Variables</u>

$Capy_q$ = Output capacity of qualifying unit output in BTUs/hour

$Capy_t$ = Output capacity of the typical heating unit output in Btus/hour

$Capy_{avg}$ = Output capacity of the average heating unit output in Btus/hour

EFLH = The Equivalent Full Load Hours of operation for the average unit.

$DuctSF_h$ = The Duct Sealing Factor or the assumed savings due to proper sealing of all heating ducts

$AFUE_{avg}$ = Annual Fuel Utilization Efficiency of the average furnace or boiler

$AFUE_q$ = Annual Fuel Utilization Efficiency of the qualifying baseline furnace or boiler

$AFUE_b$ = Annual Fuel Utilization Efficiency of the baseline furnace or boiler

$AFUE_{LI}$ = Annual Fuel Utilization Efficiency of the Low Income Program replaced furnace or boiler.

Average Heating Usage = The weighted average annual heating usage (therms) of typical New Jersey heating customers

savBoilerControl = Assumed energy savings, as a percent, per installed boiler control for a qualifying boiler.

Space Heating

Component	Type	Value	Source
$Capy_q$	Variable		Application
$Capy_t$	Fixed	$CAPY_Q$	1
$DuctSF_h$	Fixed	13%	5
$AFUE_{avg}$	Variable		Application
$AFUE_q$	Variable		Application
$AFUE_b$	Fixed	Gas Furnaces: 80% Gas Boilers: Water - 83% Steam – 80% Oil Boilers: Water – 84% Steam – 82% Electric Resistance Heating: 35%	2,8
$AFUE_{LI}$	Variable		Application or utility estimates
EFLH[1]	Fixed	965 hours	3
Avg. Heating Usage	Fixed	860 therms	5
Time Period Allocation Factors	Fixed	Summer = 12% Winter = 88%	4
savBoilerControls	Fixed	11%	9

Sources:

1. NJ Residential HVAC Baseline Study
2. Based on the quantity of models available by efficiency ratings as listed in the April 2003 Gamma Consumers Directory of Certified Efficiency Ratings.
3. NJ utility analysis of heating customers, annual gas heating usage

[1] Residential Gas Measures ELFH are subject to change barring the results of impact evaluations.

4. Prorated based on 12% of the annual degree days falling in the summer period and 88% of the annual degree days falling in the winter period.
5. Northeast Energy Efficiency Partnerships, Inc., "Benefits of HVAC Contractor Training", (February 2006): Appendix C Benefits of HVAC Contractor Training: Field Research Results 03-STAC-01
6. KEMA, *NJ Clean Energy Program Energy Impact Evaluation Protocol Review*. 2009.
7. Electric resistance heat calculated by determining the overall fuel cycle efficiency by dividing the average PJM heat rate (9,642 BTU per kWh) by the BTUs per kWh (3,413 BTU per kWh), giving a 2.83 BTU_{in} per BTU_{out}.
8. "Residential Boiler Controls" Emerging Technologies Report American Council for an Energy Efficient Economy, 2007.

Water Heaters

Algorithms

Gas Savings = $((EF_q - EF_b)/EF_q)$ X Baseline Water Heater Usage

Gas Savings (Solar DHW) = GsavSHW

Gas Savings (Drain Water Heat Recover) = GsavDWHR * Baseline Water Heater Usage

Definition of Variables

EF_q = Energy factor of the qualifying energy efficient water heater.

Note: For qualifying units not rated with an Energy Factor, the estimated EF_q shall be used:

Est. EF_q = Q_{out}/Q_{in}

= 41,094[2]/ (41,094/TE + Volume*SLratio*24hours)

Where: TE = Thermal (or Recovery) Efficiency of the unit as a percentage

Volume = Volume of storage water heater, in gallons.

SLratio = Average ratio of rated standby losses water heater (BTU loss per hour for > 90% TE units less than 130 Gallons = 9.73[3]

EF_b = 0.67 – (0.0019 * Gallons of Capacity)

Baseline Water Heater Usage = Annual usage of the baseline water heater, in therms.

GsavSHW = Gas savings, in therms, for a solar hot water installation augmented by a new gas hot water heater.

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[2] Based upon the test conditions of the DOE test protocol for residential water heaters, the amount of energy delivered is equal to 64.3 gallons * density of water (8.3lb/gal) * Specific heat of water (1 BTU/lb-F) and the temperature rise of 77degF (135F-58F).

[3] Based upon February, 2012 query of ARHI/GAMA database http://cafs.ahrinet.org/gama_cafs/sdpsearch/search.jsp?table=CWH

GsavDWHR = Gas savings, as a percentage, for a drain water heat recovery installation in a home with a gas hot water heater.

Water Heaters

Component	Type	Value	Source
EF_q	Variable		Application Form, confirmed with Manufacturer Data
TE	Variable		Application Form, confirmed with Manufacturer Data
Stdby	Variable		Application Form, confirmed with Manufacturer Data
EF_b	Variable	For Electric Resistance (only): 35%	Application Form, confirmed with Manufacturer Data
Baseline Water Heater Usage	Fixed	180 therms	2
Time Period Allocation Factors	Fixed	Summer = 50% Winter = 50%	3
GsavSHW	Fixed	130.27	4
$GSav_{DWHR}$	Fixed	30%	5

Sources:

1. Federal EPACT Standard for a 40 gallon gas water heater. Calculated as 0.62 – (0.0019 X gallons of capacity).
2. KEMA. *NJ Clean Energy Program Energy Impact Evaluation Protocol Review. 2009.*
3. Prorated based on 6 months in the summer period and 6 months in the winter period.
4. Savings derived from US DOE estimates for the SEEARP (ENERGY STAR® Residential Water Heaters: Final Criteria Analysis)
5. Zaloum, C. Lafrance, M. Gusdorf, J. "Drain Water Heat Recovery Characterization and Modeling" Natural Resources Canada. 2007. Savings vary due to a number of factors including make, model, installation-type, and household behaviors.

Residential Low Income Program

Protocols

The Protocols set out below are applicable to both the Comfort Partners component of the Low-income Program currently implemented by the State's electric and gas utilities and the Weatherization Assistance component of the Low-income Program implemented by the New Jersey Department of Community Affairs (DCA).

The savings protocols for the low-income program are based upon estimated per unit installed savings. In some cases, such as lighting and refrigerators, the savings per unit estimate is based on direct observation or monitoring of the existing equipment being replaced. For other measures, for example air sealing and insulation, the protocols calculation is based on an average % savings of pre-treatment consumption.

Base Load Measures

Efficient Lighting

Savings from installation of screw-in CFLs, high performance fixtures, ~~and~~ fluorescent torchieres, LEDs and LED nightlights are based on a straightforward algorithm that calculates the difference between existing and new wattage, and the average daily hours of usage for the lighting unit being replaced.

Algorithm

Compact Fluorescent Screw In Lamp

Electricity Impact (kWh) = $((CFL_{watts}) \times (CFL_{hours} \times 365))/1000$

Peak Demand Impact (kW) = $(CFL_{watts}) \times$ Light CF

Efficient Fixtures

Electricity Impact (kWh) = $((Fixt_{watts}) \times (Fixt_{hours} \times 365))/1000$

Peak Demand Impact (kW) = $(Fixt_{watts}) \times$ Light CF

Efficient Torchieres

Electricity Impact (kWh) = $((Torch_{watts}) \times (Torch_{hours} \times 365))/1000$

Peak Demand Impact (kW) = $(Torch_{watts}) \times$ Light CF

LED Screw In Lamp

Electricity Impact (kWh) = $((LED_{watts}) \times (LED_{hours} \times 365))/1000$

Peak Demand Impact (kW) = $(LED_{watts}) \times$ Light CF

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LED Nightlight

Electricity Impact (kWh) = $((LEDN_{watts}) \times (LEDN_{hours} \times 365))/1000$

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Hot Water Conservation Measures

The protocols savings estimates are based on an average package of domestic hot water measures typically installed by low-income programs. It is proposed that the engineering savings estimates detailed in the Apprise Memo Dated June 27, 2014, NJ Comfort Partners Energy Savings Protocols and Engineering Estimates be adopted.

Showerheads and Aerators

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The following protocol is from the Ohio 2010 Technical Reference Manual.[4]

$$\Delta kWh = ISR \times (GPM_{base} - GPM_{low}) \times \left(\frac{kWh}{GPM_{reduced}}\right)$$

$$\Delta MMBtu = ISR \times (GPM_{base} - GPM_{low}) \times \left(\frac{MMBtu}{GPM_{reduced}}\right)$$

Table IV-19
Definitions and Values for Showerheads

Term	Definition	Value
ISR	In Service Rate – Fraction of Units Installed	1.0
GPM_{base}	Gallons Per Minute of baseline showerhead	2.87
GPM_{low}	Gallons Per Minute of low flow showerhead	1.75
$kWh/GPM_{reduced}$	Assumed kWh savings per GPM reduction	149
MMBtu/GPM Reduced	Assumed MMBtu savings per GPM of reduction	0.66

A. Aerators

The following protocols are from the New York 2010 Technical Reference Manual.[5]

$$kWh\ savings = \frac{\left[water\ savings \times (temp\ faucet - temp\ to\ heater) \times \left(\frac{8.3}{3{,}413}\right)\right]}{water\ heater\ efficiency_{elec}}$$

$$therm\ savings = \frac{\left[water\ savings \times (temp\ faucet - temp\ to\ heater) \times \left(\frac{8.3}{100{,}000}\right)\right]}{water\ heater\ efficiency_{gas}}$$

[4]Vermont Energy Investment Corporation. "State of Ohio Energy Efficiency Technical Reference Manual, Including Predetermined Savings Values and Protocols for Determining Energy and Demand Savings." August 6, 2010. Pages 93-96.

[5]New York Evaluation Advisory Contractor Team and TecMarket Works. "New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs; Residential, Multi-Family, and Commercial/Industrial Measures." October 15, 2010. Pages 94-96..

$$Water\ savings = (Std_{aero} - LF_{aero}) \times \frac{duration}{use} \times \frac{\#\ uses}{day} \times \frac{days}{year}$$

Table IV-20
Definitions and Values for Aerators

Term	Definition	Value
Std_{aero}	Standard aerator GPM	2.2
LF_{aero}	Low flow aerator GPM	1.5
	Duration/use	0.5 minutes
	# uses/day	30
	Days/year	365
	Temp faucet	80°F
	Temp to heater	Table IV-12
8.3	Conversion factor: lbs. per gallon	
3,413	Conversion factor (electric): Btu per kWh	
100,000	Conversion factor (gas): Btu per Therm	
	Water heater efficiency$_{elec}$	0.97
	Water heater efficiencygas	0.75

Algorithm

~~Electricity Impact (kWh) = HW_{eavg}~~

~~Gas Savings (MMBtu) = HW_{gavg}~~

~~Peak Demand Impact (kW) = HW_{watts} X HW CF~~

~~Water Savings (gallons) = WS~~

Efficient Refrigerators

The eligibility for refrigerator replacement is determined by comparing monitored consumption for the existing refrigerator with the rated consumption of the eligible replacement. Estimated savings are directly calculated based on the difference between these two values. Note that in the case where an under-utilized or unneeded refrigerator unit is removed, and no replacement is installed, the Ref_{new} term of the equation will be zero.

It is further proposed that the Low Income Program will make a procedural and operational change to capture the savings of a second refrigerator replacement.

Algorithm

Electricity Impact (kWh) = $Ref_{old} – Ref_{new}$

Peak Demand Impact (kW) = $(Ref_{old} – Ref_{new})$ *(Ref DF)

Space Conditioning Measures

When available, gas heat measure savings will be based on heating use. If only total gas use is known, heating use will be estimated as total use less 300 therms.

Air Sealing

It is assumed that air sealing is the first priority among candidate space conditioning measures. Expected percentage savings is based on previous experiences with measured savings from similar programs. Note there are no summer coincident electric peak demand savings estimated at this time. The recommendation is to adopt the $300.00 air sealing threshold for gas and electric projects as found in the Apprise Memo Dated June 27, 2014, NJ Comfort Partners Energy Savings Protocols and Engineering Estimates.

Algorithm

Electricity Impact (kWh) = ESC_{pre} X 0.05

MMBtu savings = (GHpre X 0.05)

Furnace/Boiler Replacement

Quantification of savings due to furnace and boiler replacements implemented under the low-income program will be based on the algorithms presented in the Residential Gas HVAC section of these Protocols. However, during the course of the year, the protocol will be reviewed to determine the benefit of calculating energy savings based on the comparison of the capacity of the removed furnace/boiler, against the capacity of the new installed boiler / furnace. All other parts of the savings calculation would remain the same.

Current Algorithm is as follows:

Savings = [(Capyq/AFUELI) – (Capyq/ AFUEq)] * EFLH / 100,000 BTUs/therm

- Capyq = Output capacity of qualifying unit output in BTUs/hour
- AFUELI = Annual Fuel Utilization Efficiency of the Low Income Program replaced furnace or boiler.
- AFUEq = Annual Fuel Utilization Efficiency of the qualifying baseline furnace or boiler.
- EFLH = Equivalent full load hours of operation for the average unit. This value is fixed at 965 for heating and 600 for cooling hours.

The Algorithm to be reviewed:

Savings = [(Capyq 1. /AFUELI) – (Capyq 2. / AFUEq)] * EFLH / 100,000 BTUs/therm

- Capyq 1. = Output capacity of qualifying removed unit output in BTUs/hour
- Capyq 2. = Output capacity of new installed unit output in BTUs/hour

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- AFUELI = Annual Fuel Utilization Efficiency of the Low Income Program replaced furnace or boiler.
- AFUEq = Annual Fuel Utilization Efficiency of the qualifying baseline furnace or boiler.
- EFLH = Equivalent full load hours of operation for the average unit. This value is fixed at 965 for heating and 600 for cooling hours.

Duct Sealing and Repair

The second priority for homes with either Central Air Conditioning (CAC) or some other form of ducted distribution of electric space conditioning (electric furnace, gas furnace or heat pump) is ensuring integrity and effectiveness of the ducted distribution system.

Algorithm

With CAC

Electricity Impact (kWh) = ($ECool_{pre}$) X 0.10

Peak Demand Impact (kW) = ($Ecool_{pre}$ X 0.10) / EFLH X AC CF

MMBtu savings = (GHpre X 0.02)

No CAC

Electricity Impact (kWh) = ($ESC_{pre.}$) X 0.02

MMBtu savings = (GHpre X 0.02)

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Combined space and water heating (Combo)

As recommended by the recent evaluation performed by Apprise, the program is proposing to adopt protocols to capture the energy savings from Combination Boilers, that produce both heating and water heating.

The algorithm to capture these savings is under review by the current NJCEP Market Manager for use in the Warm Advantage Program. At the current time, participants installing a qualifying boiler or furnace and a qualifying water heater at the same time earn a special incentive under the Warm Program. For savings calculations, there is no special consideration. The heating system savings are calculated according to the appropriate algorithm and the water heating savings are calculated separately according to the system type. In an effort to help inform this process, please see the below recommended protocol supplied by Apprise (Utility Working Group Memo, June 27, 2014, page 9), which was taken from the Connecticut 2012 program savings document*

$$ACCF = ACCF_H + ACCF_w$$

$$ACCF_H = \frac{ABTU_H}{102{,}900}$$

$$ABTU_H = SF \times HF \times \left(\frac{1}{AFUE_E} - \frac{1}{AFEU_I}\right)$$

$$ACCF_W = \frac{ABTU_W}{102{,}900}$$

$$ABTU_W = ADHW \times \left(\frac{1}{AFUE_E} - \frac{1}{AFEU_I}\right)$$

$$ADHW = GPY \times 8.3 \times (T_{dhw} - T_{aiw})$$

Table IV-1
Definitions and Values for Combined Boiler and Water Heater Protocol

Term	Definition	Value
ACCF	Annual natural gas savings (Ccf/year)	
$ACCF_H$	Annual natural gas savings – heating (Ccf/year)	
$ACCF_W$	Annual natural gas savings – water heating (Ccf/year)	
$ABTU_H$	Annual Btu savings – heating (Btu/year)	
SF	Heated area served by boiler (square feet)	
HF	Heating factor based on age of home ($Btu/ft^2/year$)	See Table IV-2
$AFUE_E$	Annual fuel utilization efficiency, existing	See Table IV-3
$AFUE_I$	Annual fuel utilization efficiency, installed	83%
ADHW	Annual domestic water heating load (Btu)	11,197,132 Btu
GPY	Annual domestic home water usage (gallons)	19,839 gallons
T_{dhw}	Domestic hot water heater set point	125°F
T_{aiw}	Average annual incoming water temperature	57°F
102,900	Conversion factor: Btu per ccf natural gas	
8.3	Conversion factor: density of water	

Note *

[1]Connecticut Light and Power and United Illuminating. "Connecticut Program Savings Document, 8th Edition for 2013 Program Year." October 30, 2012. Pages 143-148, 241-242.

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Indirect Hot Water Heaters

It is recommended to adopt the engineering estimates as stated in the Apprise Memo Dated June 27, 2014, NJ Comfort Partners Energy Savings Protocols and Engineering Estimates.

Wisconsin's 2013 Focus on Energy Deemed Savings are as follows.[6]

$$\Delta Therm = Therm_{Std} - Therm_{Eff}$$

$$Therm_{Out} = EF_{Std} \times Therm_{StdTank}$$

$$Therm_{Std} = Standby_{Std} \times 8{,}760 \times 1/100{,}000/AFUE_{Std} + Therm_{Out} \times 1/AFUE_{std}$$

[6]The Cadmus Group, Inc. "Final Report Focus on Energy Evaluated Deemed Savings Changes." *Prepared for the Public Service Commission of Wisconsin.* November 26, 2013. Pages 15-16.

[1] Average hot water use per person were taken from: Lutz, James D., Liu, Xiaomin, McMahan, James E., Dunham, Camilla, Shown, Leslie J., McCure, Quandra T; "Modeling patterns of hot water use in households;" LBL-37805 Rev. Lawrence Berkeley Laboratory, 1996.

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$$Therm_{Eff} = Standby_{Eff} \times 8{,}760 \times 1/100{,}000/AFUE_{Eff} + Therm_{Out} \times 1/AFUE_{Eff}$$

$$Standby_{Std} = Vol_{Std} \times \left(\frac{°F}{hr_{Std}}\right) \times 8.33$$

$$Standby_{Eff} = Vol_{Eff} \times \left(\frac{°F}{hr_{Eff}}\right) \times 8.33$$

Table IV-13
Definitions and Values for Indirect Hot Water Heaters

Term	Definition	Value
∆Therm	Gas Savings	
$Therm_{Std}$	Calculated therms standard tank	206
$Therm_{Eff}$	Calculated therms replacement tank	177.52
$Therm_{Out}$		
EF_{Std}	Federal standard energy factor	(.67 – (.0019xvolume))=.58
$Therm_{StdTank}$	Therms used by standard tank	223
$Standby_{Std}$	Standby loss from standard water heater	434 BTU/hr*
$AFUE_{Std}$	Efficiency (AFUE) of standard water heater	80%
$Standby_{Eff}$	Standby loss from efficient water heater	397 BTU/hr**
$AFUE_{Eff}$	Efficiency (AFUE) of efficient water heater	93%
Vol_{Std}	Volume of standard water heater (gallons)	63.50
Vol_{Eff}	Volume of efficient water heater (gallons)	51.20
$°F/hr_{Std}$	Heat lost per hour from standard water heater tank	0.8
$°F/hr_{Eff}$	Heat lost per hour from efficient water heater tank	0.93
	Conversion factor: density of water (lbs./gallon)	8.33

*AHRI Database. **Data model look-ups of AHRI Certifications.

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Insulation Up-Grades

For savings calculations, it is assumed that any applicable air sealing and duct sealing/repair have been done, thereby reducing the space conditioning load, before consideration of upgrading insulation. Attic insulation savings are then projected on the basis of the "new" load. Gas savings are somewhat greater, as homes with gas heat generally have less insulation. The APPRISE evaluation provided a recommendation for projecting savings from insulation in Comfort Partners jobs, where the percentage savings be reduced (from the current 13%) and that it be applied to jobs with at least $300 in insulation costs. While the analysis showed a specific reduction "for illustrative purposes", it did not specifically recommend what the percentage savings should be. The conservative percentage shown in the memo was based upon a comparison of protocol savings and billing analysis savings estimates from the APPRISE evaluation. The billing analysis savings estimates were low, based on the work that was evaluated. However, since the time of the evaluation, the CP program has increased the comprehensiveness of insulation and improved quality control which are both expected to lead to greater savings. Additionally, because the majority of the insulation installed is at the higher end of the cost level and results in higher savings, a revised recommendation is to implement a protocol where savings are projected to be 9% of pre-treatment gas space consumption where there is at least $300 in spending on insulation.

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Algorithm

Electricity Impact (kWh) = $(ESC_{pre)}$ X 0.08

MMBtu savings = GH_{pre} X 0.13

Thermostat Replacement

Thermostats are eligible for consideration as an electric space conditioning measure only after the first three priority items. Savings projections are based on a conservative 3% of the "new" load after installation of any of the top three priority measures.

Algorithm

Electricity Impact (kWh) = ($ESC_{pre)}$ X 0.03

MMBtu savings = (GH_{pre} X 0.03)

Heating and Cooling Equipment Maintenance Repair/Replacement

The Low Income Program supports the engineering estimates as stated in the for gas heating repairs as stated in the Apprise Memo Dated June 27, 2014, NJ Comfort Partners Energy Savings Protocols and Engineering Estimates. In order to implement a protocol to capture these savings, a new Gas and Electric system repair savings trigger would need to be created which would account for whether the system was replaced. That would avoid the risk of counting savings for systems which were cleaned and tuned, if those systems had to be replaced.

Savings projections for heat pump charge and air flow correction. Protocol savings account for shell measures having been installed that reduce the pre-existing load.

Algorithm

Electricity Impact (kWh) = ($ESC_{pre)}$ X 0.17

Peak Demand Impact (kW) = (Capy/EER X 1000) X HP CF X DSF

Other "Custom" Measures

In addition to the typical measures for which savings algorithms have been developed, it is assumed that there will be niche opportunities that should be identified and addressed. The savings for these custom measures will be reported based on the individual calculations supplied with the reporting. As necessary the program working group will develop specific guidelines for frequent custom measures for use in reporting and contractor tracking.

Definition of Terms

CFL_{watts} = Average watts replaced for a CFL installation.

CFL_{hours} = Average daily burn time for CFL replacements.

$Fixt_{watts}$ = Average watts replaced for an efficient fixture installation.

$Fixt_{hours}$ = Average daily burn time for CFL replacements.

$Torch_{watts}$ = Average watts replaced for a Torchiere replacement.

$Torch_{hours}$ = Average daily burn time for a Torchiere replacements.

LED_{watts} = Average watts replaced for an LED installation.

LED_{hours} = Average daily burn time for LED replacements.

$LEDN_{watts}$ = Average watts replaced for an LED nightlight installation.

$LEDN_{hours}$ = Average daily burn time for LED nightlight replacements.

Light CF = Summer demand coincidence factor for all lighting measures. Currently fixed at 5%.

HW_{eavg} = Average electricity savings from typical electric hot water measure package.

HW_{gavg} = Average natural gas savings from typical electric hot water measure package.

HW_{watts} = Connected load reduction for typical hot water efficiency measures

HW CF = Summer demand coincidence factor for electric hot water measure package. Currently fixed at 75%.

Ref_{old} = Annual energy consumption of existing refrigerator based on on-site monitoring.

Ref_{new} = Rated annual energy consumption of the new refrigerator.

Ref DF = kW /kWh of savings. Refrigerator demand savings factor.

Ref CF = Summer demand coincidence factor for refrigeration. Currently 100%, diversity accounted for in the Ref DF factor.

ESC_{pre} = Pre-treatment electric space conditioning consumption.

$ECool_{pre}$ = Pre-treatment electric cooling consumption.

EFLH = Equivalent full load hours of operation for the average unit. This value is currently fixed at 650 hours.

AC CF = Summer demand coincidence factor for air conditioning. Currently 85%.

Capy = Capacity of Heat Pump in Btuh

EER = Energy Efficiency Ratio of average heat pump receiving charge and air flow service. Fixed at 9.2

HP CF = Summer demand coincidence factor for heat pump. Currently fixed at 70%.

DSF = Demand savings factor for charge and air flow correction. Currently fixed at 7%.

GC_{pre} = Pre-treatment gas consumption.

GH_{pre} = Pre-treatment gas space heat consumption (=.GC_{pre} less 300 therms if only total gas use is known.

WS = Water Savings associated with water conservation measures. Currently fixed at 3,640 gallons per year per home receiving low flow showerheads, plus 730 gallons saved per year aerator installed.

Residential Low Income

Component	Type	Value	Sources
CFL_{Watts}	Fixed	42 Watts	1
CFL_{Hours}	Fixed	2.5 hours	1
$Fixt_{Watts}$	Fixed	100-120 Watts	1
$Fixt_{Hours}$	Fixed	3.5 hours	1
$Torch_{Watts}$	Fixed	245 Watts	1
$Torch_{Hours}$	Fixed	3.5 hours	1
LED_{Watts}	Fixed	52 Watts	14
LED_{Hours}	Fixed	2.5 hours	14
$LEDN_{Watts}$	Fixed	6.75 Watts	14
$LEDN_{Hours}$	Fixed	24 hours	14
Light CF	Fixed	5%	2
Elec. Water Heating Savings	Fixed	178 kWh	3
Gas Water Heating Savings	Fixed	1.01 MMBTU	3
WS Water Savings	Fixed	3,640 gal/year per home receiving low flow shower heads, plus 1,460 gal/year per home receiving aerators.	12
HW_{watts}	Fixed	0.022 kW	4
HW CF	Fixed	75%	4
Ref_{old}	Variable		Contractor Tracking

Component	Type	Value	Sources
Ref_{new}	Variable		Contractor Tracking and Manufacturer data
Ref DF	Fixed	0.000139 kW/kWh savings	5
RefCF	Fixed	100%	6
ESC_{pre}	Variable		7
$Ecool_{pre}$	Variable		7
ELFH	Fixed	650 hours	8
AC CF	Fixed	85%	4
Capy	Fixed	33,000 Btu/hr	1
EER	Fixed	11.3	8
HP CF	Fixed	70%	9
DSF	Fixed	7%	10
GC_{pre}	Variable		7
GH_{pre}	Variable		7
Time Period Allocation Factors - Electric	Fixed	Summer/On-Peak 21% Summer/Off-Peak 22% Winter/On-Peak 28% Winter/Off-Peak 29%	11
Time Period Allocation Factors - Gas	Fixed	Heating: Summer 12% Winter 88% Non-Heating: Summer 50% Winter 50%	13

Sources/Notes:

1. Working group expected averages for product specific measures.
2. Efficiency Vermont Reference Manual – average for lighting products.
3. Experience with average hot water measure savings from low income and direct install programs.
4. VEIC estimate.
5. UI Refrigerator Load Data profile, .16 kW (5pm July) and 1,147 kWh annual consumption.
6. Diversity accounted for by Ref DF.
7. Billing histories and (for electricity) contractor calculations based on program procedures for estimating space conditioning and cooling consumption.
8. Average EER for SEER 13 units.
9. Analysis of data from 6 utilities by Proctor Engineering
10. From Neme, Proctor and Nadel, 1999.
11. These allocations may change with actual penetration numbers are available.

12. VEIC estimate, assuming 1 GPM reduction for 14 five minute showers per week for shower heads, and 4 gallons saved per day for aerators.
13. Heating: Prorated based on 12% of the annual degree days falling in the summer period and 88% of the annual degree days falling in the winter period.
    Non-Heating: Prorated based on 6 months in the summer period and 6 months in the winter period.
14. APPRISE memo on energy saving protocols, July 2014.
15. Drain Water Heat Recovery System (GFX) Installation. – Due to the lack of opportunities to install this measure the recommendations of the Apprise Memo Dated June 27, 2014, NJ Comfort Partners Energy Savings Protocols and Engineering Estimates are not being adopted by the Low Income Program at this time.
16. Heat Pump Water Heaters. – Same as #15.
17. Solar Hot Water – This item is outside the scope of this program.
18. Water Heater Tank Wrap. It is recommended to adopt the protocols as stated in the Apprise Memo Dated June 27, 2014, NJ Comfort Partners Energy Savings Protocols and Engineering Estimates.
19. Widow Air Conditioners – The Program will need to research if the recommendation found in the Apprise Memo Dated June 27, 2014, NJ Comfort Partners Energy Savings Protocols and Engineering Estimates, is something that can be recommended.
20. LED Lighting. The Program recommends approval of the protocol found in the Apprise Memo Dated June 27, 2014, NJ Comfort Partners Energy Savings Protocols and Engineering Estimates.

    Project Savings = Δ Watts/1,000 * Hours/day *365

    Fixed Values
    - Δ Watts = 52
    - Hours/day = 2.5

21. Smart Strips. The recommendation of the Apprise Memo Dated June 27, 2014, NJ Comfort Partners Energy Savings Protocols and Engineering Estimates, is not being recommended for support at this time.
22. Cool Roofs – As a result of the Low Income Pilot Projects, it has been decided not to pursue the recommendation stated in Apprise Memo Dated June 27, 2014.

Gas Usage Disaggregation

This is an item recommended in the Apprise Memo Dated June 27, 2014, NJ Comfort Partners Energy Savings Protocols and Engineering Estimates. At the current time, system restrictions and data privacy issues prevent the Low Income Program from implementing this recommendation at this time.

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Residential New Construction Program

Protocols

Insulation Up-Grades, Efficient Windows, Air Sealing, Efficient HVAC Equipment, and Duct Sealing

Energy savings due to improvements in Residential New Construction will be a direct output of accredited Home Energy Ratings (HERS) software that meets the applicable Mortgage Industry National Home Energy Rating System Standards. REM/Rate is cited as an example of an accredited software which has a module that compares the energy characteristics of the energy efficient home to the baseline/reference home and calculates savings.

The system peak electric demand savings will be calculated from the software output with the following savings algorithms, which are based on compliance and certification of the energy efficient home to the EPA's ENERGY STAR for New Homes program standard:

Peak demand of the baseline home = (PL_b X OF_b) / ($SEER_b$ X BLEER X 1,000)

Peak demand of the qualifying home = (PL_q X OF_q) / (EER_q X 1,000)

Coincident system peak electric demand savings = (Peak demand of the baseline home – Peak demand of the qualifying home) X CF

<u>Definition of Terms</u>

PL_b = Peak load of the baseline home in Btuh.

OF_b = The oversizing factor for the HVAC unit in the baseline home.

$SEER_b$ = The Seasonal Energy Efficiency Ratio of the baseline unit.

BLEER = Factor to convert baseline $SEER_b$ to EER_b.

PL_q = The actual predicted peak load for the program qualifying home constructed, in Btuh.

OF_q = The oversizing factor for the HVAC unit in the program qualifying home.

EER_q = The EER associated with the HVAC system in the qualifying home.

CF = The coincidence factor which equates the installed HVAC system's demand to its demand at time of system peak.

In March 2011 energy code changes took place with the adoption of IECC 2009. This code change affects baselines for variables used in the protocols. Therefore, to reflect these changes, tables and or values are identified as needed for installations completed after December 31, 2011. The application of the code changes to completions starting in January 2012 allows for the time lag between when the permits are issued and a when a home would reasonably be expected to be completed.

A summary of the input values and their data sources follows:

Applicable to building completions from April 2003 to present

Component	Type	Value	Sources
PL_b	Variable		1
OF_b	Fixed	1.6	2
$SEER_b$	Fixed	13	3
BLEER	Fixed	0.92	4
PL_q	Variable		Software Output
OF_q	Fixed	1.15	5
EER_q	Variable		Program Application
CF	Fixed	0.70	6

Sources:

1. Calculation of peak load of baseline home from the home energy rating tool, based on the reference home energy characteristics.
2. PSE&G 1997 Residential New Construction baseline study.
3. Federal Register, Vol. 66, No. 14, Monday, January 22, 2001/Rules and Regulations, p. 7170-7200
4. Engineering calculation.
5. Program guideline for qualifying home.
6. Based on an analysis of six different utilities by Proctor Engineering.

Lighting and Appliances

Quantification of additional saving due to the addition of high efficiency lighting and clothes washers will be based on the algorithms presented for these appliances in the Energy Star Lighting Protocols and the Energy Star Appliances Protocols, respectively. These protocols to measure savings are found in the Energy Star Products Program. Total savings will be calculated as follows:

Lighting Savings = Number of Units X Savings per Unit

Energy savings due to efficient lighting will be based on a fixed average quantity of sockets per home derived from regional baseline studies. A fixed percentage of sockets will be assumed to be filled with efficient lighting due to energy code requirements and market transformation. These sockets will be subtracted from the average number of sockets per home and not counted toward program savings goals.

Lighting Savings = (Total efficient units[1] – (Total units[2] x 18%[3])) x Savings per Unit X Building Type Multipler[4]

Where the program requirement is based on efficient *fixtures*, rather than sockets, an average number of sockets shall be derived as follows:

(Average number of fixtures x 2[5]) X 82%[6].

Notes

[1] Total efficient units is calculated as the average number of sockets per home X program requirement (percent of bulbs)

[2] The average quantity of sockets per home is assumed to be 60 for single family. There is a building type multiplier for multi-single and multifamily units. This value is based on six regional Residential New Construction studies conducted between 2002 and 2012. These studies are: Northeast Utilities and United Illuminating Company Baseline Evaluation for the Energy Star Home New Construction Program Final Report (2002), Long Island Residential new Construction Technical Baseline Study (2004), Massachusetts ENERGY STAR Homes 2005 Baseline Study (2005), Maine Residential New Construction Technical Baseline Study (2008), Vermont Residential New Construction baseline Study Analysis of On-site Audits (2008), Residential Lighting Markdown Report, New England Residential Lighting Measure Life Study (2009), and the New York Energy Code Compliance Study (2012).

[3] The saturation rate, or percentage of sockets assumed to be filled with efficient lighting due to energy code requirements and market transformation, is 18%, based on a 2010 NMR Group study title, "Results of the Multistate CFL Modeling Effort."

[4] The average number of sockets per home is based on single-family detached homes. For multi-single homes this value shall be multiplied by 80%. For multi-family homes this number shall be multiplied by 50%. This number is based on VEIC analysis of the above six regional Residential New Construction studies.

[5] ENERGY STAR® qualified lighting savings calculator assumption is 2 sockets per fixture. http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=LF

[6] Multiplier to convert fixtures to total socket count is based on a recent study where both fixture and socket counts were obtained (New York Energy Code Compliance Study, 2012).

Ventilation Equipment

Additional energy savings of 175 kWh and peak demand saving of 60 Watts will be added to the output of the home energy rating software to account for the installation of high efficiency ventilation equipment. These values are based on a baseline fan of 80 Watts and an efficient fan of 20 Watts running for 8 hours per day.

The following table describes the characteristics of the three reference homes.

New Jersey ENERGY STAR Homes
REMRate User Defined Reference Homes -- Applicable to building completions from January 2012 to present -- Reflects IECC 2009

Data Point	**Single and Multiple Family Except as Noted.**		
	Climate Zone 4	Climate Zone 5	
Active Solar	None		
Ceiling Insulation	U=0.030 (1)	U=0.030 (1)	
Radiant Barrier	None	None	
Rim/Band Joist	U=0.082 (1)	U=0.057 (1)	
Exterior Walls - Wood	U=0.082 (1)	U=0.057 (1)	
Exterior Walls - Steel	U=0.082 (1)	U=.057 (1)	
Foundation Walls	U=0.059	U=0.059	
Doors	U=0.35 (1)	U=0.35 (1)	
Windows	U=0.35 (1), No SHGC req.	U=0.35 (1),No SHGC req.	
Glass Doors	U=0.35 (1), No SHGC req.	U=0.35 (1),No SHGC req.	
Skylights	U=0.60 (1), No SHGC req.	U=0.60 (1), No SHGC req.	
Floor	U=0.047 (2)	U=.033 (2)	
Unheated Slab on Grade	R-10, 2 ft	R-10, 2 ft	
Heated Slab on Grade	R-15, 2 ft	R-15, 2 ft	
Air Infiltration Rate	7 ACH50	7 ACH50	
Duct Leakage	8 cfm25 per 100ft^2 CFA	8 cfm25 per 100ft^2 CFA	
Mechanical Ventilation	None		
Lights and Appliances	Use RESNET Default (3)	Use RESNET Default (3)	
Setback Thermostat	Yes, where primary heat is forced hot air	Yes, where primary heating is forced hot air	
Heating Efficiency			
Furnace	80% AFUE (4)	80% AFUE (4)	
Boiler	80% AFUE	80% AFUE	
Combo Water Heater	76% AFUE (recovery efficiency)	76% AFUE (recovery efficiency)	

Data Point	Single and Multiple Family Except as Noted.		
Air Source Heat Pump	7.7 HSPF	7.7 HSPF	
PTAC / PTHP	Not differentiated from air source HP	Not differentiated from air source HP	
Cooling Efficiency			
Central Air Conditioning	13.0 SEER	13.0 SEER	
Air Source Heat Pump	13.0 SEER	13.0 SEER	
PTAC / PTHP	Not differentiated from central AC	Not differentiated from central AC	
Window Air Conditioners	Not differentiated from central AC	Not differentiated from central AC	
Domestic WH Efficiency			
Electric stand-alone tank	0.90 EF (5)	0.90 EF (5)	
Natural Gas stand-alone tank	0.58 EF (5)	0.58 EF (5)	
Electric instantaneous	0.93 EF (5)	0.93 EF (5)	
Natural Gas instantaneous	0.62 EF (5)	0.62 EF (5)	
Water Heater Tank Insulation	None	None	
Duct Insulation, attic supply	R-8	R-8	
Duct Insulation, all other	R-6	R-6	

Notes:

(1) Varies with heating degree-days (“HHD”). Above value reflects 5000 HDD average for New Jersey.
U values represent total wall system U value, including all components (i.e., clear wall, windows, doors).
Type A-1 - Detached one and two family dwellings.
Type A-2 - All other residential buildings, three stories in height or less.
(2) All frame floors shall meet this requirement. There is no requirement for floors over basements and/or unvented crawl spaces when the basement and/or unvented crawl space walls are insulated.
(3) Absent any NJ specific lighting study, lighting savings is derived from a baseline installed efficient lighting default of 10% per RESNET guidelines.

(4) MEC 95 minimum requirement is 78 AFUE. However, 80 AFUE is adopted for New Jersey based on typical minimum availability and practice.
(5) Based on the Federal Government standard for calculating EF (50 gallon assumed):
•Gas-fired Storage-type EF: 0.67 - (0.0019 x Rated Storage Volume in gallons)
•Electric Storage-type EF: 0.97 - (0.00132 x Rated Storage Volume in gallons)

Data Point	Single and Multiple Family Except as Noted.		

•Instantaneous Gas-fired EF: 0.62 - (0.0019 x Rated Storage Volume in gallons)
•Instantaneous Electric EF: 0.93 - (0.0013 x Rated Storage Volume in gallons

ENERGY STAR Products Program

ENERGY STAR Appliances, ENERGY STAR Lighting, ENERGY STAR Windows, and ENERGY STAR Audit

ENERGY STAR Appliances

Protocols

The general form of the equation for the ENERGY STAR Appliance Program measure savings algorithms is:

Number of Units X Savings per Unit

To determine resource savings, the per unit estimates in the protocols will be multiplied by the number of appliance units. The number of units will be determined using market assessments and market tracking.

ENERGY STAR Refrigerators – CEE Tier 2

Electricity Impact (kWh) = $ESav_{REF2}$

Demand Impact (kW) = $DSav_{REF2}$ x CF_{REF}

ENERGY STAR Clothes Washers - CEE Tier 2

Electricity Impact (kWh) = $ESav_{CW2}$

Demand Impact (kW) = $DSav_{CW2}$ x CF_{CW}

Gas Impact (Therms) = $EGSav_{CW2}$

Water Impact (gallons) = $WSav_{CW2}$

ENERGY STAR Set Top Boxes

Electricity Impact (kWh) = $ESav_{STB}$

Demand Impact (kW) = $DSav_{STB}$ x CF_{STB}

Advanced Power Strip

Electricity Impact (kWh) = $ESav_{APS}$

Demand Impact (kW) = $DSav_{APS}$ x CF_{APS}

ENERGY STAR Clothes Dryers

Electricity Impact (kWh) = $ESav_{CD}$

Demand Impact (kW) = $DSav_{CD}$ x CF_{CD}

Gas Impact (Therms) = $GSav_{CDG}$

Definition of Terms

$ESav_{REF2}$ = Electricity savings per purchased ENERGY STAR refrigerator – CEE Tier 2.

$DSav_{REF2}$ = Summer demand savings per purchased ENERGY STAR refrigerator – CEE Tier 2.

$ESav_{CW2}$ = Electricity savings per purchased ENERGY STAR clothes washer.

$DSav_{CW2}$ = Summer demand savings per purchased ENERGY STAR clothes washer.

$GSav_{CW2}$ = Gas savings per purchased clothes washer

$WSav_{CW2}$ = Water savings per purchased clothes washer.

$ESav_{STB}$ = Electricity savings per purchased ENERGY STAR set top box.

$DSav_{STB}$ = Summer demand savings per purchased ENERGY STAR set top box.

$ESav_{APS}$ = Electricity savings per purchased advanced power strip.

$DSav_{APS}$ = Summer demand savings per purchased advanced power strip.

$ESav_{APS2}$ = Electricity savings per purchased Tier 2 advanced power strip.

$DSav_{APS2}$ = Summer demand savings per purchased Tier 2 advanced power strip.

$ESav_{CDE}$ = Electricity savings per purchased ENERGY STAR electric clothes dryer.

$DSav_{CDE}$ = Summer demand savings per purchased ENERGY STAR electric clothes dryer.

$ESav_{CDG}$ = Electricity savings per purchased ENERGY STAR gas clothes dryer.

$DSav_{CDG}$ = summer demand savings per purchased ENERGY STAR gas clothes dryer.

$GSav_{CDG}$ = Gas savings per purchased ENERGY STAR gas clothes dryer.

$ESav_{CDE2}$ = Electricity savings per purchased electric clothes dryer meeting the ENERGY STAR 2014 Emerging Technology Award criteria.

$DSav_{CDE2}$ = Demand savings per purchased electric clothes dryer meeting the ENERGY STAR 2014 Emerging Technology Award criteria.

CF_{REF}, CF_{CW}, , CF_{DH}, CF_{RAC}, , CF_{STB}, , , , CF_{APS}, CF_{CD}= Summer demand coincidence factor.

ENERGY STAR Appliances

Component	Type	Value	Sources
$ESav_{REF2}$	Fixed	87 kWh	5
$DSav_{REF2}$	Fixed	0.01 kW	5
REF Time Period Allocation Factors	Fixed	Summer/On-Peak 20.9% Summer/Off-Peak 21.7% Winter/On-Peak 28.0% Winter/Off-Peak 29.4%	1
$ESav_{CW2}$	Fixed	128 kWh	2
$Gsav_{CW2}$	Fixed	9.00 therms	2
$DSav_{CW2}$	Fixed	0.0170 kW	2
$WSav_{CW2}$	Fixed	9433 gallons	2
CW, CD Electricity Time Period Allocation Factors	Fixed	Summer/On-Peak 24.5% Summer/Off-Peak 12.8% Winter/On-Peak 41.7% Winter/Off-Peak 21.0%	1
CW, CD Gas Time Period Allocation Factors	Fixed	Summer 50% Winter 50%	3
CF_{REF}, CF_{CW}, CF_{STB}, CF_{APS}, CF_{CD}	Fixed	1.0, 1.0, 1.0, 1.0, 1.0, 1.0	4
$ESav_{STB}$	Fixed	44 kWh	6
$DSav_{STB}$	Fixed	0.005 kW	6
$ESav_{APS}$	Fixed	102.8 kWh	8
$DSav_{APS}$	Fixed	0.012 kW	8
$ESav_{APS2}$	Fixed	346 kWh	9
$DSav_{APS2}$	Fixed	0.039 kW	9
APS, STB Time Period Allocation Factors	Fixed	Summer/On-Peak 16% Summer/Off-Peak 17% Winter/On-Peak 32% Winter/Off-Peak 35%	10
$ESav_{CDE}$	Fixed	186 kWh	12
$DSav_{CDE}$	Fixed	0.016 kW	12

Component	Type	Value	Sources
$ESav_{CDG}$	Fixed	9 kWh	12
$DSav_{CDG}$	Fixed	0.001 kW	12
$GSav_{CDG}$	Fixed	5.8 therms	12
$ESav_{CDE}$	Fixed	388 kWh	12,13
$DSav_{CDE}$	Fixed	0.029 kW	12,13

Sources:

1. Time period allocation factors used in cost-effectiveness analysis. From residential appliance load shapes.
2. CEE Tier 2 clothes washers energy and water savings estimates based on a representative clothes washer that meets the federal standard (MEF 1.26) and one with an MEF of 2.2 and water factor (WF) of 4.5. Assumes 75% of participants have gas water heating and 60% have gas drying (the balance being electric). Demand savings are calculated based on 282 annual cycles from 2005 RECS data for the mid-Atlantic and load shapes from Itron eShapes for Upstate New York.
3. Prorated based on 6 months in the summer period and 6 months in the winter period.
4. The coincidence of average appliance demand to summer system peak equals 1 for demand impacts for all appliances reflecting embedded coincidence in the DSav factor.
5. ENERGY STAR refrigerator savings are weighted based on 2014 program participation and represent the difference between the average 2014 measured energy use (614 kWh) and the average 2014 Federal Standard (701 kWh) for eligible CEE Tier 2 models. Demand savings estimated based on a flat 8760 hours of use during the year. Ref: https://data.energystar.gov/Active-Specifications/ENERGY-STAR-Certified-Residential-Refrigerators/p5st-her9
6. Energy savings represent the difference between the weighted average eligible ENERGY STAR V4.1 models (132 kWh) and minimum requirements of the 2012 voluntary agreement established by the cable industry and tied to ENERGY STAR V3.0 (88 kWh). Demand savings estimated based on a flat 8760 hours of use during the year. On average, demand savings are the same for both Active and Standby states and is based on 8760 hours usage.
7. Set top box lifetimes: National Resource Defense Counsel, *Cable and Satellite Set-Top Boxes Opportunities for Energy Savings*, 2005. http://www.nrdc.org/air/energy/energyeff/stb.pdf
8. 2010 NYSERDA Measure Characterization for Advanced Power Strips. Study based on review of:
    a. Smart Strip Electrical Savings and Usability, Power Smart Engineering, October 27, 2008.
    b. Final Field Research Report, Ecos Consulting, October 31, 2006. Prepared for California Energy Commission's PIER Program.
    c. Developing and Testing Low Power Mode Measurement Methods, Lawrence Berkeley National Laboratory (LBNL), September 2004. Prepared for California Energy
    Commission's Public Interest Energy Research (PIER) Program.
    d. 2005 Intrusive Residential Standby Survey Report, Energy Efficient Strategies, March, 2006.

9. Energy savings estimates are based on a California Plug Load Research Center report, “Tier 2 Advanced Power Strip Evaluation for Energy Saving Incentive.” Demand savings estimated based on a flat 8760 hours of use during the year. Savings for Tier 2 APS are temporarily included pending additional support.
10. 2011 Efficiency Vermont Load shape for Advanced Power Strips
11. Advanced Power Strip Measure Life: David Rogers, Power Smart Engineering, October 2008: "Smart Strip electrical savings and usability", p22.
12. Clothes dryer energy and demand savings are based on the estimated ENERGY STAR baseline (CEF of 3.11 lbs/kWh) (http://www.energystar.gov/sites/default/files/specs//ENERGY%20STAR%20Draft%202%20Version%201.0%20Clothes%20Dryers%20Data%20and%20Analysis.xlsx) and products meeting the ENERGY STAR specification and 2014 Emerging Technology Award criteria. Demand savings are calculated based on 282 annual cycles from 2005 RECS data for the mid-Atlantic and an average 10.4 lb load based on paired ENERGY STAR washers.
13. Savings for clothes dryers meeting the 2014 Emerging Technology Award criteria assume an average of measured performance and a 50% usage of both normal and most efficient dryer settings for eligible models.

Residential ENERGY STAR Lighting

Protocols

Savings from installation of screw-in ENERGY STAR CFLs, ENERGY STAR fluorescent torchieres, ENERGY STAR indoor fixtures and ENERGY STAR outdoor fixtures are based on a straightforward algorithm that calculates the difference between existing and new wattage, and the average daily hours of usage for the lighting unit being replaced. An “in-service” rate is used to reflect the fact that not all lighting products purchased are actually installed.

The general form of the equation for the ENERGY STAR or other high efficiency lighting energy savings algorithm is:

Number of Units X Savings per Unit

Per unit savings estimates are derived primarily from a 2004 Nexus Market Research report evaluating similar retail lighting programs in New England (MA, RI and VT). Per unit savings will decrease for CFLs in operation after 2012 due to the effects of federal minimum efficiency standards for incandescent lighting. Because CFLs typically have rated lifespans of 6-8000 hours (5-7 years) and incandescent light bulbs are rated at 1000 hours (1 year), after 2013 there will be less of a difference between CFLs in service and the incandescents that they would have been replacing.

National lighting efficiency standards are being increased according to the Energy Independence and Security Act of 2007 (EISA).[7] EISA pertains to the efficiency of newly manufactured bulbs, not existing stock. Existing *Protocol* baselines and measure lifetimes will remain until the impact of the standard can be fully measured and quantified. The future EISA wattage standards are:

EISA Phase 1 Standard for General Service Bulbs

Rated Lumen Ranges	Maximum Rate Wattage	Minimum Rate Lifetime	Effective Date	Efficacy Ranges (lumens per watt)
1490-2600 (~90W – 150W)	72	1000 hrs	1/1/2012	21 – 36
1050-1489 (~75W – 90W)	53	1000 hrs	1/1/2013	20 – 28
750-1049 (~60W – 75W)	43	1000 hrs	1/1/2014	17 – 24
310-749 (~30W – 60W)	29	1000 hrs	1/1/2014	11 – 26

<u>ENERGY STAR CFL Bulbs</u>

Energy Savings (kWh) = $(CFL_{watts}/1000) \text{ X } CFL_{hours} \text{ X } 365 \text{ X } CFL_{ISR}$

Demand Savings (kW) = $(CFL_{watts}/1000) \text{ X } CF \text{ X } CFL_{ISR}$

<u>ENERGY STAR Torchieres</u>

Electricity Impact (kWh) = $(Torch_{watts}/1000) \text{ X } Torch_{hours} \text{ X } 365 \text{ X } Torch_{ISR}$

Peak Demand Impact (kW) = $(Torch_{watts}/1000) \text{ X Light CF X } Torch_{ISR}$

<u>ENERGY STAR Indoor Fixture</u>

Electricity Impact (kWh) = $(IF_{watts}/1000) \text{ X } IF_{hours} \text{ X } 365 \text{ X } IF_{ISR}$

Peak Demand Impact (kW) = $(IF_{watts}/1000) \text{ X Light CF X } IF_{ISR}$

<u>ENERGY STAR Outdoor Fixture</u>

Electricity Impact (kWh) = $(OF_{watts}/1000) \text{ X } OF_{hours} \text{ X } 365 \text{ X } OF_{ISR}$

Peak Demand Impact (kW) = $(OF_{watts}/1000) \text{ X Light CF X } OF_{ISR}$

<u>ENERGY STAR LED Recessed Downlights & Integral Lamps</u>

Energy Savings (kWh) = $((LED_{watts} / 1000) \text{ X } LED_{Hours} \text{ X } 365 \text{ X } LED_{ISR}$

[7] EISA information available at http://www1.eere.energy.gov/femp/regulations/eisa.html

$$\text{Demand Savings (kW)} = (LED_{watts} / 1000) \times CF \times LED_{ISR}$$

Definition of Terms

CFL_{watts} = Average difference in watts between baseline and ENERGY STAR CFL

CFL_{hours} = Average hours of use per day per CFL

CF_{Bulb} = Summer demand coincidence factor for CFLs and LEDs

CFL_{ISR} = In-service rate per CFL

$Torch_{watts}$ = Average delta watts per purchased ENERGY STAR torchiere

$Torch_{hours}$ = Average hours of use per day per torchiere

$Torch_{ISR}$ = In-service rate per Torchier

IF_{watts} = Average delta watts per purchased ENERGY STAR Indoor Fixture

IF_{hours} = Average hours of use per day per Indoor Fixture

IF_{ISR} = In-service rate per Indoor Fixture

OF_{watts} = Average delta watts per purchased ENERGY STAR Outdoor Fixture

OF_{hours} = Average hours of use per day per Outdoor Fixture

OF_{ISR} = In-service rate per Outdoor Fixture

$CF_{Fixtures}$ = Summer demand coincidence factor for CFL fixtures.

LED_{watts} = Average delta watts per purchased LED recessed downlight or integral lamp

LED_{hours} = Average hours of use per day per LED recessed downlight or integral lamp

LED_{ISR} = In-service rate per LED recessed downlight or integral lamp

ENERGY STAR Lighting

Component	Type	Value	Sources
CFL_{watts}	Fixed	32.9	5
CFL_{hours}	Fixed	2.8	6
CFL_{ISR}	Fixed	83.4%	5
CF_{Bulb}	Fixed	9.9 %	4

Component	Type	Value	Sources
$Torch_{watts}$	Fixed	78.5	1
$Torch_{hours}$	Fixed	3.0	2
$Torch_{ISR}$	Fixed	83%	3
IF_{watts}	Fixed	32.9	1
IF_{hours}	Fixed	2.6	2
IF_{ISR}	Fixed	95%	3
OF_{watts}	Fixed	64.2	1
OF_{hours}	Fixed	4.5	2
OF_{ISR}	Fixed	87%	3
$CF_{Fixture}$	Fixed	5%	4
LED_{watts}	Fixed	36.8	7
LED_{hours}	Fixed	2.8	6
LED_{ISR}	Fixed	100%	7

Sources:

1. Nexus Market Research, "Impact Evaluation of the Massachusetts, Rhode Island and Vermont 2003 Residential Lighting Programs", Final Report, October 1, 2004, p. 43 (Table 4-9) The delta watts are reduced by 22.2% in the same proportion to individual CFLs (48.5W to 32.9W) following full enactment of EISA requirements.
2. US Department of Energy, Energy Star Calculator.
3. Nexus Market Research, "Impact Evaluation of the Massachusetts, Rhode Island and Vermont 2003 Residential Lighting Programs", Final Report, October 1, 2004. p. 42 (Table 4-7). These values reflect both actual installations and the % of units planned to be installed within a year from the logged sample. The logged % is used because the adjusted values (i.e. to account for differences between logging and telephone survey samples) were not available for both installs and planned installs. However, this seems appropriate because the % actual installed in the logged sample from this table is essentially identical to the % after adjusting for differences between the logged group and the telephone sample (p. 100, Table 9-3).
4. RLW Analytics, "Development of Common Demand Impacts for Energy Efficiency Measures/Programs for the ISO Forward Capacity Market (FCM)", prepared for the New England State Program Working Group (SPWG), March 25, 2007, p. IV.
5. The average wattage (18.4W) of the standard CFL established in the 2009 "NJCEP *Residential CFL Impact Evaluation and Protocol Review",* September 28, 2008, p.3-8 (Table 3-6) is adjusted by a post-EISA multiplier (1.79) of the 2014 Mid-Atlantic Technical Reference Manual V4.0 for calculating the new delta watts after the incandescent bulb wattage is reduced (from 100W to 72W in 2012, 75W to 53W in 2013 and 60W to 43W and 40W to 29W in 2014).
6. RLW Analytics, *New England Residential Lighting Markdown Impact Evaluation*, January 20, 2009.
7. For determining demand savings the baseline was adopted from 2009 KEMA evaluation and represents the replacement of a 65W BR30 downlight and high efficiency is the average of ENERGY STAR qualified downlights (11/10/2009) with lighting output exceeding 475 lumens. Due to the high incremental cost and limited market availability

of products, the higher ISR reflects the assumption that every LED downlight purchased is directed towards immediate use.

ENERGY STAR Windows

Protocols

The general form of the equation for the ENERGY STAR or other high efficiency windows energy savings algorithms is:

Square Feet of Window Area X Savings per Square Foot

To determine resource savings, the per square foot estimates in the protocols will be multiplied by the number of square feet of window area. The number of square feet of window area will be determined using market assessments and market tracking. Some of these market tracking mechanisms are under development. The per unit energy and demand savings estimates are based on prior building simulations of windows.

ENERGY STAR Windows

Savings estimates for ENERGY STAR Windows are based on modeling a typical 2,500 square foot home using REM Rate, the home energy rating tool. Savings are per square foot of qualifying window area. Savings will vary based on heating and cooling system type and fuel. These fuel and HVAC system market shares will need to be estimated from prior market research efforts or from future program evaluation results.

<u>Heat Pump</u>

Electricity Impact (kWh) = $ESav_{HP}$

Demand Impact (kW) = $DSav_{HP}$ x CF

<u>Gas Heat/CAC</u>

Electricity Impact (kWh) = $ESav_{GAS/CAC}$

Demand Impact (kW) = $DSav_{CAC}$ x CF

Gas Impact (therms) = $GSav_{GAS}$

<u>Gas Heat/No CAC</u>

Electricity Impact (kWh) = $ESav_{GAS/NOCAC}$

Demand Impact (kW) = $DSav_{NOCAC}$ x CF

Gas Impact (therms) = $GSav_{GAS}$

Oil Heat/CAC

Electricity Impact (kWh) = $ESav_{OIL/CAC}$

Demand Impact (kW) = $DSav_{CAC}$ x CF

Oil Impact (MMBtu) = $OSav_{OIL}$

Oil Heat/No CAC

Electricity Impact (kWh) = $ESav_{OIL/NOCAC}$

Demand Impact (kW) = $DSav_{NOCAC}$ x CF

Oil Impact (MMBtu) = $OSav_{OIL}$

Electric Heat/CAC

Electricity Impact (kWh) = $ESav_{RES/CAC}$

Demand Impact (kW) = $DSav_{CAC}$ x CF

Electric Heat/No CAC

Electricity Impact (kWh) = $ESav_{RES/NOCAC}$

Demand Impact (kW) = $DSav_{NOCAC}$ x CF

Definition of Terms

$ESav_{HP}$ = Electricity savings (heating and cooling) with heat pump installed.

$ESav_{GAS/CAC}$ = Electricity savings with gas heating and central AC installed.

$ESav_{GAS/NOCAC}$ = Electricity savings with gas heating and no central AC installed.

$ESav_{OIL/CAC}$ = Electricity savings with oil heating and central AC installed.

$ESav_{OIL/NOCAC}$ = Electricity savings with oil heating and no central AC installed.

$ESav_{RES/CAC}$ = Electricity savings with electric resistance heating and central AC installed.

$ESav_{RES/NOCAC}$ = Electricity savings with electric resistance heating and no central AC installed.

$DSav_{HP}$ = Summer demand savings with heat pump installed.

$DSav_{CAC}$ = Summer demand savings with central AC installed.

$DSav_{NOCAC}$ = Summer demand savings with no central AC installed.

CF = System peak demand coincidence factor. Coincidence of building cooling demand to summer system peak.

$GSav_{GAS}$ = Gas savings with gas heating installed.

$OSav_{OIL}$ = Oil savings with oil heating installed.

ENERGY STAR Windows

Component	Type	Value	Sources
$ESav_{HP}$	Fixed	2.2395 kWh	1
HP Time Period Allocation Factors	Fixed	Summer/On-Peak 10% Summer/Off-Peak 7% Winter/On-Peak 40% Winter/Off-Peak 44%	2
$ESav_{GAS/CAC}$	Fixed	0.2462 kWh	1
Gas/CAC Electricity Time Period Allocation Factors	Fixed	Summer/On-Peak 65% Summer/Off-Peak 35% Winter/On-Peak 0% Winter/Off-Peak 0%	2
$ESav_{GAS/NOCAC}$	Fixed	0.00 kWh	1
Gas/No CAC Electricity Time Period Allocation Factors	Fixed	Summer/On-Peak 3% Summer/Off-Peak 3% Winter/On-Peak 45% Winter/Off-Peak 49%	2
Gas Heating Gas Time Period Allocation Factors	Fixed	Summer = 12% Winter = 88%	4
$ESav_{OIL/CAC}$	Fixed	0.2462 kWh	1
Oil/CAC Time Period Allocation Factors	Fixed	Summer/On-Peak 65% Summer/Off-Peak 35% Winter/On-Peak 0% Winter/Off-Peak 0%	2
$ESav_{OIL/NOCAC}$	Fixed	0.00 kWh	1
Oil/No CAC Time Period Allocation Factors	Fixed	Summer/On-Peak 3% Summer/Off-Peak 3% Winter/On-Peak 45% Winter/Off-Peak 49%	2
$ESav_{RES/CAC}$	Fixed	4.0 kWh	1
Res/CAC Time Period Allocation Factors	Fixed	Summer/On-Peak 10% Summer/Off-Peak 7% Winter/On-Peak 40% Winter/Off-Peak 44%	2
$ESav_{RES/NOCAC}$	Fixed	3.97 kWh	1
Res/No CAC Time Period Allocation Factors	Fixed	Summer/On-Peak 3% Summer/Off-Peak 3% Winter/On-Peak 45% Winter/Off-Peak 49%	2
$DSav_{HP}$	Fixed	0.000602 kW	1
$DSav_{CAC}$	Fixed	0.000602 kW	1
$DSav_{NOCAC}$	Fixed	0.00 kW	1
$GSav_{GAS}$	Fixed	0.169 therms	1
$OSav_{OIL}$	Fixed	0.0169 MMBtu	1

Component	Type	Value	Sources
CF	Fixed	0.75	3

Sources:

1. From REMRATE Modeling of a typical 2,500 sq. ft. NJ home. Savings expressed on a per sq. ft. of window area basis. New Brunswick climate data.
2. Time period allocation factors used in cost-effectiveness analysis.
3. Based on reduction in peak cooling load.
4. Prorated based on 12% of the annual degree days falling in the summer period and 88% of the annual degree days falling in the winter period.

Home Energy Reporting System

Protocols

The purpose of the program is to provide information and tools that residential customers can use to make decisions about what actions to take to improve energy efficiency in their homes. The information is mailed in reports separately from a utility's regular bill to create a neighbor-to-neighbor comparison where homes of similar size are compared to each other, as well as targeting energy saving tips to individuals. The quantity and timing of mailed reports will vary by utility and fuel type.

Home Energy Reporting System

Gas Savings (Therms) = $GSav_{HERS}$

Component	Type	Value	Sources
$Gsav_{HERS}$	Fixed	13.1 therms	1

Sources:

1. The average natural gas savings from similar program offered to Puget Sound Energy customers. (Reference: Evidence from Two Large Field Experiments that Peer Comparison Feedback Can Reduce Residential Energy Usage, Ayres, 2009)

Refrigerator/Freezer Retirement Program

Protocols

The general form of the equation for the Refrigerator/Freezer Retirement Program savings algorithm is:

Number of Units X Savings per Unit

To determine resource savings, the per unit estimates in the protocols will be multiplied by the number of appliance units.

Unit savings are the product of average fridge/freezer consumption (gross annual savings), and a net to gross ratio that adjusts for both free ridership and the portion of retired units that are replaced with more efficient new units.

Algorithm

Electricity Impact (kWh) = $ESav_{RetFridge}$ * NTG

Demand Impact (kW) = $DSav_{RetFridge}$ x $CF_{RetFridge}$

Definition of Terms

$ESav_{RetFridge}$ = Gross annual energy savings per unit retired appliance

NTG = Net-to-Gross Adjustment factor.

$DSav_{RetFridge}$ = Summer demand savings per retired refrigerator/freezer

$CF_{RetFridge}$ = Summer demand coincidence factor.

REFRIGERATOR/FREEZER RECYCLING

Component	Type	Value	Sources
$ESav_{RetFridge}$	Fixed	1,728 kWh	1
NTG	Fixed	55%	2
$DSav_{RetFridge}$	Fixed	.2376 kW	3
$CF_{RetFridge}$	Fixed	1	4

Sources:

1. The average power consumption of units retired under similar recent programs:
   a. Fort Collins Utilities, February 2005. Refrigerator and Freezer Recycling Program 2004 Evaluation Report.
   b. Midwest Energy Efficiency Alliance, 2005. 2005 Missouri Energy Star Refrigerator Rebate and Recycling Program Final Report
   c. Pacific Gas and Electric, 2007. PGE ARP 2006-2008 Climate Change Impacts Model (spreadsheet)
   d. Quantec, Aug 2005. Evaluation of the Utah Refrigerator and Freezer Recycling Program (Draft Final Report).
   e. CPUC DEER website, http://eega.cpuc.ca.gov/deer/measure.asp?s=1&c=2&sc=7&m=389059
   f. Snohomish PUD, February 2007. 2006 Refrigerator/Freezer Recycling Program Evaluation.
   g. Ontario Energy Board, 2006. Total Resource Cost Guide.
2. The average net to gross ratios estimated for several recent programs
   a. Fort Collins Utilities, February 2005. Refrigerator and Freezer Recycling Program 2004 Evaluation Report.
   b. SCE, 2001. The Multi-Megawatt Refrigerator/Freezer Recycling Summer Initiative Program Final Report.
   c. Pacific Gas and Electric, 2007. PGE ARP 2006-2008 Climate Change Impacts Model (spreadsheet)
   d. Quantec, Aug 2005. Evaluation of the Utah Refrigerator and Freezer Recycling Program (Draft Final Report).
   e. Snohomish PUD, February 2007. 2006 Refrigerator/Freezer Recycling Program Evaluation.
   f. Ontario Energy Board, 2006. Total Resource Cost Guide.

3. Applied the kW to kWh ratio derived from Refrigerator savings in the ENERGY STAR Appliances Program.
4. Coincidence factor already embedded in summer peak demand reduction estimates

Home Performance with ENERGY STAR Program

In order to implement Home Performance with Energy Star, there are various standards a program implementer must adhere to in order to deliver the program. The program implementer must use software that meets a national standard for savings calculations from whole-house approaches such as home performance. The software the program implementer uses must adhere to at least one of the following standards:

- A software tool whose performance has passed testing according to the National Renewable Energy Laboratory's HERS BESTEST software energy simulation testing protocol.[8]
- Software approved by the US Department of Energy's Weatherization Assistance Program.[9]
- RESNET approved rating software.[10]

There are numerous software packages that comply with these standards. Some examples of the software packages are REM/Rate, Real Home Analyzer, EnergyGauge, TREAT, and HomeCheck.

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[8] A new standard for BESTEST is currently being developed. The existing 1995 standard can be found at http://www.nrel.gov/docs/legosti/fy96/7332a.pdf .
[9] A listing of the approved software available at http://www.waptac.org/si.asp?id=736 .
[10] A listing of the approved software available at http://resnet.us .

Commercial and Industrial Energy Efficient Construction

C&I Electric Protocols

Baselines and Code Changes

In general, efficiency baselines are designed to reflect current market practices - typically, the higher of applicable codes or the minimum efficiency of available new equipment - and are updated periodically to reflect upgrades in code or information from evaluation results. There are exceptions to this approach, as in the Direct Install program (see below).

Baseline data reflect ASHRAE 90.12007 unless otherwise noted for applications designated "2011".

The Energy Independence and Security Act of 2007 (EISA) is scheduled to be implemented on July 14, 2012 for general service fluorescent lamps and general service bulbs. EISA pertains to the efficiency of newly manufactured lamps, not existing stock. Existing *Protocol* baselines and measure lifetimes will remain until the impact of the standard can be fully measured and quantified. The future EISA wattage standards are:

EISA Phase 1 Standard for General Service Fluorescent Lamps

Lamp/Tube type	Correlated color temperature (CCT)	Minimum average lamp efficacy (lm/W)
4-foot medium bipin	≤4,500K	89
	>4,500K and ≤7,000K	88
2-foot U-shaped	≤4,500K	84
	>4,500K and ≤7,000K	81
8-foot slimline	≤4,500K	97
	>4,500K and ≤7,000K	93
8-foot high output	≤4,500K	92
	>4,500K and ≤7,000K	88
4-foot miniature bipin standard output	≤4,500K	86
	>4,500K and ≤7,000K	81
4-foot miniature bipin high output	≤4,500K	76
	>4,500K and ≤7,000K	72

The wattage table for general service light bulbs is located in the Residential ENERGY STAR Lighting section of the *Protocols*.

Building Shell

Building shell measures identified in an approved Local Government Energy Audit (or equivalent) are eligible for program incentives for a limited time through ARRA funding. Savings for these measures will vary from project to project based on factors such as building size, existing levels of insulation and infiltration levels. As a result, energy savings for these installed building shell measures will be taken from what is provided in the approved Audit.

Performance Lighting

For new construction and entire facility rehabilitation projects, savings are calculated by comparing lighting power density of fixture being installed to the baseline power densities from ASHRAE 90.1 2007.

Lighting equipment includes fluorescent fixtures, ballasts, compact fluorescent fixtures, exit signs, LED fixtures, and metal halide lamps. The measurement of energy savings is based on algorithms with measurement of key variables (i.e., Coincidence Factor and Operating Hours) through end-use metering data accumulated from a large sample of participating facilities from 1995 through 1999.

Algorithms

Demand Savings = ΔkW X CF X (1+IF)

Energy Savings = ΔkW X EFLH X (1+IF)

$\Delta kW = (LPD_{base} - LPD_{inst}) \text{ X } SF$

Definition of Variables

ΔkW = Change in connected load from baseline to efficient lighting level.

LPD_{base} = Baseline lighting power density in Watt per square foot of space floor area, based on ASHRAE 90.1 Table 9.6.1 (Space-by-Space Method)

LPD_{inst} = Lighting power density of installed fixtures, equal to the sum of installed fixture wattage divided by floor area of the space where the fixtures are installed. Wattage of installed fixtures is based on table at http://www.sce.com/NR/rdonlyres/FC51087D-2848-42DF-A52A-BDBA1A09BF8D/0/SCE_B_StandardFixtureWatts010108.pdf.

SF = space floor area, Square Foot

CF = Coincidence Factor

EFLH = Equivalent Full Load Hours

IF = Interactive Factor

Lighting Verification Summary

Component	Type	Value	Source
ΔkW	Fixed	See Lighting Wattage Table derived from the California SPC Table: http://www.sce.com/NR/rdonlyres/FC51087D-2848-42DF-A52A-BDBA1A09BF8D/0/SCE_B_StandardFixtureWatts010108.pdf And Formula Above.	• 1 • Baseline LPD from ASHRAE 90.1-2007 Table 9.6.1 • Installed LPD, space type and floor area from customer application.
CF	Fixed	See Lighting Table by BuildingType	2
IF	Fixed	See Lighting Table by Building Type	3
EFLH	Fixed	See Lighting Table by Building Type	4

Lighting Wattage Table

Fixture Type Installed	Fixture Installed	kW/Fixture
Fluorescent - 1 L STD T-8	17 W (1) 2' T-8 Lamp	0.017
Fluorescent - 1 L STD T-8	25 W (1) 3' T-8 Lamp	0.023
Fluorescent - 1 L STD T-8	32 W (1) 4' T-8 Lamp	0.030
Fluorescent - 1 L STD T-8	40 W (1) 5' T-8 Lamp	0.035
Fluorescent - 1 L STD T-8	59 W (1) 8' T-8 Lamp	0.057
Fluorescent - 2 L STD T-8	17 W (2) 2' T-8 Lamp	0.032
Fluorescent - 2 L STD T-8	25 W (2) 3' T-8 Lamp	0.045
Fluorescent - 2 L STD T-8	32 W (2) 4' T-8 Lamp	0.056
Fluorescent - 2 L STD T-8	40 W (2) 5' T-8 Lamp	0.070
Fluorescent - 2 L STD T-8	59 W (2) 8' T-8 Lamp	0.109
Fluorescent - 3 L STD T-8	17 W (3) 2' T-8 Lamp	0.050
Fluorescent - 3 L STD T-8	25 W (3) 3' T-8 Lamp	0.070

Fluorescent - 3 L STD T-8	32 W (3) 4' T-8 Lamp	0.086
Fluorescent - 3 L STD T-8	40 W (3) 5' T-8 Lamp	0.106
Fluorescent - 3 L STD T-8	59 W (3) 8' T-8 Lamp	0.167
Fluorescent - 4 L STD T-8	17 W (4) 2' T-8 Lamp	0.065
Fluorescent - 4 L STD T-8	25 W (4) 3' T-8 Lamp	0.088
Fluorescent - 4 L STD T-8	32 W (4) 4' T-8 Lamp	0.111
Fluorescent - 4 L STD T-8	40 W (4) 5' T-8 Lamp	0.134
Fluorescent - 4 L STD T-8	59 W (4) 8' T-8 Lamp	0.219
Fluorescent - 5 L STD T-8	32 W (5) 4' T-8 Lamp	0.148
Fluorescent - 6 L STD T-8	32 W (6) 4' T-8 Lamp	0.172
Fluorescent - 6 L STD T-8	59 W (6) 8' T-8 Lamp	0.328
Fluorescent - 8 L STD T-8	32 W (8) 4' T-8 Lamp	0.217
Fluorescent - 1 L T-8 U-Tube	32 W (1) U-Tube T-8 Lamp	0.032
Fluorescent - 2 L T-8 U-Tube	32 W (2) U-Tube T-8 Lamp	0.059
Fluorescent - 3 L T-8 U-Tube	32 W (3) U-Tube T-8 Lamp	0.089
Fluorescent - 1 L STD T-5	14 W (1) 2' T-5 Lamp	0.018
Fluorescent - 1 L STD T-5	21 W (1) 3' T-5 Lamp	0.025
Fluorescent - 1 L STD T-5	28 W (1) 4' T-5 Lamp	0.033
Fluorescent - 1 L STD T-5	35 W (1) 5' T-5 Lamp	0.040
Fluorescent - 1 L STD T-5	14 W (2) 2' T-5 Lamp	0.034
Fluorescent - 2 L STD T-5	21 W (2) 3' T-5 Lamp	0.048
Fluorescent - 2 L STD T-5	28 W (2) 4' T-5 Lamp	0.064
Fluorescent - 2 L STD T-5	35 W (2) 5' T-5 Lamp	0.078
Fluorescent - 2 L STD T-5	14 W (3) 2' T-5 Lamp	0.052
Fluorescent - 2 L STD T-5	21 W (3) 3' T-5 Lamp	0.073
Fluorescent - 3 L STD T-5	28 W (3) 4' T-5 Lamp	0.097
Fluorescent - 3 L STD T-5	35 W (3) 5' T-5 Lamp	0.118
Fluorescent - 3 L STD T-5	14 W (4) 2' T-5 Lamp	0.068
Fluorescent - 3 L STD T-5	21 W (4) 3' T-5 Lamp	0.096
Fluorescent - 3 L STD T-5	28 W (4) 4' T-5 Lamp	0.128
Fluorescent - 4 L STD T-5	35 W (4) 5' T-5 Lamp	0.156
Fluorescent - 4 L STD T-5	28 W (6) 4' T-5 Lamp	0.192
Fluorescent - 4 L STD T-5	35 W (6) 5' T-5 Lamp	0.234
Fluorescent - 4 L STD T-5	28 W (8) 4' T-5 Lamp	0.256
Fluorescent - T-5 HO	24 W (1) 2' T-5/HO Lamp	0.027
Fluorescent - T-5 HO	38 W (1) 3' T-5/HO Lamp	0.042
Fluorescent - T-5 HO	54 W (1) 4' T-5/HO Lamp	0.0605
Fluorescent - T-5 HO	80 W (1) 5' T-5/HO Lamp	0.089
Fluorescent - T-5 HO	24 W (2) 2' T-5/HO Lamp	0.052
Fluorescent - T-5 HO	38 W (2) 3' T-5/HO Lamp	0.085
Fluorescent - T-5 HO	54 W (2) 4' T-5/HO Lamp	0.117

Fluorescent - T-5 HO	24 W (3) 2' T-5/HO Lamp	0.079
Fluorescent - T-5 HO	38 W (3) 3' T-5/HO Lamp	0.127
Fluorescent - T-5 HO	54 W (3) 4' T-5/HO Lamp	0.179
Fluorescent - T-5 HO	24 W (4) 2' T-5/HO Lamp	0.104
Fluorescent - T-5 HO	38 W (4) 3' T-5/HO Lamp	0.17
Fluorescent - T-5 HO	54 W (4) 4' T-5/HO Lamp	0.234
Fluorescent - T-5 HO	38 W (6) 3' T-5/HO Lamp	0.255
Fluorescent - T-5 HO	54 W (6) 4' T-5/HO Lamp	0.351
Fluorescent - T-5 HO	38 W (8) 3' T-5/HO Lamp	0.34
Fluorescent - T-5 HO	54 W (8) 4' T-5/HO Lamp	0.468
Fluorescent - T-8 HO	32 W (1) 4' T-8/HO Lamp	0.0345
Fluorescent - T-8 HO	32 W (2) 4' T-8/HO Lamp	0.0675
Fluorescent - T-8 HO	32 W (3) 4' T-8/HO Lamp	0.0955
Fluorescent - T-8 HO	32 W (4) 4' T-8/HO Lamp	0.135
Fluorescent - T-8 HO	32 W (5) 4' T-8/HO Lamp	0.163
Fluorescent - T-8 HO	32 W (6) 4' T-8/HO Lamp	0.191
Fluorescent - T-8 HO	32 W (8) 4' T-8/HO Lamp	0.27
Fluorescent - T-8 HO	86 W (1) 8' T-8/HO Lamp	0.08
Fluorescent - T-8 HO	86 W (2) 8' T-8/HO Lamp	0.16
Fluorescent - T-8 HO	86 W (4) 8' T-8/HO Lamp	0.32
Metal Halide (non Pulse Start), 1 L	32 W (1) Metal Halide	0.043
Metal Halide (non Pulse Start), 1 L	50 W (1) Metal Halide	0.072
Metal Halide (non Pulse Start), 1 L	70 W (1) Metal Halide	0.095
Metal Halide (non Pulse Start), 1 L	100 W (1) Metal Halide	0.128
Metal Halide (non Pulse Start), 1 L	150 W (1) Metal Halide	0.19
Metal Halide (non Pulse Start), 1 L	175 W (1) Metal Halide	0.215
Metal Halide (non Pulse Start), 1 L	250 W (1) Metal Halide	0.295
Metal Halide (non Pulse Start), 1 L	400 W (1) Metal Halide	0.458
Metal Halide (non Pulse Start), 1 L	750 W (1) Metal Halide	0.85
Metal Halide (non Pulse Start), 1 L	1000 W (1) Metal Halide	1.08
Metal Halide (non Pulse Start), 1 L	1500 W (1) Metal Halide	1.61
Metal Halide (non Pulse Start), 2 L	400 W (2) Metal Halide	0.916
Pulse Start Metal Halide	150 W - Pulse Start Metal Halide	0.185
Pulse Start Metal Halide	175 W - Pulse Start Metal Halide	0.208
Pulse Start Metal Halide	200 W - Pulse Start Metal Halide	0.235
Pulse Start Metal Halide	250 W - Pulse Start Metal Halide	0.288
Pulse Start Metal Halide	300 W - Pulse Start Metal Halide	0.342
Pulse Start Metal Halide	320 W - Pulse Start Metal Halide	0.368
Pulse Start Metal Halide	350 W - Pulse Start Metal Halide	0.4
Pulse Start Metal Halide	400 W - Pulse Start Metal Halide	0.45
Pulse Start Metal Halide	750 W - Pulse Start Metal Halide	0.815

Pulse Start Metal Halide	1000 W - Pulse Start Metal Halide	1.075
LED Exit Sign	Light Emitting Diode, (1) 2 W, Single Sided	0.006
LED Exit Sign	Light Emitting Diode, (2) 2 W, Dual Sided	0.009
CFL - Twin Tube	1 Lamp, 32 W	0.034
CFL - Twin Tube	1 Lamp, 40 W	0.043
CFL - Twin Tube	2 Lamp, 32 W	0.062
CFL - Twin Tube	2 Lamp, 40 W	0.072
CFL - Twin Tube	3 Lamp, 40 W	0.105
CFL - Twin Tube	6 Lamp, 32 W	0.186
CFL - Quad Tube	1 Lamp, 13 W	0.015
CFL - Quad Tube	1 Lamp, 18 W	0.020
CFL - Quad Tube	1 Lamp, 26 W	0.027
CFL - Quad Tube	2 Lamp, 13 W	0.028
CFL - Quad Tube	2 Lamp, 18 W	0.038
CFL - Quad Tube	2 Lamp, 26 W	0.050
CFL - Quad Tube	6 Lamp, 26 W	0.150
CFL - Screw-in	7 W	0.007
CFL - Screw-in	9 W	0.009
CFL - Screw-in	11 W	0.011
CFL - Screw-in	13 W	0.013
CFL - Screw-in	15 W	0.015
CFL - Screw-in	16 W	0.016
CFL - Screw-in	17 W	0.017
CFL - Screw-in	18 W	0.018
CFL - Screw-in	20 W	0.02
CFL - Screw-in	23 W	0.023
CFL - Screw-in	25 W	0.025
CFL - Screw-in	28 W	0.028
Mercury Vapor	40 W, 1 Lamp	0.05
Mercury Vapor	50 W, 1 Lamp	0.074
Mercury Vapor	75 W, 1 Lamp	0.093
Mercury Vapor	100 W, 1 Lamp	0.125
Mercury Vapor	175 W, 1 Lamp	0.205
Mercury Vapor	250 W, 1 Lamp	0.29
Mercury Vapor	400 W, 1 Lamp	0.455
Mercury Vapor	700 W, 1 Lamp	0.78
Mercury Vapor	1000 W, 1 Lamp	1.075
Mercury Vapor	400 W, 2 Lamp	0.91
High Pressure Sodium	35 W	0.046
High Pressure Sodium	50 W	0.066
High Pressure Sodium	70 W	0.095

High Pressure Sodium	100 W	0.138
High Pressure Sodium	150 W	0.188
High Pressure Sodium	200 W	0.25
High Pressure Sodium	250 W	0.295
High Pressure Sodium	310 W	0.365
High Pressure Sodium	360 W	0.414
High Pressure Sodium	400 W	0.465
High Pressure Sodium	1000 W	1.1
Halogen Incandescent	42 W, 1 Lamp	0.042
Halogen Incandescent	45 W, 1 Lamp	0.045
Halogen Incandescent	50 W, 1 Lamp	0.055
Halogen Incandescent	52 W, 1 Lamp	0.052
Halogen Incandescent	55 W, 1 Lamp	0.055
Halogen Incandescent	60 W, 1 Lamp	0.060
Halogen Incandescent	72 W, 1 Lamp	0.072
Halogen Incandescent	75 W, 1 Lamp	0.075
Halogen Incandescent	90 W, 1 Lamp	0.090
Halogen Incandescent	100 W, 1 Lamp	0.100
Halogen Incandescent	150 W, 1 Lamp	0.150
Halogen Incandescent	300 W, 1 Lamp	0.300
Halogen Incandescent	500 W, 1 Lamp	0.500
Halogen Incandescent	45 W, 2 Lamp	0.090
Halogen Incandescent	50 W, 2 Lamp	0.100
Halogen Incandescent	55 W, 2 Lamp	0.110
Halogen Incandescent	75 W, 2 Lamp	0.150
Halogen Incandescent	90 W, 2 Lamp	0.180
Halogen Incandescent	150 W, 2 Lamp	0.300
Incandescent, 1 L	15 W, 1 Lamp	0.015
Incandescent, 1 L	20 W, 1 Lamp	0.02
Incandescent, 1 L	25 W, 1 Lamp	0.025
Incandescent, 1 L	34 W, 1 Lamp	0.034
Incandescent, 1 L	36 W, 1 Lamp	0.036
Incandescent, 1 L	40 W, 1 Lamp	0.04
Incandescent, 1 L	42 W, 1 Lamp	0.042
Incandescent, 1 L	45 W, 1 Lamp	0.045
Incandescent, 1 L	50 W, 1 Lamp	0.05
Incandescent, 1 L	52 W, 1 Lamp	0.052
Incandescent, 1 L	54 W, 1 Lamp	0.054
Incandescent, 1 L	55 W, 1 Lamp	0.055
Incandescent, 1 L	60 W, 1 Lamp	0.06
Incandescent, 1 L	65 W, 1 Lamp	0.065

Incandescent, 1 L	67 W, 1 Lamp	0.067
Incandescent, 1 L	69 W, 1 Lamp	0.069
Incandescent, 1 L	72 W, 1 Lamp	0.072
Incandescent, 1 L	75 W, 1 Lamp	0.075
Incandescent, 1 L	80 W, 1 Lamp	0.08
Incandescent, 1 L	85 W, 1 Lamp	0.085
Incandescent, 1 L	90 W, 1 Lamp	0.09
Incandescent, 1 L	93 W, 1 Lamp	0.093
Incandescent, 1 L	95 W, 1 Lamp	0.095
Incandescent, 1 L	120 W, 1 Lamp	0.12
Incandescent, 1 L	125 W, 1 Lamp	0.125
Incandescent, 1 L	135 W, 1 Lamp	0.135
Incandescent, 1 L	150 W, 1 Lamp	0.15
Incandescent, 1 L	170 W, 1 Lamp	0.17
Incandescent, 1 L	200 W, 1 Lamp	0.2
Incandescent, 1 L	250 W, 1 Lamp	0.25
Incandescent, 1 L	300 W, 1 Lamp	0.3
Incandescent, 1 L	400 W, 1 Lamp	0.4
Incandescent, 1 L	448 W, 1 Lamp	0.448
Incandescent, 1 L	500 W, 1 Lamp	0.5
Incandescent, 1 L	750 W, 1 Lamp	0.75
Incandescent, 1 L	1000 W, 1 Lamp	1
Incandescent, 1 L	1500 W, 1 Lamp	1.5
Incandescent, 1 L	2000 W, 1 Lamp	2
Incandescent, 2 L	15 W, 2 Lamp	0.03
Incandescent, 2 L	20 W, 2 Lamp	0.04
Incandescent, 2 L	25 W, 2 Lamp	0.05
Incandescent, 2 L	34 W, 2 Lamp	0.068
Incandescent, 2 L	40 W, 2 Lamp	0.08
Incandescent, 2 L	50 W, 2 Lamp	0.1
Incandescent, 2 L	52 W, 2 Lamp	0.104
Incandescent, 2 L	54 W, 2 Lamp	0.108
Incandescent, 2 L	55 W, 2 Lamp	0.11
Incandescent, 2 L	60 W, 2 Lamp	0.12
Incandescent, 2 L	65 W, 2 Lamp	0.13
Incandescent, 2 L	67 W, 2 Lamp	0.134
Incandescent, 2 L	75 W, 2 Lamp	0.15
Incandescent, 2 L	90 W, 2 Lamp	0.18
Incandescent, 2 L	95 W, 2 Lamp	0.19
Incandescent, 2 L	100 W, 2 Lamp	0.2
Incandescent, 2 L	120 W, 2 Lamp	0.24

Incandescent, 2 L	135 W, 2 Lamp	0.27
Incandescent, 2 L	150 W, 2 Lamp	0.3
Incandescent, 2 L	200 W, 2 Lamp	0.4
Incandescent, 3 L	60 W, 3 Lamp	0.18
Incandescent, 3 L	67 W, 3 Lamp	0.201
Incandescent, 3 L	75 W, 3 Lamp	0.225
Incandescent, 3 L	90 W, 3 Lamp	0.27
Incandescent, 3 L	100 W, 3 Lamp	0.3
Incandescent, 4 L	25 W, 4 Lamp	0.1
Incandescent, 4 L	60 W, 4 Lamp	0.24
Incandescent, 4 L	75 W, 4 Lamp	0.3
Incandescent, 4 L	100 W, 4 Lamp	0.4
Incandescent, 5 L	60 W, 5 Lamp	0.3
Incandescent, 5 L	100 W, 5 Lamp	0.5
Induction	40 W	0.045
Induction	50 W	0.055
Induction	55 W	0.060
Induction	80 W	0.085
Induction	85 W	0.090
Induction	150 W	0.155
Induction	165 W	0.170
LED Strips, Center Strip	38 W, 5'	0.038
LED Strips, Center Strip	46 W, 6'	0.046
LED Strips, End Strip	19 W, 5'	0.019
LED Strips, End Strip	23 W, 6'	0.023
Low Bay LED	85 W	0.085

Lighting by Building Type

Building Type	EFLH	CF	IF
Education – Primary School	1,440	0.57	0.15
Education – Secondary School	2,305	0.57	0.15
Education – Community College	3,792	0.64	0.15
Education – University	3,073	0.64	0.15
Grocery	5,824	0.88	0.13
Medical – Hospital	8,736	0.72	0.18
Medical – Clinic	4,212	0.72	0.18
Lodging Hotel (Guest Rooms)	1,145	0.67	0.14
Lodging Motel	8,736	1.00	0.14
Manufacturing – Light Industrial	4,290	0.63	0.04
Office- Large	2,808	0.68	0.17
Office-Small	2,808	0.68	0.17
Restaurant – Sit-Down	4,368	0.76	0.15
Restaurant – Fast-Food	6,188	0.76	0.15
Retail – 3-Story Large	4,259	0.78	0.11
Retail – Single-Story Large	4,368	0.78	0.11
Retail – Small	4,004	0.78	0.11
Storage Conditioned	4,290	0.69	0.06
Storage Heated or Unconditioned	4,290	0.69	0.00
Warehouse	3,900	0.69	0.06
Average = Miscellaneous	4,242	0.72	0.13

Sources:

1. California Standard Performance Contracting Program
2. RLW Analytics, *Coincident Factor Study, Residential and Commercial & Industrial Lighting Measures*, 2007.
3. Quantum Consulting, Inc., for Pacific Gas & Electric Company , *Evaluation of Pacific Gas & Electric Company's 1997 Commercial Energy Efficiency Incentives Program: Lighting Technologies*", March 1, 1999
4. Quantum Consulting, Inc., for Pacific Gas & Electric Company , *Evaluation of Pacific Gas & Electric Company's 1997 Commercial Energy Efficiency Incentives Program: Lighting Technologies*", March 1, 1999
5. KEMA. *New Jersey's Clean Energy Program Energy Impact Evaluation and Protocol Review*. 2009.

Prescriptive Lighting

This is a fixture replacement program for existing commercial customers targeted for facilities performing efficiency upgrades to their lighting systems.

The baseline is existing T-12 fixtures with energy efficient lamps and magnetic ballast.

The baseline for compact fluorescent is that the fixture replaced was 4 times the wattage of the replacement compact fluorescent.

The baseline for LED fixtures is the actual fixture being replaced.

The baseline for induction lighting is an equivalent pulse start metal halide fixture (6).

The baseline for LED refrigerator Case Lighting is that the fixture replaced was 2.63 times the wattage of the replacement LED (7).

New fixtures and technologies available after publication will be periodically updated. Baselines will be established based on the guidelines noted below.

Algorithms

Demand Savings = (ΔkW) X (CF) X (1+ IF)

Energy Savings = (ΔkW) X (1 + IF) X (EFLH)

> ΔKW= (Number of fixtures installed X baseline wattage for new fixture) – (number of replaced fixtures X wattage from table)

For LED strip fixtures, the following protocols will be applied to account for the lighting and refrigeration energy savings associated with this measure.

Algorithms

Demand Savings = (ΔkW) X (CF) X (1+ IF) X (1 + (0.28 X Eff))

Energy Savings = (ΔkW) X (1 + IF) X EFLH X (1 + (0.28 X Eff))

Definition of Variables

ΔkW = Change in connected load from baseline to efficient lighting level.

CF = Coincidence Factor

EFLH = Equivalent Full Load Hours

IF = Interactive Factor

0.28 = Conversion from kW to tons (Refrigeration)

Eff = Efficiency of typical refrigeration system in kW/ton

Prescriptive Lighting for Commercial Customers

Component	Type	Value	Source
ΔkW	Fixed	See Lighting Wattage Table derived from California SPC Table at: (http://www.sce.com/NR/rdonlyres/FC51087D-2848-42DF-A52A-BDBA1A09BF8D/0/SCE_B_StandardFixtureWatts010108.pdf)	1
CF	Fixed	See Lighting Table by Building in Performance Lighting Section Above	2
EFLH	Fixed	See Lighting Table by Building in Performance Lighting Section Above	3
IF	Fixed	See Lighting Table by Building Type in Performance Lighting Section Above	4
Eff	Fixed	1.6	5

Sources & Notes:

1. California Standard Performance Contracting Program
2. RLW Analytics, *Coincident Factor Study, Residential and Commercial & Industrial Lighting Measures*, 2007.
3. Quantum Consulting, Inc., for Pacific Gas & Electric Company , *Evaluation of Pacific Gas & Electric Company's 1997 Commercial Energy Efficiency Incentives Program: Lighting Technologies*", March 1, 1999
4. Quantum Consulting, Inc., for Pacific Gas & Electric Company , *Evaluation of Pacific Gas & Electric Company's 1997 Commercial Energy Efficiency Incentives Program: Lighting Technologies*", March 1, 1999
5. Select Energy Services, Inc. *Cooler Control Measure Impact Spreadsheet User's Manual.* 2004.
6. For induction Lighting, used the lowest PSMH that would produce a 30% reduction in wattage to the induction fixture, which is the minimum requirement for incentives replacing HID with induction lighting. Assume 5% increase for input wattage vs nominal wattage.

7. Based on assuming LED is 62% more efficient than replacement as per RPI study: http://www.lrc.rpi.edu/programs/solidstate/pdf/SPIE4776-13_Raghavan.pdf

Lighting Controls

Lighting controls include occupancy sensors, daylight dimmer systems, and occupancy controlled hi-low controls for fluorescent, and HID fixtures. The measurement of energy savings is based on algorithms with key variables (i.e., coincidence factor, equivalent full load hours) provided through existing end-use metering of a sample of facilities or from other utility programs with experience with these measures (i.e., % of annual lighting energy saved by lighting control). For lighting controls, the baseline is a manual switch, based on the findings of the New Jersey Commercial Energy Efficient Construction Baseline Study.

Algorithms

Demand Savings = kW_c X SVG X CF X (1+ IF)

Energy Savings = kW_c X SVG X EFLH X (1+IF)

Definition of Variables

SVG = % of annual lighting energy saved by lighting control; refer to table by control type

kW_c = kW lighting load connected to control

IF = Interactive Factor – This applies to C&I interior lighting only. This represents the secondary demand and energy savings in reduced HVAC consumption resulting from decreased indoor lighting wattage. This value will be fixed at 5%.

CF = Coincidence Factor – This value represents the percentage of the total load which is on during electric system's peak window.

EFLH = Equivalent full load hours.

Lighting Controls

Component	Type	Value	Source
kW_c	Variable	Load connected to control	Application
SVG	Fixed	Occupancy Sensor, Controlled Hi-Low Fluorescent Control and controlled HID = 30% Daylight Dimmer System=50%	See sources below
CF	Fixed	See Lighting Table by Building in Performance Lighting Section Above	1
EFLH	Fixed	See Lighting Table by Building in Performance Lighting Section Above	2

Component	Type	Value	Source
IF	Fixed	See Lighting Table by Building in Performance Lighting Section Above	3

Sources:

1. RLW Analytics, *Coincident Factor Study, Residential and Commercial & Industrial Lighting Measures*, 2007.
2. Quantum Consulting, Inc., for Pacific Gas & Electric Company , *Evaluation of Pacific Gas & Electric Company's 1997 Commercial Energy Efficiency Incentives Program: Lighting Technologies*", March 1, 1999
3. Quantum Consulting, Inc., for Pacific Gas & Electric Company , *Evaluation of Pacific Gas & Electric Company's 1997 Commercial Energy Efficiency Incentives Program: Lighting Technologies*", March 1, 1999

Motors

For premium efficiency motors 1-200 HP.

Algorithms

From application form calculate ΔkW where:

$$\Delta kW = 0.746 * HP * IF_{VFD} * (1/\eta_{base} - 1/\eta_{prem})$$

Demand Savings = (ΔkW) X CF

Energy Savings = (ΔkW)*HRS * LF

Definition of Variables

ΔkW = kW Savings at full load

HP = Rated horsepower of qualifying motor, from nameplate/manufacturer specs.

LF = Load Factor, percent of full load at typical operating condition

IF_{VFD} = VFD Interaction Factor, 1.0 without VFD, 0.9 with VFD

η_{base} = Efficiency of the baseline motor

η_{prem} = Efficiency of the energy-efficient motor

HRS = Annual operating hours

CF = Coincidence Factor

Motors

Component	Type	Value	Source
HP	Variable	Nameplate/Manufacturer Spec. Sheet	Application
LF	Fixed	0.75	1
hp_{base}	Fixed	EPACT Baseline Efficiency Table	EPACT Directory
hp_{prem}	Variable	Nameplate/Manufacturer Spec. Sheet	Application
IF_{VFD}	Fixed	1.0 or 0.9	3
Efficiency - η_{ee}	Variable	Nameplate/Manufacturer Spec. Sheet	Application
CF	Fixed	0.74	1
HRS	Fixed	Annual Operating Hours Table	1

EPAct Baseline Motor Efficiency Table

Motor Horsepower	1200 RPM (6 pole)		1800 RPM (4 pole)		3600 RPM (2 pole)	
	ODP	TEFC	ODP	TEFC	ODP	TEFC
1	0.8	0.8	0.825	0.825	na	0.755
1.5	0.84	0.855	0.84	0.84	0.825	0.825
2	0.855	0.865	0.84	0.84	0.84	0.84
3	0.865	0.875	0.865	0.875	0.84	0.855
5	0.875	0.875	0.875	0.875	0.855	0.875
7.5	0.885	0.895	0.885	0.895	0.875	0.885
10	0.9002	0.895	0.895	0.895	0.885	0.895
15	0.902	0.902	0.91	0.91	0.895	0.902
20	0.91	0.902	0.91	0.91	0.902	0.902
25	0.917	0.917	0.917	0.924	0.91	0.91
30	0.924	0.917	0.924	0.924	0.91	0.91
40	0.93	0.93	0.93	0.93	0.917	0.917
50	0.93	0.93	0.93	0.93	0.924	0.924
60	0.936	0.936	0.936	0.936	0.93	0.93
75	0.936	0.936	0.941	0.941	0.93	0.93
100	0.941	0.941	0.941	0.945	0.93	0.936
125	0.941	0.941	0.945	0.945	0.936	0.945
150	0.945	0.95	0.95	0.95	0.936	0.945
200	0.945	0.95	0.95	0.95	0.945	0.95

*Note: For the Direct Install Program, different baseline efficiency values are used.

NEMA Premium Motor Efficiency Table

Motor Horsepower	1200 RPM (6 pole)		1800 RPM (4 pole)		3600 RPM (2 pole)	
	ODP	TEFC	ODP	TEFC	ODP	TEFC
1	0.825	0.825	0.855	0.855	0.77	0.77
1.5	0.865	0.875	0.865	0.865	0.84	0.84
2	0.875	0.885	0.865	0.865	0.855	0.855
3	0.885	0.895	0.895	0.895	0.855	0.865
5	0.895	0.895	0.895	0.895	0.865	0.885
7.5	0.902	0.91	0.91	0.917	0.885	0.895
10	0.917	0.91	0.917	0.917	0.895	0.902
15	0.917	0.917	0.93	0.924	0.902	0.91
20	0.924	0.917	0.93	0.93	0.91	0.91
25	0.93	0.93	0.936	0.936	0.917	0.917
30	0.936	0.93	0.941	0.936	0.917	0.917
40	0.941	0.941	0.941	0.941	0.924	0.924
50	0.941	0.941	0.945	0.945	0.93	0.93
60	0.945	0.945	0.95	0.95	0.936	0.936
75	0.945	0.945	0.95	0.954	0.936	0.936
100	0.95	0.95	0.954	0.954	0.936	0.941
100	0.95	0.95	0.954	0.954	0.941	0.95
150	0.954	0.958	0.958	0.958	0.941	0.95
200	0.954	0.958	0.958	0.962	0.95	0.954

Annual Operating Hours Table

Motor Horsepower	Operating Hours, HRS
1 to 5 HP	2,745
6 to 20 HP	3,391
21 to 50 HP	4,067
51 to 100 HP	5,329
101 to 200 HP	5,200

Electronically Commutated Motors for Refrigeration

This measure is applicable to existing walk-in, multi-deck and free standing coolers and freezers with shaded pole or permanent split capacitor (PSC) motors. These fractional horsepower motors are significantly more efficient than mechanically commutated, brushed motors, particularly at low speeds or partial load. By employing variable-speed technology, EC motors are able to optimize fan speeds for changing load requirements. Because these motors are brushless and utilize DC power, losses due to friction and phase shifting are eliminated. Calculations of savings for this measure take into account both the increased efficiency of the motor as well as the reduction in refrigeration load due to motor heat loss.

EC Motor retrofits in Walk-in Coolers and Freezers

Algorithms

$\Delta kW = ((Amps_{EF} * Volts_{EF} * (Phase_{EF})^{1/2})/1000) * PF_{EF} * LR65\%$

Gross kWh Savings = $kWh\ Savings_{EF} + kWh\ Savings_{RH}$

$kWh\ Savings_{EF} = ((Amps_{EF} * Volts_{EF} * (Phase_{EF})^{1/2})/1000) * PF_{EF} * \text{Operating Hours} * LR65\%$

$kWh\ Savings_{RH} = \text{kWh } Savings_{EF} * 0.28 * 1.6$

PLEASE NOTE:
*"$((Amps_{EF} * Volts_{EF} * (Phase_{EF})^{1/2})/1000) * PF_{EF}$" is equivalent to "HP * 0.746"*

Definition of Variables

ΔkW = Demand Savings due to EC Motor Retrofit

$kWh\ Savings_{EF}$ = Savings due to Evaporator Fan Motors being replaced

$kWh\ Savings_{RH}$ = Savings due to reduced heat from Evaporator Fans

$Amps_{EF}$ = Nameplate Amps of Evaporator Fan

$Volts_{EF}$ = Nameplate Volts of Evaporator Fan

$Phase_{EF}$ = Phase of Evaporator Fan

PF_{EF} = Evaporator Fan Power Factor

Operating Hours = Annual operating hours if Evaporator Fan Control

LR = Percent reduction of load by replacing motors

0.28 = Conversion from kW to tons (Refrigeration)

1.6 = Efficiency of typical refrigeration system in kW/ton

Case Motor Replacement

Algorithms

Gross kWh Savings = $kWh\ Savings_{CM} + kWh\ Savings_{RH}$

$kWh\ Savings_{CM}$ = kW * ER * RT8, 500

$kWh\ Savings_{RH}$ = kWh $Savings_{EF}$ * 0.28 * Eff

Definition of Variables

$kWh\ Savings_{CM}$= Savings due to Case Motors being replaced

$kWh\ Savings_{RH}$ = Savings due to reduced heat from Case Motors

kW = Metered load of Case Motors

ER = Energy reduction if a motor is being replaced

RT = Average runtime of Case Motors

0.28 = Conversion from kW to tons (Refrigeration)

Eff = Efficiency of typical refrigeration system in kW/ton

ECM Fraction HP Motors

Component	Type	Value	Source
$Amps_{EF}$	Variable	Nameplate/Manufacturer Spec. Sheet	Application
$Volts_{EF}$	Variable	Nameplate/Manufacturer Spec. Sheet	Application
$Phase_{EF}$	Variable	Nameplate/Manufacturer Spec. Sheet	Application
PF_{EF}	Fixed	0.55	1
Operating Hours	Fixed	Not Installed = 8,760 Installed = 5,600	
LR	Fixed	65%	2
ER	Fixed	Shaded Pole Motor Replaced = 53% PSC Motor Replaced = 29%	3
RT	Fixed	8500	
Eff	Fixed	1.6	

Sources:

1. Select Energy Services, Inc. *Cooler Control Measure Impact Spreadsheet User's Manual.* 2004.
2. This value is an estimate by NRM based on several pre and post meter readings of installations. This is supported by RLW report for National Grid, "Small Business Services, Custom Measure Impact Evaluation", March 23, 2007.
3. Based on numerous pre and post-meterings conducted by NRM.

Electric HVAC Systems

The measurement of energy and demand savings for C/I Efficient HVAC program for Room AC, Central AC, and air cooled DX is based on algorithms. (Includes split systems, air to air heat pumps, packaged terminal systems, water source heat pumps, central DX AC systems, ground water or ground source heat pumps)

Algorithms

Air Conditioning Algorithms:

Demand Savings = (BtuH/1000) X ($1/EER_b$-$1/EER_q$) X CF

Energy Savings = (BtuH/1000) X ($1/EER_b$-$1/EER_q$) X EFLH

Heat Pump Algorithms

Energy Savings-Cooling = ($BtuH_c$/1000) X ($1/EER_b$-$1/EER_q$) X $EFLH_c$

Energy Savings-Heating = $BtuH_h$/1000 X ((1/ (COP_b X 3.412))-(1/ (COP_q X 3.412))) X $EFLH_h$

Where $_c$ is for cooling and $_h$ is for heating.

Definition of Variables

BtuH = Cooling capacity in Btu/Hour – This value comes from ARI/AHRI or AHAM rating or manufacturer data.

COP_b = Coefficient of Performance of the baseline unit. This data is found in the HVAC and Heat Pump verification summary table. For units < 65,000, SEER and HSPF/3.412 should be used for cooling and heating savings, respectively.

COP_q = Coefficient of Performance of the High Efficiency unit – This value comes from the ARI/AHRI or AHAM directories or manufacturer data. For units < 65,000, SEER and HSPF/3.412 should be used for cooling and heating savings, respectively.

CF = Coincidence Factor – This value represents the percentage of the total load which is on during electric system's Peak Window. This value will be based on existing measured usage and determined as the average number of operating hours during the peak window period.

EFLH = Equivalent Full Load Hours – This represents a measure of energy use by season during the on-peak and off peak periods. This value will be determined by existing measured data of kWh during the period divided by kW at design conditions.

HVAC and Heat Pumps

Component	Type	Value	Source
BtuH	Variable	ARI/AHRI or AHAM or Manufacturer Data	Application
EER_b	Variable	See Table below	Collaborative agreement and C/I baseline study
EER_q	Variable	ARI/AHRI or AHAM Values	Application
CF	Fixed	67%	Engineering estimate
EFLH	Fixed	HVAC 1,131 HP cooling 381 HP heating 800	JCP&L metered data[11]

HVAC Baseline Table

Equipment Type	Baseline = ASHRAE Std. 90.1 - 2007
Unitary HVAC/Split Systems, Air Cooled · <=5.4 tons: · >5.4 to 11.25 tons · >11.25 to 20 tons .> 21 to 63 tons >63 Tons	 13 SEER 11 EER 10.8 EER 9.8 EER 9.5 EER
Air-Air Heat Pump Systems · <=5.4 tons: · >5.4 to 11.25 tons · >11.25 to 20 tons .>= 21	 13 SEER 10.8 EER 10.4 EER 9.3 EER
Package Terminal Systems < 0.74 tons .75 – 1 ton > 1 ton	 12.5-(0.213*BTUHc/1000)
Water Source Heat Pumps All Capacities	 12.0 EER
GWSHPs Open and Closed Loop All Capacities	 16.2 EER

Baseline heat pump efficiency in heating mode must be based on ASHRAE 90.1-2007 table 6.8.1 B

[11] Results reflect metered use from 1995 – 1999.

Fuel Use Economizers

Algorithms
Electric Savings (kWh) = (AEU * 0.13)

Definition of Variables
AEU = Annual Electric Usage for an uncontrolled AC or refrigeration unit (kWh) = (Input power in kW) * (annual run time)
0.13 = Approximate energy savings factor related to installation of fuel use economizers

Sources:

1. Approximate energy savings factor of 0.13 based on average % savings for test sites represented in Table 2 (page 3) of NYSERDA Study: A Technology Demonstration and Validation Project for Intellidyne Energy Saving Controls; Intellidyne LLC & Brookhaven National Laboratories; 2006 (http://www.cleargreenpartners.com/attachments/File/NYSERDA_Report.pdf)

Dual Enthalpy Economizers

Algorithms

Energy Savings (kWh) = OTF*SF*Cap/Eff

Demand Savings (kW) = Savings/Operating Hours

Definition of Variables

OTF = Operational Testing Factor

SF = Approximate savings factor based on regional temperature bin data (assume 4576 for equipment under 5.4 tons where a fixed damper is assumed for the baseline and 3318 for larger equipment where a dry bulb economizer is assumed for the baseline). (Units for savings factor are in kWh x rated EER per ton of cooling or kWh*EER/Ton)

Cap = Capacity of connected cooling load (tons)

Eff = Cooling equipment energy efficiency ratio (EER)

Operating Hours = 4,438 = Approximate number of economizer operating hours

Dual Enthalpy Economizers

Component	Type	Value	Source
OTF	Fixed	1.0 when operational testing is performed, 0.8 otherwise	
SF		4576 for equipment under 5.4 tons, 3318 otherwise	1
Cap	Variable		Application
Eff	Variable		Application
Operating Hours	Fixed	4,438	2

Sources:
1. DOE-2 Simulation Modeling
2. ClimateQuest Economizer Savings Calculator

Electric Chillers

The measurement of energy and demand savings for C&I Chillers program is based on algorithms with key variables (i.e., kW/ton, Coincidence Factor, Equivalent Full Load Hours) measured through existing end-use metering of a sample of facilities.

Algorithms

For IPLV:

Demand Savings = Tons PDC X ($IPLV_b$ – $IPLV_q$)

Energy Savings = Tons X EFLH X ($IPLV_b$ – $IPLV_q$)

For FLV:

Demand Savings = Tons PDC X (FLV_b – FLV_q)

Energy Savings = Tons X EFLH X (FLV_b – FLV_q)

Definition of Variables

Tons = Rated equipment cooling capacity

EFLH = Equivalent Full Load Hours – This represents a measure of chiller use by season determined by measured kWh during the period divided by kW at design conditions from JCP&L measurement data.

PDC = Peak Duty Cycle: fraction of time the compressor runs during peak hours

$IPLV_b$ = Integrated Part Load Value of baseline equipment, kW/Ton. The efficiency of the chiller under partial-load conditions.

$IPLV_q$ = Integrated Part Load Value of qualifying equipment, kW/Ton. The efficiency of the chiller under partial-load conditions.

FLV_b = Full Load Value of baseline equipment, kW/Ton. The efficiency of the chiller under full-load conditions.

FLV_q = Full Load Value of qualifying equipment, kW/Ton. The efficiency of the chiller under full-load conditions.

Electric Chillers

Component	Type	Situation	Value	Source
$IPLV_b$ (kW/ton)	Fixed	Air Cooled with Condenser (All)	1.153	ASHRAE 90.1-2007
		Air Cooled w/o Condenser (All)	1.019	
		Water Cooled, reciprocating	0.696	ASHRAE 90.1-2007
		Water Cooled (<150 tons)	0.676	ASHRAE 90.1-2007
		Water Cooled (151 to 300 tons)	0.628	
		Water Cooled, screw/scroll (>300 tons)	0.572	ASHRAE 90.1-2007
		Water Cooled, centrifugal (<150 tons)	0.670	ASHRAE 90.1-2007
		Water Cooled, centrifugal (>=150 tons to 300 tons)	0.596	ASHRAE 90.1-2007
		Water Cooled, centrifugal >300 tons)	0.549	ASHRAE 90.1-2007
FLV_b (kW/ton)	Fixed	Air Cooled with Condenser (All)	1.256	ASHRAE 90.1-2007
		Air Cooled w/o Condenser (All)	1.135	ASHRAE 90.1-2007
		Water Cooled, reciprocating	0.837	ASHRAE 90.1-2007
		Water Cooled (<150 tons)	0.790	ASHRAE 90.1-2007
		Water Cooled (151 to 300 tons)	0.718	ASHRAE 90.1-2007
		Water Cooled, screw/scroll (>300 tons)	0.639	ASHRAE 90.1-2007
		Water Cooled, centrifugal (<150 tons)	0.7034	ASHRAE 90.1-2007
		Water Cooled, centrifugal (>=150 tons to 300 tons)	0.634	ASHRAE 90.1-2007
		Water Cooled, centrifugal >300 tons)	0.577	ASHRAE 90.1-2007
Tons	Variable	All	Varies	From Application
$IPLV_q$ (kW/ton)	Variable	All	Varies	From Application (per AHRI Std. 550/590)
PDC	Fixed	All	67%	Engineering Estimate
EFLH	Fixed	All	1,360	California DEER

Variable Frequency Drives

The measurement of energy and demand savings for C/I Variable Frequency Drive for VFD applications is for constant and variable air volume system HVAC fans, water pumps, boiler feed water pumps and draft fans only. VFD applications for other than this use should follow the custom path.

Algorithms

Energy Savings (kWh) = 0.746*HP*HRS*(ESF/η_{motor})

Demand Savings (kW) = 0.746*HP*(DSF/η_{motor})

Definitions of Variables

HP = nameplate motor horsepower or manufacturer spec. sheet per application

η_{motor} = Motor efficiency at the peak load. Motor efficiency varies with load. At low loads relative to the rated hp (usually below 50%) efficiency often drops dramatically.

ESF = Energy Savings Factor. The energy savings factor is calculated by determining the ratio of the power requirement for baseline and VFD control at peak conditions.

DSF = Demand Savings Factor. The demand savings factor is calculated by determining the ratio of the power requirement for baseline and VFD control at peak conditions

HRS = annual operating hours

Variable Frequency Drives

Component	Type	Value	Source
Motor HP	Variable	Nameplate/Manufacturer Spec. Sheet	Application
η_{motor}	Variable	Nameplate/Manufacturer Spec. Sheet	Application
ESF	Variable	See Table Below	Connecticut Light and Power
DSF	Variable	See Table Below	Connecticut Light and Power
HRS	Variable	>2,000	Application

VFD Savings Factors

Component	Energy Savings Factor, ESF	Demand Savings Factor, DSF
Airfoil/Backward Inclined Fans	0.475	0.448
Forward Curved Fans	0.240	0.216
Chilled Water Pumps	0.580	0.201
Cooling Tower Fans	0.580	0.000

Air Compressors with Variable Frequency Drives
The measurement of energy and demand savings for variable frequency drive (VFD) air compressors.

Algorithms

Energy Savings (kWh) = HRS*(Maximum kW/HP Savings)*Motor HP

Demand Savings (kW) = PDC*(Maximum kW/HP Savings)*Motor HP

Maximum kW/HP Savings = Percent Energy Savings * (0.746 / EFF_b)

Definitions of Variables

HRS = Annual compressor runtime (hours) from application.

PDC = Peak Duty Cycle: fraction of time the compressor runs during peak hours

EEF_b = Efficiency of the industry standard compressor at average load

0.746 = kW to HP conversion factor

Air Compressors with VFDs

Component	**Type**	**Value**	**Source**
Motor HP	Variable	Nameplate	Application
Maximum kW/HP Savings	Fixed	0.274	Calculated
PDC	Fixed	0.865	1
HRS	Fixed	4957	2
Percent Energy Savings	Fixed	22%	3
EEF_b	Fixed	0.60	3

Sources:

1. Aspen Systems Corporation, *Prescriptive Variable Speed Drive Incentive Program Support for Industrial Air Compressors*, June 20, 2005.
2. Xenergy, *Assessment of the Market for Compressed Air Efficiency Systems*. 2001.
3. ACEEE, *Modeling and Simulation of Air Compressor Energy Use*. 2005.

New and Retrofit Kitchen Hoods with Variable Frequency Drives

Kitchen Hoods with Variable Frequency Control utilize optical and temperature sensors at the hood inlet to monitor cooking activity. Kitchen hood exhaust fans are throttled in response to real time ventilation requirements. Energy savings result from fan power reduction during part load operation as well as a decrease in heating and cooling requirement of make-up air.

Algorithms

Electric Fan Savings (kWh) = Q*(HP*LF*0.746/FEFF)*RH*PR

Heating Savings (MMBtu) = SF*CFM/SF*OF*FR*HDD*24*1.08/(HEFF*1000000)

Cooling Savings (kWh) = SF*CFM/SF*OF*FR*CDD*24*1.08/ (CEFF*3412)

Definition of Variables

Q=Quantity of Kitchen Hood Fan Motors

HP = Kitchen Hood Fan Motor HP

LF = Existing Motor Loading Factor

0.746 = Conversion from HP to kW

FEFF = Efficiency of Kitchen Hood Fan Motors (%)

RH = Kitchen Hood Fan Run Hours

PR = Fan Motor Power Reduction resultant from VFD/Control Installation

SF = Kitchen Square Footage

CFM/SF = Code required ventilation rate per square foot for Commercial Kitchen spaces

OF = Ventilation rate oversize factor (compared to code requirement)

FR = Flow Reduction resultant from VFD/Control Installation

HDD_{mod} = Modified Heating Degree Days based on location and facility type

CDD_{mod} = Modified Cooling Degree Days based on location and facility type

24 = Hours per Day

1.08 = Sensible heat factor for air ((Btu/hr)/(CFM *Deg F))

HEFF = Efficiency of Heating System (AFUE %)

CEFF = Efficiency of Cooling System (COP)

3412 = Conversion factor from Btu to kWh (3412 Btu = 1 kWh)

1000000 = Btu/MMBtu

Kitchen Hoods with VFDs

Component	**Type**	**Value**	**Source**
Q	Variable	Quantity	Application
HP	Variable	Nameplate	Application
LF	Fixed	0.9	Melink Analysis Sample[1]
FEFF	Variable	Based on Motor HP	NEMA Premium Efficiency, TEFC 1800 RPM
RH	Variable	Based on Facility Type	Facility Specific Value Table
PR	Variable	Based on Facility Type	Facility Specific Value Table
SF	Variable	Kitchen Square Footage	Application
CFM / SF	Fixed	0.7	ASHRAE 62.1 2007 Table 6.4
OF	Fixed	1.4	Estimated Typical Kitchen Design[2]
FR	Variable	Based on Facility Type	Facility Specific Value Table
HDD_{mod}	Variable		Heating Degree Day Table
CDD_{mod}	Variable		Cooling Degree Day Table
HEFF	Fixed	0.8	ASHRAE 90.1 2007 Table 6.81F[3]
CEFF	Fixed	3.00	Estimated Cooling System Efficiency[4]

Facility-Specific Values Table[5]

Facility Type	**Run Hours**	**Power Reduction (PR)**	**Flow Reduction (FR)**
Campus	5250	0.568	0.295
Lodging	8736	0.618	0.330
Restaurant	5824	0.552	0.295
Supermarket	5824	0.597	0.320
Other	5250	0.584	0.310

Modified Heating Degree Days Table[6]

Building Type	Heating Energy Density (kBtu/sf)	Degree Day Adjustment Factor	Atlantic City (HDD)	Newark (HDD)	Philadelphia (HDD)	Monticello (HDD)
Education	29.5	0.55	2792	2783	2655	3886
Food Sales	35.6	0.66	3369	3359	3204	4689
Food Service	39.0	0.73	3691	3680	3510	5137
Health Care	53.6	1.00	5073	5057	4824	7060
Lodging	15.0	0.28	1420	1415	1350	1976
Retail	29.3	0.55	2773	2764	2637	3859
Office	28.1	0.52	2660	2651	2529	3701
Public Assembly	33.8	0.63	3199	3189	3042	4452
Public Order/Safety	24.1	0.45	2281	2274	2169	3174
Religious Worship	29.1	0.54	2754	2745	2619	3833
Service	47.8	0.89	4524	4510	4302	6296
Warehouse/Storage	20.2	0.38	1912	1906	1818	2661

Modified Cooling Degree Days Table[7]

Building Type	Degree Day Adjustment Factor	Atlantic City (CDD)	Newark (CDD)	Philadelphia (CDD)	Monticello (CDD)
Education	0.55	824	893	806	625
Food Sales	0.66	989	1071	967	750
Food Service	0.73	1094	1185	1069	830
Health Care	1.00	1499	1623	1465	1137
Lodging	0.28	420	454	410	318
Retail	0.55	824	893	806	625
Office	0.52	779	844	762	591
Public Assembly	0.63	944	1022	923	716
Public Order/Safety	0.45	675	730	659	512
Religious Worship	0.54	809	876	791	614
Service	0.89	1334	1444	1304	1012
Warehouse/Storage	0.38	570	617	557	432

Sources

1. To assist with development of this protocol, Melink Corporation provided several sample analyses performed on typical facilities utilizing Intelli-Hood control systems. The analysis performed is used nationwide by Melink to develop energy savings and financial reports related to installation of these systems for interested building owners. Melink's analysis is mirrored in this protocol and includes several of the assumed values utilized here, including an average 0.9 load factor on hood fan motors, as well as operating hours for typical campus, lodging, restaurant and supermarket facility types.
2. Oversize factor of 1.4 is a best estimate based on past experience, assessments conducted at facilities with commercial food service equipment and approximations based on Melink sample analyses, which lead to average commercial kitchen ventilation rate of 1 CFM/SF (0.7 * 1.4). While exact ventilation rate is dependent on installed equipment and other factors, this figure is meant to represent average ventilation across potential retrofit and new installation projects.

3. A typical heating system efficiency of 80% AFUE is assumed based on estimates of average facility size, heating system age, and past and present code requirements, as well as assumptions indicated in Melink sample analyses. This figure is meant to represent average heating system efficiency across potential retrofit and new installation projects.
4. A typical cooling system efficiency of 3.00 COP (10.24 EER, 1.17 kW/Ton) is assumed based on estimates of average facility size, cooling system age, and past and present code requirements, as well as assumptions indicated in Melink sample analyses. This figure is meant to represent average cooling system efficiency across potential retrofit and new installation projects.
5. Facility Specific Values table constructed based on consolidation of Melink sample analysis data. Facility run hours were averaged across all like sample analyses. Fan power and flow reductions were calculated utilizing fan power profiles included in each sample analysis.
6. KEMA, *Smartstart Program Protocol Review*. 2009.
7. Modified Cooling Degree Days table utilizes Degree Day Adjustment factors from Heating Degree Days table and cooling degree days for each of the four representative cities as indicated by degreedays.net.

Commercial Refrigeration Measures

For Aluminum Night Curtains, Door Heater Controls, Electric Defrost Controls, Evaporator Fan Controls, and Novelty Cooler Shutoff, see applicable protocols for the commercial Direct Install program.

For Energy Efficient Doors for Open Refrigerated Cases:

<u>Algorithms</u>

Demand Savings: $\Delta kW = (HG \times EF \times CL) / (EER \times 1000)$

Annual Energy Savings: $\Delta kWh = \Delta kW \times Usage$

Definition of Terms

ΔkW = gross customer connected load kW savings for the measure (kW)

HG = Loss of cold air or heat gain for refrigerated cases with no cover (Btu/hr-ft opening)

EF = Efficiency Factor, fraction of heat gain prevented by case door

CL = Case Length, open length of the refrigerated case in feet (from application)

EER = Compressor efficiency (Btu/hr-watt)

1000 = Conversion from watts to kW (W/kW).

ΔkWh = gross customer annual kWh savings for the measure (kWh)

Usage = hours per year

Commercial Refrigeration

Component	Type	Value	Source
HG	Fixed	760	PG&E study by ENCON Mechanical & Nuclear Engineering, 1992
EF	Fixed	0.85	PG&E study by ENCON Mechanical & Nuclear Engineering, 1992
CL	Variable		Rebate Application or Manufacturer Data
EER	Fixed	9.0	Average based on custom applications for the NJCEP C&I Program in 2010
Usage	Fixed	8760	365 days/year, 24 hours/day

Commercial Refrigerators and Freezers

This measure is applicable to replacement of existing commercial grade refrigerators and freezers with energy efficient glass and solid door units complying with ANSI/ASHRAE Standard 72-2005, Method of Testing Commercial Refrigerators and Freezers. The measurement of energy savings for this measure is based on algorithms with key variables provided by manufacturer data or prescribed herein.

Algorithms

Annual Energy Savings (kWh) = $D*(E_b - E_q)$

Demand Savings (kW) = kWh Savings/ (D*H)

Definition of Variables

D = Operating Days per Year (assume 365)
H = Daily Operating Hours (assume 24)
E_b = Daily kWh Consumption of Baseline Equipment (from Table 1 below)
E_q = Daily kWh Consumption of Qualifying Equipment (from Application)

Table 1: Baseline Equipment Daily kWh Consumption	
Proposed Equipment Type	***kWh Consumption (V = Unit Volume in ft^3)***
Glass Door Freezer	0.75V + 4.1
Glass Door Refrigerator	0.12V + 3.34
Solid Door Freezer	0.4V + 1.38
Solid Door Refrigerator	0.1V + 2.04

Source
Savings algorithm, baseline values, assumed values and lifetimes developed from information on the Food Service Technology Center program's website, www.fishnick.com, by Fisher-Nickel, Inc. and funded by California utility customers and administered by Pacific Gas and Electric Company under the auspices of the California Public Utility Commission.

Commercial Ice Machines

This measure is applicable to replacement of existing ice makers with energy efficient, air-cooled ice machines tested in accordance with ARI Standard 810. The measurement of energy savings for this measure is based on algorithms with key variables provided by manufacturer data or prescribed herein.

Algorithms

Annual Energy Savings (kWh) = D*DC*(IHR/100)*(E_b – E_q)

Demand Savings (kW) = kWh Savings/(D*24*DC)

Definition of Variables

D = Operating Days per Year (assume 365)
DC = Duty Cycle, defined as Ice Harvest Rate/Actual Daily Ice Production (assume 75%)
IHR = Proposed Equipment Ice Harvest Rate in lbs/day (from Application)
E_b = kWh Consumption of Baseline Equipment in kWh/100 lbs (from Table 1 below)
E_q = kWh Consumption of Qualifying Equipment in kWh/100 lbs (from Application)
24 = Hours per Day

Table 1: Baseline Energy Consumption	
Ice Harvest Rate (lbs/day)	***Baseline Energy Consumption (kWh/100 lbs)***
0-100	18.0
101-200	16.0
201-300	11.0
301-400	8.5
401-500	7.6
501-1000	6.9
1001-1500	6.4
1501	6.1

Source

Savings algorithm, baseline values, assumed values and lifetimes developed from information on the Food Service Technology Center program's website, www.fishnick.com, by Fisher-Nickel, Inc. and funded by California utility customers and administered by Pacific Gas and Electric Company under the auspices of the California Public Utility Commission.

Commercial Dishwashers

This measure is applicable to replacement of existing dishwashers with energy efficient under counter, door type, single-rack and multi-rack conveyor machines testing in accordance with NSF/ANSI 3-2007, ASTM F1696, and ASTM F1920 standards. The measurement of energy savings for this measure is based on algorithms with key variables provided by manufacturer data or prescribed herein.

Algorithms

Annual Energy Savings (kWh or Therms) = $E_{Build} + E_{Boost} + E_{Idle}$

Demand Savings (kW) = kWh Savings/8760

Note: Depending on water heating system configuration (e.g. gas building water heater with electric booster water heater), annual energy savings may be reported in both therms and kWh.

Definition of Variables

E_{Build} = Annual Building Water Heater Energy Savings, in kWh or Therms (from tables below)
E_{Boost} = Annual Booster Water Heater Energy Savings, in kWh or Therms (from tables below)
E_{Idle} = Annual Dishwasher Idle Energy Savings, in kWh (from tables below)
8760 = Hours per Year

Table 1: Low Temperature Dishwasher Savings

Dishwasher Type	Electric Building Water Heater Savings (kWh)	Gas Building Water Heater Savings (Therms)	Electric Booster Water Heater Savings (kWh)	Gas Booster Water Heater Savings (Therms)	Idle Energy Savings (kWh)
Under Counter	1,213	56.2	0	0.0	0
Door Type	12,135	562.1	0	0.0	0
Single Tank Conveyor	11,384	527.3	0	0.0	0
Multi Tank Conveyor	17,465	809.0	0	0.0	0

Table 2: High Temperature Dishwasher Savings					
Dishwasher Type	Electric Building Water Heater Savings (kWh)	Gas Building Water Heater Savings (Therms)	Electric Booster Water Heater Savings (kWh)	Gas Booster Water Heater Savings (Therms)	Idle Energy Savings (kWh)
Under Counter	4,754	220.2	2,717	110.1	0
Door Type	8,875	411.1	5,071	205.5	198
Single Tank Conveyor	11,126	515.3	6,358	257.7	1,752
Multi Tank Conveyor	21,734	1,006.7	12,419	503.3	0

Source

Savings algorithm, baseline values, assumed values and lifetimes developed from information on the Food Service Technology Center program's website, www.fishnick.com, by Fisher-Nickel, Inc. and funded by California utility customers and administered by Pacific Gas and Electric Company under the auspices of the California Public Utility Commission and from the *Savings Calculator for ENERGY STAR Qualified Commercial Kitchen Equipment*.

C&I Construction Gas Protocols

For measures installed as part of the Direct Install program, different baselines will be utilized to estimate savings as defined further in the Direct Install section of these Protocols.

The following fuel conversions will be used to calculate energy savings for propane and oil equipment for all eligible C&I programs including C&I Construction, Direct Install, and Pay for Performance.

1 therm of gas = 1.087 gal of propane = 0.721 gal of #2 oil

1 therm = 100,000 Btu
1 gal of propane = 92,000 Btu
1 gal of #2 oil = 138,700 Btu

Gas Chillers

The measurement of energy savings for C&I gas fired chillers and chiller heaters is based on algorithms with key variables (i.e., Equivalent Full Load Hours, Vacuum Boiler Efficiency, Input Rating, Coincidence Factor) provided by manufacturer data or measured through existing end-use metering of a sample of facilities.

Algorithms

Winter Gas Savings = $(VBE_q - BE_b)/VBE_q$ X IR X EFLH

Electric Demand Savings = Tons X $(kW/Ton_b - kW/Ton_{gc})$ X CF

Electric Energy Savings = Tons X $(kW/Ton_b - kW/Ton_{gc})$ X EFLH

Summer Gas Usage (MMBtu) = MMBtu Output Capacity / COP X EFLH

Net Energy Savings = Electric Energy Savings + Winter Gas Savings – Summer Gas Usage

Definition of Terms

VBE_q = Vacuum Boiler Efficiency

BE_b = Efficiency of the baseline gas boiler

IR = Input Rating = Therms/hour

Tons = The capacity of the chiller (in tons) at site design conditions accepted by the program.

kW/Ton_b = The baseline efficiency for electric chillers, as shown in the Gas Chiller Verification Summary table below.

kW/Ton_{gc} = Parasitic electrical requirement for gas chiller.

COP = Efficiency of the gas chiller

MMBtu Output Capacity = Cooling Capacity of gas chiller in MMBtu.

CF = Coincidence Factor. This value represents the percentage of the total load that is on during electric system peak.

EFLH = Equivalent Full Load Hours. This represents a measure of chiller use by season.

Gas Chillers

Component	Type	Value	Source
VBE_q	Variable		Rebate Application or Manufacturer Data
BE_b	Fixed	75%	ASHRAE 90.1-2004
IR	Variable		Rebate Application or Manufacturer Data
Tons	Variable		Rebate Application
MMBtu	Variable		Rebate Application
kW/Ton_b	Fixed	<100 tones 1.25 kW/ton **100 to < 150 tons** 0.703 kW/ton **150 to <300 tons:** 0.634 kW/Ton **300 tons or more:** 0.577 kW/ton	Collaborative agreement and C/I baseline study Assumes new electric chiller baseline using air cooled unit for chillers less than 100 tons; water cooled for chillers greater than 100 tons
kW/Ton_{gc}	Variable		Manufacturer Data
COP	Variable		Manufacturer Data

Component	Type	Value	Source
CF	Fixed	67%	Engineering estimate
EFLH	Fixed	1,360	JCP&L Measured data[12]

Variable data will be captured on the application form or from manufacturer's data sheets and collaborative/utility studies.

For certain fixed components, studies and surveys developed by the utilities in the State or based on a review of manufacturer's data, other utilities, regulatory commissions or consultants' reports will be used to update the values for future filings.

Gas Fired Desiccants

Gas-fired desiccant systems employ a desiccant wheel (a rotating disk filled with a dry desiccant such as silica gel, titanium gel, or dry lithium chloride) which adsorbs outside air moisture, reducing the air's latent heat content. This air is then conditioned by the building's cooling system, before being delivered to the occupied space. By reducing the relative humidity of the air, the operating temperature of the building can be increased, as comfort levels are maintained at higher temperatures when air moisture content is decreased. Electric savings are realized from a reduction in the required cooling load as a result of decreased humidity.

In order to maintain the usefulness of the desiccant (to keep it dry) hot air must be passed through the desiccant that has been used to remove moisture from the outside air. To supply this hot air, a gas-fired heater is employed to heat "regeneration" air, which picks up moisture from the saturated desiccant and exhausts it to the outside. As a result, in addition to electric benefits, these systems will also incur a natural gas penalty.

Electric savings and natural gas consumption will vary significantly from system to system depending on regional temperature and humidity, facility type, occupancy, site processes, desiccant system design parameters, ventilation requirements and cooling load and system specifications. Due to the multitude of site and equipment specific factors, along with the relative infrequency of these systems, gas-fired desiccant systems will be treated on a case-by-case basis.

Gas Booster Water Heaters

C&I gas booster water heaters are substitutes for electric water heaters. The measurement of energy savings is based on engineering algorithms with key variables (i.e., Input Rating Coincidence Factor, Equivalent Full Load Hours) provided by manufacturer data or measured through existing end-use metering of a sample of facilities.

[12] Results reflect metered use from 1995 – 1999.

Algorithms

Demand Savings (kW) = IR X EFF/3412 X CF

Energy Savings (kWh) = IR X EFF/3412 X EFLH

Gas Usage Increase = IR X EFLH

Net Energy Savings = Electric Energy Savings – Gas Usage Increase
(Calculated in MMBtu)

Definition of Variables

IR = Input Rating in Btuh

EFF = Efficiency

CF = Coincidence Factor

EFLH = Equivalent Full Load Hours

The 3412 used in the denominator is used to convert Btus to kWh.

Gas Booster Water Heaters

Component	Type	Value	Source
IR	Variable		Application Form or Manufacturer Data
CF	Fixed	30%	Summit Blue NJ Market Assessment
EFLH	Fixed	1,000	PSE&G
EF	Variable		Application Form or Manufacturer Data

Water Heaters

This prescriptive measure targets solely the use of smaller-scale domestic water heaters (50 gallons or less per unit) in all commercial facilities. Larger gas water heaters are treated under the custom measure path. The measurement of energy savings for C&I gas water heaters is based on algorithms with key variables (i.e., energy factor) provided by manufacturer data.

Algorithms

Gas Savings = $((EFF_q - EFF_b)/EFF_q)$ X Energy Use Density X (Area)

Definition of Variables

EFF_q = Efficiency of the qualifying energy efficient water heater.

EFF_b = Efficiency of the baseline water heater.

Area = Square feet served by the water heater

Water Heaters

Component	Type	Value	Source
EFF_q	Variable		Application
EFF_b	Fixed	<50 gal or <75,000 Btu/h: EF >50 gal or >75,000 Btu/h: TE EF = Energy Factor TE = Thermal Efficiency	From ASHRAE 90.1 2007
Energy Use Density	Variable	See Table Below	1
Fluid Capacity	Variable		Application

Energy Use Density Lookup Table

Building Type	Energy Use Density (kBtu/SF/yr)
Education	5.2
Food Sales	3.2
Food Service	40.0
Health Care	28.9
- Inpatient	39.4
- Outpatient	3.5
Lodging	29.2
Retail (Other Than Mall)	1.0
Office	1.6
Public Assembly	0.9
Public Order and Safety	15.1
Religious Worship	0.9
Service	0.9
Warehouse and Storage	0.7
Other	1.7

Sources

1. Energy Information Administration, *Commercial Building Energy Consumption Survey*. 2003.

Furnaces and Boilers

This prescriptive measure targets the use of smaller-scale boilers (less than or equal to 4000 MBH) and furnaces (no size limitation) in all commercial facilities. Larger sized boilers are treated under the custom measure path. The measurement of energy savings for C&I gas, oil, and propane fired furnaces and boilers is based on algorithms with key variables (i.e. Annual Fuel Utilization Efficiency, capacity of the furnace, EFLH) provided by manufacturer data or utility data. Savings are calculated for four zones throughout the state by heating degree days and for twelve different building types.

Infrared Heaters

Opportunities to target replacement of existing unit heater equipment with gas or propane infrared heating is an available measure under the Direct Install Program.

Algorithms

$$Gas\ Savings\ (Therms) = \left[\frac{OF \times HDD_{mod} \times 24 \times \left(\left(CAPY_{B.out} \times AFUE_q\right) - \left(CAPY_{Q.out} \times AFUE_b \times ICF\right)\right)}{\Delta T \times HC_{fuel} \times AFUE_b \times AFUE_q \times ICF}\right]$$

Definition of Variables

OF = Oversize factor of standard heater (OF=0.8)

$CAPY_{B.out}$ = Total output capacity of the baseline heater(s) in Btu/hour

$AFUE_Q$ = Efficiency of qualifying heater(s) (AFUE %)

$CAPY_{Q.out}$ = Total output capacity of the qualifying heater(s) in Btu/hour

$AFUE_B$ = Efficiency of baseline heaters (AFUE %)

ICF = Infrared Compensation Factor (ICF = 0.8 for IR Heaters)

HDD_{mod} = HDD by zone and building type

24 = Hours/Day

ΔT = design temperature difference

HC_{fuel} = Conversion from Btu to Therms of gas (100,000 Btu/Therm)

Furnaces and Boilers

Component	Type	Value	Source
$AFUE_q$	Variable		Application
$AFUE_b$	Fixed	Furnaces: 78% Boilers: 80% Infrared: 78%	EPACT Standard for furnaces and boilers
$CAPY_{in}$	Variable		Application
ΔT	Variable	See Table Below	1
HDD_{mod}	Fixed	See Table Below	1

Sources:

1. KEMA, *Smartstart Program Protocol Review*. 2009.
2. http://www.spaceray.com/1_space-ray_faqs.php

Adjusted Heating Degree Days by Building Type

Building Type	Heating Energy Density (kBtu/sf)	Degree Day Adjustment Factor	Atlantic City (HDD)	Newark (HDD)	Philadelphia (HDD)	Monticello (HDD)
Education	29.5	0.55	2792	2783	2655	3886
Food Sales	35.6	0.66	3369	3359	3204	4689
Food Service	39.0	0.73	3691	3680	3510	5137
Health Care	53.6	1.00	5073	5057	4824	7060
Lodging	15.0	0.28	1420	1415	1350	1976
Retail	29.3	0.55	2773	2764	2637	3859
Office	28.1	0.52	2660	2651	2529	3701
Public Assembly	33.8	0.63	3199	3189	3042	4452
Public Order/Safety	24.1	0.45	2281	2274	2169	3174
Religious Worship	29.1	0.54	2754	2745	2619	3833
Service	47.8	0.89	4524	4510	4302	6296
Warehouse/Storage	20.2	0.38	1912	1906	1818	2661

Heating Degree Days and Outdoor Design Temperature by Zone

Weather Station	HDD	Outdoor Design Temperature (F)
Atlantic City	5073	13
Newark	5057	14
Philadelphia, PA	4824	15
Monticello, NY	7060	8

Fuel Use Economizers

Algorithms

Fuel Savings (MMBtu) = (AFU * 0.13)

AFU = Annual Fuel Usage for an uncontrolled (gas, oil, propane) HVAC unit (MMBtu or gallons) = (Input power in MMBtu or gallons) * (annual run time)
0.13 = Approximate energy savings factor related to installation of fuel use economizers[1].

Sources:

1. Approximate energy savings factor of 0.13 based on average % savings for test sites represented in Table 2 (page 3) of NYSERDA Study: A Technology Demonstration and Validation Project for Intellidyne Energy Saving Controls; Intellidyne LLC & Brookhaven National Laboratories; 2006 (http://www.cleargreenpartners.com/attachments/File/NYSERDA_Report.pdf)

Combined Heat and Power (CHP) and Fuel Cell Program

Protocols

The measurement of energy and demand savings for Combined Heat and Power (CHP)/fuel cell systems is based primarily on the characteristics of the individual systems subject to the general principles set out below. The majority of the inputs used to estimate energy and demand impacts of CHP/fuel cell systems will be drawn from individual project applications.

CHP/fuel cell systems typically use fossil fuels to generate electricity that displaces electric generation from other sources. Therefore, the electricity generated from a CHP/fuel cell system should not be reported as either electric energy savings or renewable energy generation. Alternatively, electric generation and capacity from CHP/fuel cell systems should be reported as Distributed Generation (DG) separate from energy savings and renewable energy generation. However, any waste heat recaptured and utilized should be reported as energy savings as, discussed below.

Distributed Generation

Electric Generation (MWh) = Estimated annual and lifetime electric generation in MWh provided on the project application, as adjusted during the project review and approval process.

Electric Demand (kW) = Electric capacity of the CHP/fuel cell system in kW provided on the project application, as adjusted during the project review and approval process.

Energy Savings

Gas Energy Savings: Gas savings should be reported on a consistent basis by all applicants as the reduction in fuel related to the recapture of thermal energy (e.g., reduction in boiler gas associated with the recapture of waste heat from the CHP engine or turbine, or a fuel cell with heat recovery.)

Electric Energy Savings: Electric energy savings should be reported only in cases where the recapture of thermal energy from the CHP system is used to drive an absorption chiller that would displace electricity previously consumed for cooling.

Emission Reductions

For many CHP/fuel cell applications there can be substantial emission benefits due to the superior emission rates of many new CHP engines and turbines as compared to the average emission rate of electric generation units on the margin of the grid. However, CHP engines and turbines produce emissions, which should be offset against the displaced emissions from the electricity that would have been generated by the grid.[13]

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[13] Summit Blue, Draft Energy Efficiency Market Assessment of New Jersey Clean Energy Program, Book III, Page 196, May 26, 2006

The New Jersey Department of Environmental Protection (DEP) has provided the BPU with emission factors that are used to calculate the emission savings from energy efficiency and renewable energy projects. These factors should be used to calculate the base emission factors which the CHP system emission factors would be compared to. The emissions from the CHP system would be subtracted from the base emissions to determine the net emission changes as follows:

Emissions Factors Associated with PJM Grid

CO_2 – 1111.79 lbs per MWh
NO_X – 0.95 lbs per MWh
SO_2 – 2.21 lbs per MWh

CHP Emissions Reduction (ER) Formulas
(Assuming that the useful thermal output will displace natural gas)

CO_{2e} ER (lbs) = [1111.79 * Electrical Output (MWh) + Useful Thermal Output (MMBtu) * CO2 EF_{NG}] – [CHP CO_2 EF_f * Fuel Consumption (MMBtu)]

NO_x ER (lbs) = [0.95 * Electrical Output (MWh) + Useful Thermal Output (MMBtu) * NOx EF_{NG}] – [CHP NO_X EF_f * Fuel Consumption (MMBtu)]

SO_2 ER (lbs) = [2.21 * Electrical Output (MWh) + Useful Thermal Output (MMBtu) * SO2 EF_{NG}] – [CHP SO_2 EF_f * Fuel Consumption (MMBtu)]

Note:

1. EF_{NG} values associated with boiler fuel displacement:
   CO2 EF_{NG} = 115 lb/MMBtu
   NOX EF_{NG} = 0.12 lbs/MMBtu
   SO2 EF_{NG} = .0006 lb/MMBtu

2. CHP EF_f (lb/MWh) - Emission factor of fuel type used in the CHP system, which will vary with different projects based on the types of prime movers and emission control devices used.

NJDEP Regulatory Limits for CHP Systems

NOX: 0.047 lb/MMBtu
SO2: 0.0006 lb/MMBtu
CO: 0.157 lb/MMBtu
VOC: 0.047 lb/MMBtu
TSP: 0.01 lb/MMBtu
PM-10: 0.038 lb/MMBtu

Emission reductions from any CHP system energy savings, as discussed above, would be treated the same as any other energy savings reported.

Pay for Performance Program

Protocols

The Pay for Performance Program is a comprehensive program targeted at existing commercial and industrial buildings that have an average annual demand of 100 kW or greater. Participants in the Pay for Performance Program are required to identify and implement energy efficiency improvements that will achieve a minimum of 15% reduction in total source energy consumption.

Energy Savings Requirements
Projects are required to identify and implement energy efficiency improvements that will achieve a minimum of 15% reduction in total source energy consumption (for existing buildings) and 15% energy cost savings from the current state energy code (for new construction). Further, no more than 50% of the total savings may be derived from lighting measures, savings may not come from a single measure, the total package of measures must have at least a 10%, internal rate of return (IRR), and at least 50% of the savings must come from investor-owned electricity and/or natural gas. If 50% of the savings does not meet this criteria, then the project must save a minimum of 100,000 kWh or 2,000 therms from investor-owned utility accounts.

An exception to the 15% savings requirement will be limited to sectors such as manufacturing, pharmaceutical, chemical, refinery, packaging, food/beverage, data center, transportation, mining/mineral, paper/pulp, biotechnology, etc. The manufacturing and/or processing loads use should be equal to or greater than approximately 50% of the total metered energy use. Instead of the 15% savings requirement, the project must deliver a minimum energy savings of 100,000 kWh, 350 MMBTU or 4% of total facility consumption, whichever is greater. Exceptions must be pre-approved by Market Manager and currently only apply to existing buildings component of program

Software Requirements
In order for a project to qualify for incentives under the Pay for Performance Program, the Partner must create a whole-building energy simulation to demonstrate energy savings from recommended energy efficiency measures, as described in detail in the Simulation Guidelines section of the Pay for Performance Program Guidelines. The primary source for developing the Simulation Guidelines is ASHRAE Guideline 14. Simulation software must be compliant with ASHRAE 90.1 Section 11 or Appendix G. Examples of allowed tools include eQUEST, HAP, EnergyPlus, Trane Trace, DOE 2.1. Approval for use in LEED and Federal Tax Deductions for Commercial Buildings program may serve as the proxy to demonstrate compliance with the requirement.

Baseline Conditions
Baseline from which energy savings are measured will be based off the most recent twelve months of energy use from all sources (for existing buildings) or current state energy code, such as ASHRAE 90.1 2007 (for new construction).

Measure Savings
Measure must be modeled to demonstrate proposed energy/energy cost savings according to Pay for Performance program guidelines, including meeting or exceeding Minimum Performance Standards, or current state or local energy code, whichever is more stringent. Minimum Performance Standards generally align with C&I SmartStart Program equipment requirements.

Measurement & Verification
The Program metering requirements are based on the 2010 International Performance Measurement and Verifications Protocol ("IPMVP") and the 2008 Federal Energy Management Program ("FEMP") M&V Guidelines, Version 3.0. All projects must follow Option D, Calibrated Simulation, as defined by the IPMVP. Calibrated simulation involves the use of computer software to predict building energy consumption and savings from energy-efficiency measures. Options A and B, as defined by the IPMVP, may be used as guidelines for data collection to help create a more accurate model. Additionally, for the existing buildings component, Option C is used to measure actual savings using twelve months of post-retrofit utility data.

Energy Savings Reporting
Committed energy savings are reported upon approval of the Energy Reduction Plan and are based on modeling results of recommended measures as described above. Installed energy savings are reported upon installation of recommended measures and are based on modeling results. Unless significant changes to the scope of work occurred during construction, installed savings will be equal to committed savings. Verified savings are reported at the end of the performance period (for Existing Buildings) and are based on twelve (12) months of post-retrofit utility bills compared to pre-retrofit utility bills used during Energy Reduction Plan development, or at the end of the Commissioning process (for new construction) and may vary from committed/installed savings. Note that only installed savings are reported on New Jersey's Clean Energy Quarterly Financial and Energy Savings Reports.

Direct Install Program

Protocols

This section identifies the protocols for all measures proposed under the Direct Install Program. This section includes protocols for measures that are not included in other sections of the Protocols. In addition, for several of the where Direct Install Protocols uses algorithms and inputs from the "Commercial and Industrial Energy Efficient Construction" section of the Protocols, different equipment baselines will be used to reflect the Direct Install includes early retirement. Baseline equipment efficiency shown in this section is an estimate of existing equipment efficiency rather than currently available standard efficiency.

Electric HVAC Systems

Replacement of existing electric HVAC equipment with high efficiency units is a proposed measure under the Direct Install Program. (See C&I Construction Electric HVAC Systems Protocols). The savings protocol will be the same as previously stated in this document with the exception of the assumption for baseline efficiency. For the Direct Install program, the following values will be used for the variable identified as EER_b. These age-based efficiencies are used in estimating savings associated with the Direct Install Program because as an early replacement program, equipment is replaced as a direct result of the program.

Default Values for Mechanical System Efficiencies – Age-Based

System	*Units*	*Pre-1992*	*1992-present*
Unitary HVAC / Split Systems			
<= 5.4 tons	***SEER***	***9.10***	***10.00***
5.4 - 11.25 tons	***EER***	***7.70***	***8.46***
11.25 - 20 tons	***EER***	***7.56***	***8.31***
Air-Air Heat Pump Systems			
<= 5.4 tons	***SEER***	***9.10***	***10.00***
5.4 - 11.25 tons	***EER***	***7.56***	***8.31***
Packaged Terminal Systems			
< 0.74 tons	***EER***	***8.03***	***8.50***
0.75 - 1 ton	***EER***	***7.80***	***8.26***
> 1 ton	***EER***	***7.50***	***7.94***
Water Source Heat Pumps			
All Capacities	***EER***	***9.45***	***10.00***

Source: Based on the 2006 Mortgage Industry National Home Energy Ratings Systems Standards, Table 303.7.1(3) Default Values for Mechanical System Efficiencies (Age-based), RESNET.

NOTE – The age-based efficiencies in the above table have been interpolated from RESNET standards and current baseline figures utilized in NJ C&I Energy Efficiency Rebate programs. With no equivalent resource available specific to small commercial equipment, these combined resources reflect the closest approximation to typical efficiencies of mechanical equipment present in Direct Install project facilities. The Direct Install program is targeted towards small commercial customers. As such, eligible equipment must not exceed a maximum capacity determined to be commonplace in the small C&I sector. In most cases, these capacity ranges correlate well with equipment certified by AHRI under the designation "Residential".

Motors

Replacement of existing motors with high efficiency units is a proposed measure under the Direct Install Program. (See C&I Construction Motors Protocols). The savings protocol will be the same as previously stated in this document with the exception of the assumption for baseline efficiency. For the Direct Install program, the following values will be used for the variable identified as η_{base}. These efficiencies are used in estimating savings associated with the Direct Install Program because as an early replacement program, equipment is replaced as a direct result of the program.

Motor HP	***Baseline Efficiency***
1	***0.75***
1.5	***0.775***
2	***0.80***
3	***0.825***
5	***0.84***
7.5	***0.845***
10	***0.85***
>10	***Use EPAct Baseline Motor Efficiency Table on pg. 72***

Source: Opportunities for Energy Savings in the Residential and Commercial Sectors with High-Efficiency Electric Motors, US DOE, 1999, Figure 4-4, page 4-5.

Variable Frequency Drives

Installation of variable frequency motor drive systems is a proposed measure under the Direct Install Program. (See C&I Construction Motors Protocols). Because there is no baseline assumption included in the protocols for this measure, the savings protocol will be exactly the same as previously stated in this document.

Refrigeration Measures

Walk-in Cooler/Freezer Evaporator Fan Control

This measure is applicable to existing walk-in coolers and freezers that have evaporator fans which run continuously. The measure adds a control system feature to automatically shut off evaporator fans when the cooler's thermostat is not calling for cooling. The measurement of energy savings for this measure is based on algorithms with key variables provided by manufacturer data or prescribed herein. These savings take into account evaporator fan shut off and associated savings as a result of less heat being introduced into the walk-in, as well as the savings from the compressor, which is now being controlled through electronic temperature control.

Several case studies have been performed that verify the accuracy of these savings. The algorithms below are based on field-tested approximations of energy savings realized through installation of National Resource Management Inc. (NRM)'s Cooltrol® energy management system. [1]

Algorithms

Gross kWh Savings = $kWh\ Savings_{EF} + kWh\ Savings_{RH} + kWh\ Savings_{EC}$

$kWh\ SavingsEF = ((Amps_{EF} * Volts_{EF} * (Phase_{EF})^{1/2})/1000) * 0.55 * 8{,}760 * 35.52\%$

$kWh\ SavingsRH = kWh\ Savings_{EF} * 0.28 * 1.6$

$kWh\ SavingsEC = (((Amps_{CP} * Volts_{CP} * (Phase_{CP})^{1/2})/1000) * 0.85 * ((35\% * WH) + (55\% * NWH)) * 5\%) + (((Amps_{EF} * Volts_{EF} * (Phase_{EF})^{1/2})/1000) * 0.55 * 8{,}760 * 35.52\% * 5\%)$

Gross kW Savings = $((Amps_{EF} * Volts_{EF} * (Phase_{EF})^{1/2})/1000) * 0.55 * D$

Definition of Variables

$kWh\ Savings_{EF}$ = Savings due to Evaporator Fan being off
$kWh\ Savings_{RH}$ = Savings due to reduced heat from Evaporator Fans
$kWh\ Savings_{EC}$ = Savings due to the electronic controls on compressor and evaporator
$Amps_{EF}$ = Nameplate Amps of Evaporator Fan
$Volts_{EF}$ = Nameplate Volts of Evaporator Fan
$Phase_{EF}$ = Phase of Evaporator Fan
0.55 = Evaporator Fan Motor power factor.
8,760 = Annual Operating Hours
35.52% = Percent of time Evaporator Fan is turned off. [2]
0.28 = Conversion from kW to tons (Refrigeration).
1.6 = Efficiency of typical refrigeration system in kW/ton.[3]
$Amps_{CP}$ = Nameplate Amps of Compressor
$Volts_{CP}$ = Nameplate Volts of Compressor
$Phase_{CP}$ = Phase of Compressor

0.85 = Compressor power factor.
35% = Compressor duty cycle during winter months (estimated)
WH = Compressor hours during winter months (2,195)
55% = Compressor duty cycle during non-winter months (estimated)
NWH = Compressor hours during non-winter months (6,565)
5% = Reduced run time of Compressor and Evaporator due to electronic controls.[4]
D = 0.228 or Diversity Factor[5]

Sources

(1) Several case studies related to NRM's Cooltrol system can be found at: http://www.nrminc.com/national_resource_management_case_studies_cooltrol_cooler_control_systems.html
(2) This value is an estimate by NRM based on hundreds of downloads of hours of use data from the electronic controller. It is an 'average' savings number and has been validated through several 3rd Party Impact Evaluation Studies including study performed by HEC, "Analysis of Walk-in Cooler Air Economizers", Page 22, Table 9, October 10, 2000 for National Grid.
(3) Select Energy Services, Inc. *Cooler Control Measure Impact Spreadsheet User's Manual.* 2004.
(4) This percentage has been collaborated by several utility sponsored 3rd Party studies including study conducted by Select Energy Services for NSTAR, March 9, 2004.
(5) Based on the report "Savings from Walk-In Cooler Air Economizers and Evaporator Fan Controls", HEC, June 28, 1996.

Cooler and Freezer Door Heater Control

This measure is applicable to existing walk-in coolers and freezers that have continuously operating electric heaters on the doors to prevent condensation formation. This measure adds a control system feature to shut off the door heaters when the humidity level is low enough such that condensation will not occur if the heaters are off. This is performed by measuring the ambient humidity and temperature of the store, calculating the dewpoint, and using PWM (pulse width modulation) to control the anti-sweat heaters based on specific algorithms for freezer doors. The measurement of energy savings for this measure is based on algorithms with key variables provided by manufacturer data or prescribed herein.

Several case studies have been performed that verify the accuracy of these savings. The algorithms below are based on field-tested approximations of energy savings realized through installation of National Resource Management Inc. (NRM)'s Cooltrol® energy management system.[1]

Low Temperature (Freezer) Door Heater Control

Algorithms

kWh Savings = $(kW_{DH} * 8{,}760) - ((40\% * kW_{DH} * 4{,}000) + (65\% * kW_{DH} * 4{,}760))$

kW Savings = $kW_{DH} * 46\% * 75\%$

Definition of Variables

kW_{DH} = Total demand (kW) of the freezer door heaters, based on nameplate volts and amps.
8,760 = Annual run hours of Freezer Door Heater before controls.
40% = Percent of total run power of door heaters with controls providing maximum reduction.[2]
4,000 = Number of hours door heaters run at 40% power.
65% = Percent of total run power of door heaters with controls providing minimum reduction.[2]
4,760 = Number of hours door heaters run at 65% power.
46% = Freezer Door Heater off time.[3]
75% = Adjustment factor to account for diversity and coincidence at peak demand time.[2]

Medium Temperature (Cooler) Door Heater Control

Algorithms

kWh Savings = (kW_{DH} * 8,760) – (60% * kW_{DH} * 3,760)

kW Savings = kW_{DH} * 74% * 75%

Definition of Variables

kW_{DH} = Total demand (kW) of the cooler door heaters, based on nameplate volts and amps.
8,760 = Annual run hours of Cooler Door Heater before controls.
60% = Percent of total run power of door heaters with controls providing minimum reduction.[2]
3,760 = Number of hours door heaters run at 60% power.
74% = Cooler Door Heater off time.[3]
75% = Adjustment factor to account for diversity and coincidence at peak demand time.[2]

Notes

(1) Several case studies related to NRM's Cooltrol system can be found at: http://www.nrminc.com/national_resource_management_case_studies_cooltrol_cooler_control_systems.html
(2) Estimated by NRM based on their experience of monitoring the equipment at various sites.
(3) This value is an estimate by National Resource Management based on hundreds of downloads of hours of use data from Door Heater controllers. This supported by 3rd Party Analysis conducted by Select Energy for NSTAR, "Cooler Control Measure Impact Spreadsheet Users' Manual", Page 5, March 9, 2004.

Aluminum Night Covers

This measure is applicable to existing open-type refrigerated display cases where considerable heat is lost through an opening that is directly exposed to ambient air. These retractable aluminum woven fabric covers provide a barrier between the contents of the case and the outside environment. They are employed during non-business hours to significantly reduce heat loss from these cases when contents need not be visible.

Savings approximations are based on the report, "Effects of the Low Emissivity Shields on performance and Power use of a refrigerated display case", by Southern California Edison, August 8, 1997. Southern California Edison (SCE) conducted this test at its state-of-the-art Refrigeration Technology and Test Center (RTTC), located in Irwindale, CA. The RTTC's sophisticated instrumentation and data acquisition system provided detailed tracking of the refrigeration system's critical temperature and pressure points during the test period. These readings were then utilized to quantify various heat transfer and power related parameters within the refrigeration cycle. The results of SCE's test focused on three typical scenarios found mostly in supermarkets: low, medium and high temperature cases.

<u>Algorithms</u>

kWh Savings = W * H * F

<u>Definition of Variables</u>

W = Width of protected opening in ft.
H = Hours per year covers are in place
F = Savings factor based on case temperature:
Low temperature (-35F to -5F) F = 0.1 kW/ft
Medium temperature (0F to 30F) F = 0.06 kW/ft
High temperature (35F to 55F) F = 0.04 kW/ft

Electric Defrost Control

This measure is applicable to existing evaporator fans with a traditional electric defrost mechanism. This control system overrides defrost of evaporator fans when unnecessary, reducing annual energy consumption. The estimates for savings take into account savings from reduced defrosts as well as the reduction in heat gain from the defrost process.

Independent Testing was performed by Intertek Testing Service on a Walk-in Freezer that was retrofitted with Smart Electric Defrost capability. A baseline of 28 electric defrosts per week were established as the baseline for a two week period without the Smart Electric Defrost capability. With Smart Electric Defrost capability an average skip rate of 43.64% was observed for the following two week period.

<u>Algorithms</u>

Gross kWh Savings = $kWh\ Savings_{Defrost} + kWh\ Savings_{RH}$

$kWh\ Savings_{Defrost}$ = $KW_{Defrost}$ * 0.667 * 4 * 365 * 35%

$kWh\ Savings_{RH}$ = $kWh\ Savings_{Defrost}$ * 0.28 * 1.6

Definition of Variables

$kWh\ Savings_{Defrost}$ = Savings due to reduction of defrosts
$kWh\ Savings_{RH}$ = Savings due to reduction in refrigeration load
$KW_{Defrost}$ = Nameplate Load of Electric Defrost
0.667 = Average Length of Electric Defrost in hours
4 = Average Number of Electric Defrosts per day
365 = Number of Days in Year
35% = Average Number of Defrosts that will be eliminated in year
0.28 = Conversion from kW to tons (Refrigeration)
1.6 = Efficiency of typical refrigeration system in kW/ton[1]

(1) Select Energy Services, Inc. *Cooler Control Measure Impact Spreadsheet User's Manual.* 2004.

LED Lighting for Coolers and Freezers

This measure is applicable to existing walk-in and reach-in coolers and freezers with non-LED lighting. LED lighting is not only more efficient, but also provides higher quality lighting for cooler and freezer displays as they are more suited for cold environments. In addition, LEDs have a longer operating life than fluorescents in cooler and freezer applications, which results in reduced life cycle costs. The estimated savings for this measure take into account both reduced wattage of replacement lighting and reduced refrigeration load from lighting heat loss.

Algorithms

kWh Savings = ((($Watts_B$ - $Watts_{LED}$)/1000) * H) * (1 + (0.28 * 1.6))

kW Savings = (($Watts_B$ - $Watts_{LED}$)/1000) * (1 + (0.28 * 1.6))

Definition of Variables

$Watts_B$ = Baseline Lighting Wattage
$Watts_{LED}$ = LED Lighting Wattage
1000 = Conversion from W to kW
H = Lighting Operating Hours
0.28 = Conversion from kW to tons (Refrigeration)
1.6 = Efficiency of typical refrigeration system in kW/ton[14]

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[14] Select Energy Services, Inc. *Cooler Control Measure Impact Spreadsheet User's Manual*. 2004.

Novelty Cooler Shutoff

This measure is applicable to existing reach-in novelty coolers which run continuously. The measure adds a control system feature to automatically shut off novelty coolers based on pre-set store operating hours. Based on programmed hours, the control mechanism shuts off the cooler at end of business, and begins operation on reduced cycles. Regular operation begins the following day an hour before start of business. The measurement of energy savings for this measure is based on algorithms with key variables provided by manufacturer data or prescribed herein.

Several case studies have been performed that verify the accuracy of these savings. The algorithms below are based on field-tested approximations of energy savings realized through installation of National Resource Management Inc. (NRM)'s Cooltrol® energy management system. [1]

Algorithms

$$\text{kWh Savings} = (((\text{Amps}_{NC} * \text{Volts}_{NC} * (\text{Phase}_{NC})^{1/2})/1000) * 0.85) * ((0.45 * ((CH - 1) * 91)) + (0.5 * ((CH - 1) * 274)))$$

Definition of Variables

Amps_{NC} = Nameplate Amps of Novelty Cooler
Volts_{NC} = Nameplate Volts of Novelty Cooler
Phase_{NC} = Phase of Novelty Cooler
0.85 = Novelty Cooler power factor[2]
0.45 = Duty cycle during winter month nights[3]
CH = Closed Store hours
91 = Number of days in winter months
0.5 = Duty cycle during non-winter month nights[3]
274 = Number of days in non-winter months

Notes

(1) Several case studies related to NRM's Cooltrol system can be found at: http://www.nrminc.com/national_resource_management_case_studies_cooltrol_cooler_control_systems.html
(2) Estimated by NRM based on their experience of monitoring the equipment at various sites.
(3) Duty Cycles are consistent with 3rd Party study done by Select Energy for NSTAR"Cooler Control Measure Impact Spreadsheet Users' Manual", page 5, March 9, 2004.

Gas Space and Water Heating Measures

Gas Furnaces and Boilers

Replacement of existing gas, oil, or propane furnaces and boilers with high efficiency units is a proposed measure under the Direct Install Program. (See C&I Construction Gas Protocols). The savings protocol will be the same as previously stated in this document with the exception of the assumption for baseline efficiency. For the Direct Install program, the following values will be used for the variable identified as $AFUE_b$. These age-based efficiencies are used in estimating savings associated with the Direct Install Program because as an early replacement program, equipment is replaced as a direct result of the program.

Default Values for Mechanical System Efficiencies – Age-Based

System	Units	Pre-1992	1992- present
Gas or Propane Furnace	AFUE	0.73	0.78
Gas or Propane Boiler	AFUE	0.70	0.80
Oil Furnace or Boiler	AFUE	0.77	0.80

Source: 2006 Mortgage Industry National Home Energy Ratings Systems Standards, Table 303.7.1(3) Default Values for Mechanical System Efficiencies (Age-based), RESNET.

NOTE – The age-based efficiencies in the above table have been interpolated from RESNET standards and current baseline figures utilized in NJ C&I Energy Efficiency Rebate programs. With no equivalent resource available specific to small commercial equipment, these combined resources reflect the closest approximation to typical efficiencies of mechanical equipment present in Direct Install project facilities. The Direct Install program is targeted towards small commercial customers. As such, eligible equipment must not exceed a maximum capacity determined to be commonplace in the small C&I sector. In most cases, these capacity ranges correlate well with equipment certified by AHRI under the designation “Residential”.

Small Commercial Boilers

This section will apply only for boilers that are closed loop and for space heating.

For Boilers that are under 5000 Mbtu/h use the calculator from the Federal Energy Management Program at: http://www1.eere.energy.gov/femp/technologies/eep_boilers_calc.html

Gas and Propane Infrared Heating

Replacement of existing atmospherically vented heating with gas or propane infrared heating is an available measure under the Direct Install Program. (See C&I Construction Gas Protocols).

Gas Water Heating

Replacement of existing gas furnaces and boilers with gas high efficiency units is a proposed measure under the Direct Install Program. (See C&I Construction Gas Protocols). The savings protocol will be the same as previously stated in this document with the exception of the assumption for baseline efficiency. For the Direct Install program, the following values will be used for the variable identified as EFF_b. These age-based efficiencies are used in estimating savings associated with the Direct Install Program because as an early replacement program, equipment is replaced as a direct result of the program.

Default Values for Water Heating System Efficiencies – Age-Based

Water Heater Type	*Units*	*Pre-1992*	*1992- present*
Gas	*EF*	*0.53*	*0.56*
Oil	*EF*	*0.5*	*0.56*
Electric	*EF*	*0.87*	*0.88*

Source: 2006 Mortgage Industry National Home Energy Ratings Systems Standards, Table 303.7.1(3) Default Values for Mechanical System Efficiencies (Age-based), RESNET.

NOTE – The age-based efficiencies in the above table have been interpolated from RESNET standards and current baseline figures utilized in NJ C&I Energy Efficiency Rebate programs. With no equivalent resource available specific to small commercial equipment, these combined resources reflect the closest approximation to typical efficiencies of mechanical equipment present in Direct Install project facilities. The Direct Install program is targeted towards small commercial customers. As such, eligible equipment must not exceed a maximum capacity determined to be commonplace in the small C&I sector. In most cases, these capacity ranges correlate well with equipment certified by AHRI under the designation "Residential".

Food Service Measures

Energy efficient electric or natural gas cooking equipment of the following listed types utilized in commercial food service applications which have performance rated in accordance with the listed ASTM standards:

- Electric combination and convection ovens – ASTM 1639-F
- Gas combination and convection ovens – ASTM 1639-F
- Gas conveyor and rack ovens – ASTM 1817-F
- Electric and gas small vat fryers – ASTM 1361-F
- Electric and gas large vat fryers – ASTM 2144-F
- Electric and gas steamers – ASTM 1484-F
- Electric and gas griddles – ASTM 1275-F

- Hot food holding cabinets – ATM F2140-11

Electric and Gas Combination Oven/Steamer

The measurement of energy savings for this measure is based on algorithms with key variables provided by manufacturer data or prescribed herein.

Algorithms

Annual Energy Savings (kWh or Therms) = $D*(E_p + E_{ic} + E_{is} + E_{cc} + E_{cs})$

Demand Savings (kW) = kWh Savings/(D*H)

Preheat Savings†: $E_p = P*(PE_b – PE_q)$

Convection Mode Idle Savings†: $E_{ic} = (I_{cb} – I_{cq})*((H – (P*P_t)) – (I_{cb}/PC_{cb} – I_{cq}/PC_{cq})*Lbs)*(1 – S_t)$

Steam Mode Idle Savings†: $E_{is} = (I_{sb} – I_{sq})*((H – (P*P_t)) – (I_{sb}/PC_{sb} – I_{sq}/PC_{sq})*Lbs)*S_t$

Convection Mode Cooking Savings: $E_{cc} = Lbs*(1-S_t)*Heat_c*(1/Eff_{cb} – 1/Eff_{cq})/C$

Steam Mode Cooking Savings: $E_{cs} = Lbs*S_t*Heat_s*(1/Eff_{sb} – 1/Eff_{sq})/C$

† - For gas equipment, convert these intermediate values to therms by dividing the result by 100,000 Btu/therm

Definition of Variables (See tables of values below for more information)

D = Operating Days per Year
P = Number of Preheats per Day
PE_b = Baseline Equipment Preheat Energy
PE_q = Qualifying Equipment Preheat Energy
I_{cb} = Baseline Equipment Convection Mode Idle Energy Rate
I_{cq} = Qualifying Equipment Convection Mode Idle Energy Rate
H = Daily Operating Hours
P_t = Preheat Duration
PC_{cb} = Baseline Equipment Convection Mode Production Capacity
PC_{cq} = Qualifying Equipment Convection Mode Production Capacity
Lbs = Total Daily Food Production
S_t = Percentage of Time in Steam Mode
I_{sb} = Baseline Equipment Steam Mode Idle Energy Rate
I_{sq} = Qualifying Equipment Steam Mode Idle Energy Rate
PC_{sb} = Baseline Equipment Steam Mode Production Capacity
PC_{sq} = Qualifying Equipment Steam Mode Production Capacity
$Heat_c$ = Convection Mode Heat to Food

Eff_{cb} = Baseline Equipment Convection Mode Cooking Efficiency
Eff_{cq} = Qualifying Equipment Convection Mode Cooking Efficiency
C = Conversion Factor from Btu to kWh or Therms
$Heat_s$ = Steam Mode Heat to Food
Eff_{sb} = Baseline Equipment Steam Mode Cooking Efficiency
Eff_{sq} = Qualifying Equipment Steam Mode Cooking Efficiency

Table 1: Electric Combination Oven/Steamers

Variable	*Baseline*			*Qualifying*		
	<15 Pans	*15-28 Pans*	*>28 Pans*	*<15 Pans*	*15-28 Pans*	*>28 Pans*
D - Operating Days per Year	Table 3	Table 3	Table 3	Table 3	Table 3	Table 3
P - Number of Preheats per Day	1	1	1	1	1	1
PE_b & PE_q - Preheat Energy (kWh)	3.00	3.75	5.63	1.50	2.00	3.00
I_{cb} & I_{cq} - Convection Mode Idle Energy Rate (kW)	3.00	3.75	5.25	Application	Application	Application
H - Operating Hours per Day	Table 3	Table 3	Table 3	Table 3	Table 3	Table 3
P_t - Preheat Duration (hrs)	0.25	0.25	0.25	0.25	0.25	0.25
PC_{cb} & PC_{cq} - Convection Mode Prod. Capacity (lbs/hr)	80	100	275	100	125	325
Lbs - Total Daily Food Production (lbs)	200	250	400	200	250	400
S_t - Percentage of Time in Steam Mode	50%	50%	50%	50%	50%	50%
I_{sb} & I_{sq} - Steam Mode Idle Energy Rate (kW)	10.0	12.5	18.0	Application	Application	Application
PC_{sb} & PC_{sq} - Steam Mode Prod. Capacity (lbs/hr)	100	150	350	120	200	400
$Heat_c$ - Convection Heat to Food (Btu/lb)	250	250	250	250	250	250
Eff_{cb} & Eff_{cq} - Convection Mode Cooking Efficiency	65%	65%	65%	Application	Application	Application
C - Btu/kWh	3,412	3,412	3,412	3,412	3,412	3,412
$Heat_s$ - Steam Heat to Food (Btu/lb)	105	105	105	105	105	105
Eff_{sb} & Eff_{sq} - Steam Mode Cooking Efficiency	40%	40%	40%	Application	Application	Application

Table 2: Gas Combination Oven/Steamers

Variable	*Baseline*			*Qualifying*		
	<15 Pans	*15-28 Pans*	*>28 Pans*	*<15 Pans*	*15-28 Pans*	*>28 Pans*
D - Operating Days per Year	Table 3	Table 3	Table 3	Table 3	Table 3	Table 3
P - Number of Preheats per Day	1	1	1	1	1	1
PE_b & PE_q - Preheat Energy (Btu)	18,000	22,000	32,000	13,000	16,000	24,000
I_{cb} & I_{cq} - Convection Mode Idle Energy Rate (Btu/h)	15,000	20,000	30,000	Application	Application	Application
H - Operating Hours per Day	Table 3	Table 3	Table 3	Table 3	Table 3	Table 3
P_t - Preheat Duration (h)	0.25	0.25	0.25	0.25	0.25	0.25
PC_{cb} & PC_{cq} - Convection Mode Prod. Capacity (lbs/h)	80	100	275	100	125	325
Lbs - Total Daily Food Production (lbs)	200	250	400	200	250	400
S_t - Percentage of Time in Steam Mode	50%	50%	50%	50%	50%	50%
I_{sb} & I_{sq} - Steam Mode Idle Energy Rate (kW)	45,000	60,000	80,000	Application	Application	Application
PC_{sb} & PC_{sq} - Steam Mode Prod. Capacity (lbs/h)	100	150	350	120	200	400
$Heat_c$ - Convection Heat to Food (Btu/lb)	250	250	250	250	250	250
Eff_{cb} & Eff_{cq} - Convection Mode Cooking Efficiency	35%	35%	35%	Application	Application	Application
C - Btu/Therm	100,000	100,000	100,000	100,000	100,000	100,000
$Heat_s$ - Steam Heat to Food (Btu/lb)	105	105	105	105	105	105
Eff_{sb} & Eff_{sq} - Steam Mode Cooking Efficiency	20%	20%	20%	Application	Application	Application

Table 3: Operating Days/Hours by Building Type		
Building Type	**Days/Year**	**Hours/Day**
Education - Primary School	180	8
Education - Secondary School	210	11
Education - Community College	237	16
Education - University	192	16
Grocery	364	16
Medical - Hospital	364	24
Medical - Clinic	351	12
Lodging Hotel (Guest Rooms)	229	5
Lodging Motel	364	24
Manufacturing - Light Industrial	330	13
Office - Large	234	12
Office - Small	234	12
Restaurant - Sit-Down	364	12
Restaurant - Fast-Food	364	17
Retail - 3-Story Large	355	12
Retail - Single-Story Large	364	12
Retail - Small	364	11
Storage Conditioned	330	13
Storage Heated or Unconditioned	330	13
Warehouse	325	12
Average = Miscellaneous	303	14

Source:
Savings algorithm, baseline values, assumed values and lifetimes developed from information on the Food Service Technology Center program's website, www.fishnick.com, by Fisher-Nickel, Inc. and funded by California utility customers and administered by Pacific Gas and Electric Company under the auspices of the California Public Utility Commission.

Electric and Gas Convection Ovens, Gas Conveyor and Rack Ovens, Steamers, Fryers, and Griddles

The measurement of energy savings for these measures are based on algorithms with key variables provided by manufacturer data or prescribed herein.

Algorithms

Annual Energy Savings (kWh or Therms) = $D*(E_p + E_i + E_c)$

Demand Savings (kW) = kWh Savings/(D*H)

Preheat Savings†: $E_p = P*(PE_b – PE_q)$

Idle Savings†: $E_i = (I_b – I_q)*((H – (P*P_t)) – (I_b/PC_b – I_q/PC_q)*Lbs)$

Cooking Savings: $E_c = Lbs*Heat*(1/Eff_b – 1/Eff_q)/C$

† - For gas equipment, convert these intermediate values to therms by dividing the result by 100,000 Btu/therm

Definition of Variables (See tables of values below for more information)

D = Operating Days per Year
P = Number of Preheats per Day
PE_b = Baseline Equipment Preheat Energy
PE_q = Qualifying Equipment Preheat Energy
I_b = Baseline Equipment Idle Energy Rate
I_q = Qualifying Equipment Idle Energy Rate
H = Daily Operating Hours
P_t = Preheat Duration
PC_b = Baseline Equipment Production Capacity
PC_q = Qualifying Equipment Production Capacity
Lbs = Total Daily Food Production
Heat = Heat to Food
Eff_b = Baseline Equipment Convection Mode Cooking Efficiency
Eff_q = Qualifying Equipment Convection Mode Cooking Efficiency
C = Conversion Factor from Btu to kWh or Therms

Table 1: Electric Convection Ovens				
Variable	*Baseline*		*Qualifying*	
	Full Size	*Half Size*	*Full Size*	*Half Size*
D - Operating Days per Year	Table 11	Table 11	Table 11	Table 11
P - Number of Preheats per Day	1	1	1	1
PE_b & PE_q - Preheat Energy (kWh)	1.50	1.00	1.00	0.90
I_b & I_q - Idle Energy Rate (kW)	2.00	1.50	Application	Application
H - Operating Hours per Day	Table 11	Table 11	Table 11	Table 11
P_t - Preheat Duration (hrs)	0.25	0.25	0.25	0.25
PC_b & PC_q - Production Capacity (lbs/hr)	70	45	82	53
Lbs - Total Daily Food Production (lbs)	100	100	100	100
Heat - Heat to Food (Btu/lb)	250	250	250	250
Eff_b & Eff_q - Heavy Load Cooking Efficiency	65%	65%	Application	Application
C - Btu/kWh	3,412	3,412	3,412	3,412

Table 2: Gas Convection Ovens				
Variable	*Baseline*		*Qualifying*	
	Full Size	*Half Size*	*Full Size*	*Half Size*
D - Operating Days per Year	Table 11	Table 11	Table 11	Table 11
P - Number of Preheats per Day	1	1	1	1
PE_b & PE_q - Preheat Energy (Btu)	19,000	13,000	11,000	7,500
I_b & I_q - Idle Energy Rate (Btu/h)	18,000	12,000	Application	Application
H - Operating Hours per Day	Table 11	Table 11	Table 11	Table 11
P_t - Preheat Duration (hrs)	0.25	0.25	0.25	0.25
PC_b & PC_q - Production Capacity (lbs/hr)	70	45	83	55
Lbs - Total Daily Food Production (lbs)	100	100	100	100
Heat - Heat to Food (Btu/lb)	250	250	250	250
Eff_b & Eff_q - Heavy Load Cooking Efficiency	30%	30%	Application	Application
C - Btu/Therm	100,000	100,000	100,000	100,000

Table 3: Gas Conveyor Ovens		
Variable	*Baseline*	*Qualifying*
D - Operating Days per Year	Table 11	Table 11
P - Number of Preheats per Day	1	1
PE_b & PE_q - Preheat Energy (Btu)	35,000	18,000
I_b & I_q - Idle Energy Rate (Btu/hr)	70,000	Application
H - Operating Hours per Day	Table 11	Table 11
P_t - Preheat Duration (hrs)	0.25	0.25
PC_b & PC_q - Production Capacity (lbs/hr)	114	167
Lbs - Total Daily Food Production (lbs)	190	190
Heat - Heat to Food (Btu/lb)	250	250
Eff_b & Eff_q - Heavy Load Cooking Efficiency	20%	Application
C - Btu/Therm	100,000	100,000

Table 4: Gas Rack Ovens				
Variable	***Baseline***		***Qualifying***	
	Double Rack	*Single Rack*	*Double Rack*	*Single Rack*
D - Operating Days per Year	Table 11	Table 11	Table 5	Table 5
P - Number of Preheats per Day	1	1	1	1
PE_b & PE_q - Preheat Energy (Btu)	100,000	50,000	85,000	44,000
I_b & I_q - Idle Energy Rate (Btu/h)	65,000	43,000	Application	Application
H - Operating Hours per Day	Table 11	Table 11	Table 5	Table 5
P_t - Preheat Duration (hrs)	0.33	0.33	0.33	0.33
PC_b & PC_q - Production Capacity (lbs/hr)	250	130	280	140
Lbs - Total Daily Food Production (lbs)	1200	600	1200	600
Heat - Heat to Food (Btu/lb)	235	235	235	235
Eff_b & Eff_q - Heavy Load Cooking Efficiency	30%	30%	Application	Application
C - Btu/Therm	100,000	100,000	100,000	100,000

Table 5: Electric Steamers		
Variable	***Baseline***	***Qualifying***
D - Operating Days per Year	Table 11	Table 11
P - Number of Preheats per Day	1	1
PE_b & PE_q - Preheat Energy (kWh)	1.50	1.50
I_b & I_q - Idle Energy Rate (kW)	0.167 x No. of Pans	Application
H - Operating Hours per Day	Table 11	Table 11
P_t - Preheat Duration (hrs)	0.25	0.25
PC_b & PC_q - Production Capacity (lbs/hr)	11.7 x No. of Pans	14.7 x No. of Pans
Lbs - Total Daily Food Production (lbs)	100	100
Heat - Heat to Food (Btu/lb)	105	105
Eff_b & Eff_q - Heavy Load Cooking Efficiency	26%	Application
C - Btu/kWh	3,412	3,412

Table 6: Gas Steamers		
Variable	***Baseline***	***Qualifying***
D - Operating Days per Year	Table 11	Table 11
P - Number of Preheats per Day	1	1
PE_b & PE_q - Preheat Energy (Btu)	20,000	9,000
I_b & I_q - Idle Energy Rate (Btu/h)	2,500 x No. of Pans	Application
H - Operating Hours per Day	Table 11	Table 11
P_t - Preheat Duration (hrs)	0.25	0.25
PC_b & PC_q - Production Capacity (lbs/hr)	23.3 x No. of Pans	20.8 x No. of Pans
Lbs - Total Daily Food Production (lbs)	100	100
Heat - Heat to Food (Btu/lb)	105	105
Eff_b & Eff_q - Heavy Load Cooking Efficiency	15%	Application
C - Btu/Therm	100,000	100,000

Table 7: Electric Fryers		
Variable	***Baseline***	***Qualifying***
D - Operating Days per Year	Table 11	Table 11
P - Number of Preheats per Day	1	1
PE_b & PE_q - Preheat Energy (kWh)	2.40	1.90
I_b & I_q - Idle Energy Rate (kW)	1.2	Application
H - Operating Hours per Day	Table 11	Table 11
P_t - Preheat Duration (hrs)	0.25	0.25
PC_b & PC_q - Production Capacity (lbs/hr)	71	71
Lbs - Total Daily Food Production (lbs)	150	150
Heat - Heat to Food (Btu/lb)	570	570
Eff_b & Eff_q - Heavy Load Cooking Efficiency	75%	Application
C - Btu/kWh	3,412	3,412

Table 8: Gas Fryers		
Variable	***Baseline***	***Qualifying***
D - Operating Days per Year	Table 11	Table 11
P - Number of Preheats per Day	1	1
PE_b & PE_q - Preheat Energy (Btu)	18,500	16,000
I_b & I_q - Idle Energy Rate (Btu/h)	17,000	Application
H - Operating Hours per Day	Table 11	Table 11
P_t - Preheat Duration (hrs)	0.25	0.25
PC_b & PC_q - Production Capacity (lbs/hr)	75	75
Lbs - Total Daily Food Production (lbs)	150	150
Heat - Heat to Food (Btu/lb)	570	570
Eff_b & Eff_q - Heavy Load Cooking Efficiency	35%	Application
C - Btu/Therm	100,000	100,000

Table 9: Electric Griddles		
Variable	***Baseline***	***Qualifying***
D - Operating Days per Year	Table 11	Table 11
P - Number of Preheats per Day	1	1
PE_b & PE_q - Preheat Energy (kWh)	1.3 x Griddle Width (ft)	0.7 x Griddle Width (ft)
I_b & I_q - Idle Energy Rate (kW)	0.8 x Griddle Width (ft)	Application
H - Operating Hours per Day	Table 11	Table 11
P_t - Preheat Duration (hrs)	0.25	0.25
PC_b & PC_q - Production Capacity (lbs/hr)	11.7 x Griddle Width (ft)	13.3 x Griddle Width (ft)
Lbs - Total Daily Food Production (lbs)	100	100
Heat - Heat to Food (Btu/lb)	475	475
Eff_b & Eff_q - Heavy Load Cooking Efficiency	60%	Application
C - Btu/kWh	3,412	3,412

Table 10: Gas Griddles		
Variable	***Baseline***	***Qualifying***
D - Operating Days per Year	Table 11	Table 11
P - Number of Preheats per Day	1	1
PE_b & PE_q - Preheat Energy (Btu)	7,000 x Griddle Width (ft)	5,000 x Griddle Width (ft)
I_b & I_q - Idle Energy Rate (Btu/h)	7,000 x Griddle Width (ft)	Application
H - Operating Hours per Day	Table 11	Table 11
P_t - Preheat Duration (hrs)	0.25	0.25
PC_b & PC_q - Production Capacity (lbs/hr)	8.3 x Griddle Width (ft)	15 x Griddle Width (ft)
Lbs - Total Daily Food Production (lbs)	100	100
Heat - Heat to Food (Btu/lb)	475	475
Eff_b & Eff_q - Heavy Load Cooking Efficiency	30%	Application
C - Btu/Therm	100,000	100,000

Table 11: Operating Days/Hours by Building Type		
Building Type	**Days/Year**	**Hours/Day**
Education - Primary School	180	8
Education - Secondary School	210	11
Education - Community College	237	16
Education - University	192	16
Grocery	364	16
Medical - Hospital	364	24
Medical - Clinic	351	12
Lodging Hotel (Guest Rooms)	229	5
Lodging Motel	364	24
Manufacturing - Light Industrial	330	13
Office - Large	234	12
Office - Small	234	12
Restaurant - Sit-Down	364	12
Restaurant - Fast-Food	364	17
Retail - 3-Story Large	355	12
Retail - Single-Story Large	364	12
Retail - Small	364	11
Storage Conditioned	330	13
Storage Heated or Unconditioned	330	13
Warehouse	325	12
Average = Miscellaneous	303	14

<u>Source</u>

Savings algorithm, baseline values, assumed values and lifetimes developed from information on the Food Service Technology Center program's website, www.fishnick.com, by Fisher-Nickel, Inc. and funded by California utility customers and administered by Pacific Gas and Electric Company under the auspices of the California Public Utility Commission.

Insulated Food Holding Cabinets

The measurement of energy savings for this measure is based on algorithms with key variables provided by manufacturer data or prescribed herein.

Algorithms

Annual Energy Savings (kWh) = $D*H*(I_b - I_q)$

Demand Savings (kW) = $I_b - I_q$

Definition of Variables (See tables of values below for more information)

D = Operating Days per Year
H = Daily Operating Hours
I_b = Baseline Equipment Idle Energy Rate
I_q = Qualifying Equipment Idle Energy Rate

Table 1: Insulated Food Holding Cabinets

Variable	*Baseline*			*Qualifying*		
	Full Size	*3/4 Size*	*1/2 Size*	*Full Size*	*3/4 Size*	*1/2 Size*
D - Operating Days per Year	Table 2	Table 2	Table 2	Table 2	Table 2	Table 2
I_b & I_q - Idle Energy Rate (kW)	1.00	0.69	0.38	Application	Application	Application
H - Operating Hours per Day	Table 2	Table 2	Table 2	Table 2	Table 2	Table 2

Table 2: Operating Days/Hours by Building Type

Building Type	Days/Year	Hours/Day
Education - Primary School	180	8
Education - Secondary School	210	11
Education - Community College	237	16
Education - University	192	16
Grocery	364	16
Medical - Hospital	364	24
Medical - Clinic	351	12
Lodging Hotel (Guest Rooms)	229	5
Lodging Motel	364	24
Manufacturing - Light Industrial	330	13
Office - Large	234	12
Office - Small	234	12
Restaurant - Sit-Down	364	12
Restaurant - Fast-Food	364	17
Retail - 3-Story Large	355	12
Retail - Single-Story Large	364	12
Retail - Small	364	11
Storage Conditioned	330	13
Storage Heated or Unconditioned	330	13
Warehouse	325	12
Average = Miscellaneous	303	14

Source

Savings algorithm, baseline values, assumed values and lifetimes developed from information on the Food Service Technology Center program's website, www.fishnick.com, by Fisher-Nickel, Inc. and funded by California utility customers and administered by Pacific Gas and Electric Company under the auspices of the California Public Utility Commission.

Occupancy Controlled Thermostats

The program has received a large amount of custom electric applications for the installation of Occupancy Controlled Thermostats in hotels, motels, and, most recently, university dormitories. Due to the number of applications, consistent incentive amounts ($75 per thermostat) and predictable savings of the technology TRC recommends that a prescriptive application be created for this technology.

Standard practice today is thermostats which are manually controlled by occupants to regulate temperature within a facility. An occupancy controlled thermostat is a thermostat paired with a sensor and/or door detector to identify movement and determine if a room is occupied or unoccupied. If occupancy is sensed by the sensor, the thermostat goes into an occupied mode (i.e. programmed setpoint). If a pre-programmed time frame elapses (i.e. 30 minutes) and no occupancy is sensed during that time, the thermostat goes into an unoccupied mode (e.g., setback setpoint or off) until occupancy is sensed again. This type of thermostat is often used in hotels to conserve energy.

The occupancy controlled thermostat reduces the consumption of electricity and/or gas by requiring less heating and/or cooling when a room or a facility is vacant or unoccupied.

Algorithms

Cooling Energy Savings (kWh) = $(((T_c*(H+5)+S_c*(168-(H+5)))/168)$
$T_c)*(P_c*Cap_{hp}*12*EFLH_c/EER_{hp})$

Heating Energy Savings (kWh) = $(((T_h*(H+5)+S_h*(168-(H+5)))/168)-$
$T_h)*(P_h*Cap_{hp}*12*EFLH_h/EER_{hp})$

Heating Energy Savings (Therms) = $(T_h-(T_h*(H+5)+S_h*(168-$
$(H+5)))/168)*(P_h*Cap_h*EFLH_h/AFUE_h/100,000)$

Definition of Variables

T_h = Heating Season Facility Temp. (°F)
T_c = Cooling Season Facility Temp. (°F)
S_h = Heating Season Setback Temp. (°F)
S_c = Cooling Season Setup Temp. (°F)
H = Weekly Occupied Hours
Cap_{hp} = Connected load capacity of heat pump/AC (Tons) – Provided on Application.

Cap_h = Connected heating load capacity (Btu/hr) – Provided on Application.
$EFLH_c$ = Equivalent full load cooling hours
$EFLH_h$ = Equivalent full load heating hours
P_h = Heating season percent savings per degree setback
P_c = Cooling season percent savings per degree setup
$AFUE_h$ = Heating equipment efficiency – Provided on Application.
EER_{hp} = Heat pump/AC equipment efficiency – Provided on Application
12 = Conversion factor from Tons to kBtu/hr to acquire consumption in kWh.
168 = Hours per week.
5 = Assumed weekly hours for setback/setup adjustment period (based on 1 setback/setup per day, 5 days per week).

Occupancy Controlled Thermostats

Component	Type	Value	Source
T_h	Variable		Application
T_c	Variable		Application
S_h	Fixed	T_h-5°	
S_c	Fixed	T_c+5°	
H	Variable		Application; Default of 56 hrs/week
Cap_{hp}	Variable		Application
Cap_h	Variable		Application
$EFLH_c$	Fixed	381	1
$EFLH_h$	Fixed	900	PSE&G
P_h	Fixed	3%	2
P_c	Fixed	6%	2
$AFUE_h$	Variable		Application
EER_{hp}	Variable		Application

Sources:
1. JCP&L metered data from 1995-1999
2. ENERGY STAR Products website

Dual Enthalpy Economizers

Dual enthalpy economizers are used to control a ventilation system's outside air intake in order to reduce a facility's total cooling load. An economizer monitors the outside air to ensure that its temperature (sensible heat) and humidity (latent heat) are low enough to utilize outside air to provide cooling in place of the cooling system's compressor. This reduces the demand on the cooling system, lowering its usage hours, saving energy.

The measurement of energy savings associated with dual enthalpy economizers is based on algorithms with key variables provided through DOE-2 simulation modeling and ClimateQuest's economizer savings calculator. Savings are calculated per ton of connected cooling load. The baseline conditions are fixed damper for equipment under 5.4 tons and dry bulb economizer otherwise.

Algorithms

Energy Savings (kWh) = OTF*SF*Cap/Eff

Demand Savings (kW) = Savings/Operating Hours

Definition of Variables

OTF = Operational Testing Factor

SF = Approximate savings factor based on regional temperature bin data (assume 4576 for equipment under 5.4 tons where a fixed damper is assumed for the baseline and 3318 for larger equipment where a dry bulb economizer is assumed for the baseline). (Units for savings factor are in kWh x rated EER per ton of cooling or kWh*EER/Ton)

Cap = Capacity of connected cooling load (tons)

Eff = Cooling equipment energy efficiency ratio (EER)

Operating Hours = 4,438 = Approximate number of economizer operating hours

Duel Enthalpy Economizers

Component	Type	Value	Source
OTF	Fixed	1.0 when operational testing is performed, 0.8 otherwise	
SF		4576 for equipment under 5.4 tons, 3318 otherwise	1
Cap	Variable		Application
Eff	Variable		Application
Operating Hours	Fixed	4,438	2

Sources:

3. DOE-2 Simulation Modeling
4. ClimateQuest Economizer Savings Calculator

Electronic Fuel-Use Economizers

These devices are microprocessor-based fuel-saving controls for commercial HVAC. They optimize energy consumption by adjusting burner or compressor run patterns to match the system's load. They can be used to control gas or oil consumption for any type of boiler or forced air furnace system. There are also fuel use economizers available that control the electric consumption for commercial air conditioning and refrigeration units by optimizing compressor cycles to maximize energy efficiency.[1]

A recent study of Fuel-use economizer controls by the New York State Energy Research and Development Authority (NYSERDA) in conjunction with Brookhaven National Laboratories (BNL) found that the typical energy savings for these devices generally varies between 10.08% and 19.15%, when used under normal operating conditions and normalized for typical annual degree-days in the New York metro area.[2] The NYSERDA study tested at each of the different models of fuel-use economizers manufactured by *Intellidyne, LLC*, (under the brand name *IntelliCon*). Operational data was recorded for various commercial heating, cooling, and refrigeration systems (of different sizes and fuel types) with and without the *IntelliCon* fuel-use economizers added. The average energy savings across all system and fuel types and operational conditions was found to be 13%. Another study of *IntelliCon* fuel-use economizers by Consolidated Edison, Inc. (ConEd) found a similar range of savings for the devices when the devices were studied as a control option for commercial refrigeration units at supermarkets in New York City and the surrounding area.[3]

Test results in both studies showed a very good payback for the devices across all applications studied. However, no discernable pattern was evident to determine which installations are most likely to yield the highest savings. Though actual savings will vary somewhat from project to project, it is reasonable to assume that program-wide energy savings across all approved fuel-use economizers measures will likely be close to the average savings found in the NYSERDA study. Annual energy savings for each approved fuel-use economizer installation (for any *IntelliCon* brand or equivalent devices) can be estimated as simply 13% of the expected annual energy usage for the HVAC (or refrigeration) system without the device.

Algorithms

Electric Savings (kWh) = (AEU * 0.13)

Fuel Savings (MMBtu) = (AFU * 0.13)

Definition of Variables

AEU = Annual Electric Usage for an uncontrolled AC or refrigeration unit (kWh)

AFU = Annual Fuel Usage for an uncontrolled (gas, oil, propane) HVAC unit (MMBtu or gallons)

Notes:

(1) Some examples of the different types of fuel-use economizer controls available on the market can be found at: http://www.intellidynellc.com/02_prods.htm

(2) NYSERDA (2007) "A Technology Demonstration and Validation Project for Intellidyne Energy Saving Controls".

(3) ConEd Solutions (2000) "Report on Intellidyne Unit Installation at Six Key Food Supermarkets".

Low Flow Devices

Low flow showerheads, faucet aerators and pre-rinse spray valves save water heating energy by reducing the total flow rate from water sources.

The measurement of energy savings associated with low flow devices is based on algorithms with key variables provided through Fisher-Nickel's Life Cycle cost calculators.

Algorithms

Savings = N x (60 x H x D x (F_{base} – F_{eff}) x 8.33 x DT x (1/Eff)/ C

Definition of Variables

60 = Conversion from hours to minutes

N = Number of fixtures

H = Hours per day of device usage

D = Days per year of facility operation

F_{base} = Baseline device flow rate (gal/m)

F_{eff} = Low flow device flow rate (gal/m)

8.33 = Heat content of water (Btu/gal/°F)

DT = Difference in temperature (°F) between cold intake and output

Eff = Percent efficiency of water heating equipment

C = Conversion factor from Btu to Therms or kWh (100,000 for gas water heating (Therms), 3,413 for electric water heating (kWh))

Low Flow Devices

Component	Type	Value	Source
N	Variable		Application
H	Fixed	3 for pre-rinse spray valves	1
H	Fixed	20 minutes for showerheads 30 minutes for aerators	2
D	Variable		Application
F_{base}	Variable		Application
F_{eff}	Variable	Max of 1.0 gpm for lavatory aerators, 2.2 for kitchen aerators and 2.0 gpm for showerheads per EPA's Water Sense Label	Application
DT	Fixed	50°F for showerheads and faucet aerators, 70°F for pre-rinse spray valves	1
Eff	Variable	default of 80% for gas water heaters and 95% for electric water heaters	Application

Sources:

1. Fisher-Nickel Life Cycle cost calculator
2. FEMP Cost Calculator located at http://www1.eere.energy.gov/femp/technologies/eep_faucets_showerheads_calc.html

Demand Control Ventilation Using CO_2 Sensors

Demand control ventilation (DCV) monitors indoor air CO_2 content as a result of occupancy production levels and uses this data to regulate the amount of outdoor air that is permitted for ventilation. In order to ensure adequate air quality, standard ventilation systems permit outside air based on estimated occupancy levels in CFM/occupant. However, during low occupancy hours, the space may become over ventilated due to decreased CO_2 levels. This air must be conditioned and, therefore, unnecessary ventilation results in wasted energy. DCV reduces unnecessary outdoor air intake by regulating ventilation based on actual CO_2 levels, saving energy. DCV is most suited for facilities where occupancy levels are known to fluctuate considerably.

The measurement of energy savings associated with DCV is based on hours of operation, occupancy schedule, return air enthalpy, return air dry bulb temperature, system air flow, outside air reduction, cooling system efficiency, and other factors. As a conservative simplification of complex algorithms, DCV is assumed to save 5% of total facility HVAC load in appropriate building types based on FEMP DCV documentation.

Algorithms

Electric Savings (kWh) = $0.05 * HVAC_E$

Gas Savings (Therms) = $0.05 * HVAC_G$

Definition of Variables

$HVAC_E$ = Total electric HVAC consumption (kWh)

$HVAC_G$ = Total gas HVAC consumption (Therms)

Demand Control Ventilation Using CO_2 Sensors

Component	Type	Value	Source
$HVAC_E$	Variable		Application
$HVAC_G$	Variable		Application

Pipe Insulation

Un-insulated hot water carrying pipes lose considerable heat to outside air due to high thermal conductivity. In order to reduce this heat loss, pipes can be covered with a layer of fiberglass insulation, which will reduce source heating demand, resulting in significant energy savings.

The measurement of energy savings associated with pipe insulation is based on the length of the supply pipe, pipe diameter, relative thermal conductivity of bare and insulated piping and the temperature difference between supplied water and outside air temperature as indicated in the EPRI report referenced below. The baseline case is un-insulated copper pipe and the default proposed case is 0.5” of fiberglass insulation.

Algorithms

Energy Savings (kWh) = $(L*(HLC_{base}-HLC_{ee})/C)*\Delta T*8{,}760$

Definition of Variables

L = Length of pipe from water heating source to hot water application (ft)

HLC_{base} = Pipe heat loss coefficient by pipe diameter (baseline) (Btu/hr-°F-ft)

HLC_{ee} = Pipe heat loss coefficient by pipe diameter (proposed) (Btu/hr-°F-ft)

C = Conversion from Btu to kWh or Therms (3,413 for kWh (Electric Water Heating), 100,000 for Therms (Gas Water Heating)

ΔT = Average temperature difference between supplied water and outside air temperature (°F)

8,760 = Hours per year

Pipe Insulation

Component	Type	Value	Source
L	Variable		Application
HLC_{base}	Fixed	See Table Below	
HLC_{ee}	Fixed	See Table Below	
ΔT	Variable	Default is 65°F	EPRI Study

Pipe Heat Loss Coefficient Table

Pipe Diam. (in.)	HLC_{base}	HLC_{ee}
0.75	0.43	0.25
1.00	0.54	0.29
1.25	0.64	0.33
1.50	0.76	0.36
2.00	0.94	0.42
2.50	1.00	0.48
3.00	1.30	0.56
4.00	1.70	0.69

Source: Engineering Methods for Estimating the Impacts of Demand-Side Management Programs, Volume 2, EPRI, 1993

Lighting and Lighting Controls

For lighting and lighting control projects performed by Direct Install programs, use the C&I prescriptive lighting tables for the lighting types identified within those tables. For any fixtures not listed on the table, go to the source table for that fixture. If the fixture is not on the source table, then use manufacture cut sheets for replacement kW to calculate the savings.

C&I Large Energy Users Incentive Program

The purpose of the program is to foster self-investment in energy-efficiency, and combined heat and power projects while providing necessary financial support to large commercial and industrial utility customers in New Jersey.

Protocols

Please refer to the Pay for Performance protocols to calculate demand and energy savings for the Large Energy Users Program. If a project addresses a specific end-use technology, protocols for that technology should be used.

SREC Registration Program (SRP)

Protocols

The energy and demand impacts for customer sited generation systems participating in the program are based on algorithms that estimate each systems annual energy production and coincident peak capacity production.[15] Input data are based on fixed assumptions, engineering estimates and data supplied from the program's technical worksheets and inspection forms. The reported generation will be based on as installed conditions, as verified by site inspection documentation.

For solar electric generation, an industry standard calculation tool (PVWATTS from the National Renewable Energy Laboratory) is used for estimating PV system annual outputs.

For wind installations estimated annual energy output is calculated using approved wind resource data maps, wind speed at proposed hub height, and approved annual estimated power curves for each turbine.

For fuel cell and sustainable biomass projects the protocols include recommended formats but the energy and peak capacity for each project will be estimated on a case by case basis. This level of flexibility allows for the use of more detailed case specific engineering data in the protocol reporting.

For all technicalities, the customer sited generation protocols report the gross electrical generation from the system. Therefore, for example, the estimates for production from sustainable biomass projects do not account for estimated consumption of the applicable biomass fuel.

The following is an explanation of the algorithms used and the nature and source of all required input data.

<u>Algorithms</u>

Photovoltaic Systems

PVWATTS (Version 1) is used to estimate the energy generated by photovoltaic systems. PVWATTS was developed and is available through the Renewable Resource Data Center (RReDC). The RReDC is supported by the National Center for Photovoltaics (NCPV) and managed by the Department of Energy's Office of Energy Efficiency and Renewable Energy. The RReDC is maintained by the Distributed Energy Resources Center of the National Renewable Energy Laboratory. The subroutines used to calculate the energy generation are based on information developed by Sandia National Laboratories. PVWATTS is available

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[15] The protocols and algorithms included in this section to determine savings for renewable generation systems are considered out-of-date. Substantial revisions are currently under development and will be included in future versions of the protocols.

through the RReDC website, http://rredc.nrel.gov/solar/codes_algs/PVWATTS/. Note that program generation algorithms have used Version 1 of PVWATTS.

The following input values are used by PVWATTS to estimate average annual energy production. These are collected and/or are available for each PV project on the PV technical worksheet and inspection documentation.

- System Rated Output (AC output based on DC output at Standard Rating Conditions and default DC/AC ratings)
- Fixed, Single or Double Axis Tracking
- Array Tilt angle (for fixed axis only)
- Array Azimuth (for fixed axis only)
- Weather data (based on closest weather station data for Version 1)

The Peak demand impact for photovoltaic systems is estimated separately from the annual energy output. Summer and winter peak impacts are based on research conducted by Richard Perez, of SUNY Albany, (http://www.nrel.gov/ncpv/documents/pv_util.html). The estimated summer effective load carrying capacity (ELCC) for New Jersey is 60% to 70%. A value of 65% is adopted for these protocols.

Summer Peak Impact (kW) = System Rated Output * Summer Effective Load Carrying Capacity (ELCC).

Winter Peak Impact (kW) = System Rated Output * Winter Effective Load Carrying Capacity (WELCC).

A summary of the input values and their data sources follows:

Photovoltaic Systems

Component	Type	Value	Sources
System Rated Output (SRO)	Variable		Application Technical Worksheet, and inspection documentation
Fixed, Single, Double Axis tracking	Variable		Application Technical Worksheet, and inspection documentation
Array Tilt	Variable		Application Technical Worksheet, and inspection documentation
Azimuth Angle	Variable		Application Technical Worksheet, and inspection documentation
Weather Data	Variable	City, State – four sites will be used (Wilkes Barre PA,	Application Technical Worksheet – Version 2 if adopted provides average

Component	Type	Value	Sources
		Newark NJ, Philadelphia PA, and Atlantic City, NJ	resource data based on 40 km square grid.
ELCC	Fixed	65%	(http://www.nrel.gov/ncpv/documents/pv_util.html)
WELCC	Fixed	8%	Monitored system data from White Plains NY

Wind Systems

Estimated annual energy output for wind systems will be based on the program's method for calculating the Expected Performance Based Buy-down for system rebates. These calculations are derived from industry data resources and calculation methods. Currently there is a lack of data on the peak impact of small wind systems in New Jersey and an estimate of 0% will be used. This value will be updated if supporting data are identified.

Annual Energy Output (kWh) is a function of:

- Average annual wind speed (using one of three approved wind resource maps) at 50 meters for the proposed site
- The proposed hub height for the turbine
- An approved annual energy output curve for each turbine

Data summary of the input values and their data sources follows:

Wind Systems

Component	Type	Value	Sources
Average annual wind speed at 50 meters (m/s) or (mph)	Variable		Application Technical Worksheet, verified by checking against approved wind resource maps
Turbine hub height as installed	Variable		Application Technical Worksheet, verified by inspection documentation
Annual energy output power curve for proposed turbine	Variable look up based on wind speed and hub height at each location		Annual energy output power curves based on manufacturer's published data. Values checked against industry experience and acceptance for use in other jurisdictions.
Summer Peak Impact	Fixed	0%	Data on peak impact not available at this time

Component	Type	Value	Sources
Winter Peak Impact	Fixed	0%	Data on peak impact not available at this time

Sustainable Biomass

Estimated annual energy output and peak impacts for sustainable biomass systems will be based on case specific engineering estimates and manufacturer data.

SREC-Only Program

The measurement of energy and demand impacts for photovoltaic systems participating in the SREC-Only program is based on the rules and protocols for metering, reporting and verification in N.J.A.C. 14:8-2.9. For systems less than 10 kW, the methods used in the SRP section about for estimating each system's annual energy production and coincident peak capacity production are acceptable. For systems greater than 10 kW must submit megawatt-hour production of electrical energy. Reported generation will be based on as installed conditions, as verified by site inspection documentation.

Renewable Energy Program: Grid Connected

Energy savings/generation for projects installed pursuant to the Renewable Energy Program: Grid Connected will be determined on a case-by-case basis based on the information provided by project applicants, and inspection data for verification of as- installed conditions. The reported savings for each project participant in the REDI will be calculated and presented for review by the Office of Clean Energy.

Appendix A
Measure Lives

NEW JERSEY STATEWIDE ENERGY-EFFICIENCY PROGRAMS
Measure Lives Used in Cost-Effectiveness Screening
April 2012

If actual measure lives are available through nameplate information or other manufacturing specifications with proper documentation, those measure lives should be utilized to calculate lifetime savings. In the absence of the actual measure life, Protocol measure lives should be utilized.

PROGRAM/Measure	Measure Life
Residential Programs	
Energy Star Appliances	
ES Refrigerator post 2001	12
ES Refrigerator 2001	12
ES Dishwasher	10
ES Clothes washer	11
ES Dehumidifier	11
ES RAC	10
ES Set Top Box	4
Advanced Power Strips	4
ES Clothes Dryer	12
Energy Star Lighting	
CFL	5
Indoor Fluorescent Fixture	20
Torchiere Residential	10
Fixtures Other	20
LED	20
Energy Star Windows	20
WIN-heat pump	20
WIN-gas heat/CAC	20
WIN-gas No CAC	20
WIN-oil heat/CAC	20
WIN-oil No CAC	20
Win-elec No AC	20
Win-elec AC	20
Refrigerator/Freezer Retirement	

Refrigerator/Freezer retirement	8
Residential New Construction	
SF gas w/CAC	20
SF gas w/o CAC	20
SF oil w/CAC	20
SF all electric	20
TH gas w/CAC	20
TH gas w/o CAC	20
TH oil w/CAC	20
TH all electric	20
MF gas w/AC	20
MF gas w/o AC	20
MF oil w/CAC	20
MF all electric	20
ES Clothes washer	20
Recessed Can Fluor Fixture	20
Fixtures Other	20
Efficient Ventilation Fans w/Timer	10

PROGRAM/Measure	Measure Life
Residential Programs	
Residential Electric HVAC	
CAC 13	15
CAC 14	15
ASHP 13	15
ASHP 14	15
CAC proper sizing/install	15
CAC QIV	15
CAC Maintenance	7
CAC duct sealing	15
ASHP proper sizing/install	15
E-Star T-stat (CAC)	15
E-star T-stat (HP)	15
GSHP	30
CAC 15	15
ASHP 15	15
Residential Gas HVAC	
High Efficiency Furnace	20
High Efficiency Boiler	20
High Efficiency Gas DHW	10
E-Star T-stat	15

Boiler Reset Controls	7
Low-Income Program	
Air sealing electric heat	30
Duct Leak Fossil Heat & CAC	15
typical fossil fuel heat	17
typical electric DHW pkg	10
typical fossil fuel DHW pkg	10
screw-in CFLs	6.4
high-performance fixtures	20
fluorescent torchieres	10
TF 14	20
TF 16	20
TF 18	20
SS 20	20
TF 21	20
SS 22	20
TF 25	20
audit fees	20
Attic Insulation- ESH	30
Duct Leak - ESH	15
T-Stat- ESH	5
HP charge air flow	8
electric arrears reduction	1
gas arrears reduction	1
Home Performance with ENERGY STAR	
Blue Line Innovations – PowerCost MonitorTM	5

PROGRAM/Measure	Measure Life
Non-Residential Programs	
C&I Construction	
Commercial Lighting — New	15
Commercial Lighting — Remodel/Replacement	15
Commercial Lighting Controls — Remodel/Replacement	18
Commercial Custom — New	18
Commercial Chiller Optimization	18
Commercial Unitary HVAC — New - Tier 1	15
Commercial Unitary HVAC — Replacement - Tier 1	15
Commercial Unitary HVAC — New - Tier 2	15
Commercial Unitary HVAC — Replacement Tier 2	15
Commercial Chillers — New	25
Commercial Chillers — Replacement	25

Commercial Small Motors (1-10 HP) — New or Replacement	20
Commercial Medium Motors (11-75 HP) — New or Replacement	20
Commercial Large Motors (76-200 HP) — New or Replacement	20
Commercial VSDs — New	15
Commercial VSDs — Retrofit	15
Commercial Air Handlers Units	20
Commercial Heat Exchangers	24
Commercial Burner Replacement	20
Commercial Boilers	25
Commercial Controls (electric/electronic)	15
Commercial Controls (Pneumatic)	10
Commercial Comprehensive New Construction Design	18
Commercial Custom — Replacement	18
Industrial Lighting — New	15
Industrial Lighting — Remodel/Replacement	15
Industrial Unitary HVAC — New - Tier 1	15
Industrial Unitary HVAC — Replacement - Tier 1	15
Industrial Unitary HVAC — New - Tier 2	15
Industrial Unitary HVAC — Replacement Tier 2	15
Industrial Chillers — New	25
Industrial Chillers — Replacement	25
Industrial Small Motors (1-10 HP) — New or Replacement	20
Industrial Medium Motors (11-75 HP) — New or Replacement	20
Industrial Large Motors (76-200 HP) — New or Replacement	20
Industrial VSDs — New	15
Industrial VSDs — Retrofit	15
Industrial Custom — Non-Process	18
Industrial Custom — Process	10
Industrial Air Handler Units	20
Industrial Heat Exchangers	20
Industrial Burner Replacements	20
Small Commercial Gas Furnace — New or Replacement	20
Infrared Heating	17
Small Commercial Gas Boiler — New or Replacement	20
Small Commercial Gas DHW — New or Replacement	10
C&I Gas Absorption Chiller — New or Replacement	25
C&I Gas Custom — New or Replacement (Engine Driven Chiller)	25
C&I Gas Custom — New or Replacement (Gas Efficiency Measures)	18

PROGRAM/Measure	Measure Life
Non-Residential Programs	

Building O&M	
O&M savings	3
Compressed Air	
Compressed Air (GWh participant)	8
Refrigeration	
Evaporator Fan Control	10
Cooler and Freezer Door Heater Control	10
Polyethylene Strip Curtains	4
Food Service	
Fryers	12
Steamers	10
Griddles	12
Ovens	12

PROGRAM/Measure	Measure Life
Solar Panels	25
CHP System ≤1 MW	15
CHP System >1 MW	20
Fuel Cells	10

* For custom applications, projects will be evaluated upon industry/manufacturer data but not to exceed value in above table unless authorized by the Market Manager. Reported savings will be calculated per measure life indicated in this table.

Applied Public Policy Research
APPRISE
Institute for Study and Evaluation

MEMO

DATE: June 27, 2014

TO: NJ CP Utility Working Group

FROM: Jackie Berger

SUBJECT: NJ Comfort Partners Energy Saving Protocols and Engineering Estimates

This memo provides a review of the NJ Comfort Partners Energy Saving Protocols, recommends changes to the protocols and additional protocols for measures not included, and calculates Engineering Estimates for those proposed energy savings formulas.

I. Introduction

NJ Comfort Partner's Energy Saving Protocols are an important aspect of the program, as they are used to estimate program savings. The protocols are used to assess program impacts and calculate energy and resource savings for the following purposes.

- Report to the Board on program performance.
- Inputs for planning and cost-effectiveness calculations.
- Calculation of lost margin revenue recovery (as approved by the BPU).
- Determination of eligibility for administrative performance incentives.[1]
- Assessment of the environmental benefits of program implementation.

In this memo, we utilize findings from the evaluation to make recommendations for updating the protocols. The following research and analyses are summarized in this document.

1. Review of the calculations made with the current protocols using data in NJ CP database. The purpose of this review is to ensure that Protocol Savings Estimates are calculated in accordance with the procedures that are currently in place.

2. Recommend changes for existing protocols that can be refined to take additional information into account or to more accurately estimate savings.

3. Recommend additional protocols for measures that do not have protocols or are being considered for addition to the program.

4. Provide engineering estimates for new and recommended changes to protocols.

[1] To the extent that such incentives are approved by the BPU.

This memo provides recommendations based on research and review of the literature. An additional memo will provide details on a variety of protocols used in other programs and source documentation for those protocols.

II. Review of Energy Saving Protocol Calculations

We reviewed the current protocols and checked the calculations in the NJ CP database to ensure that savings are calculated correctly.

A. Baseload

All baseload protocols were calculated in accordance with the formulas summarized below.

Savings = Δ Watts/1000 * Hours Used * 365 Days

1. *CFLs*

   Fixed Values
   - Δ Watts = 42
   - Hours = 2.5

   Projected savings = 38.33 kWh

2. *Fixtures*

   Fixed Values
   - Δ Watts = 110
   - Hours = 3.5

   Projected savings = 140.52 kWh

3. *Lamp*

   Fixed Values
   - Δ Watts = 245
   - Hours = 3.5

   Projected savings = 312.99 kWh

B. Hot Water

All hot water protocols were calculated in accordance with the formulas summarized below.

1. *Electric*

   Average package of domestic hot water measures
   Projected savings = 178 kWh

2. *Gas*

   Average package of domestic hot water measures

Projected savings = 1.01 MMBTU = 9.85 ccf

C. Refrigerators

The refrigerator and freezer protocols were calculated in accordance with the formulas summarized below. However, no savings were calculated for additional refrigerator or freezer removal without replacement.

Savings = Baseline Refrigerator kWh – New Refrigerator kWh

The baseline refrigerator kWh is based upon the contractor metering or refrigerator usage lookups. Contractors provided a table of rated values of replacement refrigerator usage for inclusion in the calculation.

D. Space Conditioning

The following space conditioning Energy Saving protocols were reviewed.

1. *Air Sealing*

   All air sealing protocols were calculated in accordance with the formulas summarized below. In most cases, the gas seasonal use was estimated by subtracting 300 ccf from gas usage as shown below. However, in a few cases, the seasonal gas usage was included in the database and used in the calculation.

   - Electricity Savings = Pre-Treatment Electric Space Consumption * .05
   - Gas Savings = Pre-Treatment Gas Space Consumption * .05

   Pre-Treatment Gas Space Consumption = Pre Gas Consumption – 300 ccf (if seasonal use is not available.)

2. *Furnace/Boiler Replacement*

   The furnace/boiler savings calculated in accordance with the formula below do not match the protocol savings reported in the NJ CP database.

   Savings = [(Capyq/AFUELI) – (Capyq/ AFUEq)] * EFLH / 100,000 BTUs/therm

   - Capyq = Output capacity of qualifying unit output in BTUs/hour
   - AFUELI = Annual Fuel Utilization Efficiency of the Low Income Program replaced furnace or boiler.
   - AFUEq = Annual Fuel Utilization Efficiency of the qualifying baseline furnace or boiler.
   - EFLH = Equivalent full load hours of operation for the average unit. This value is fixed at 965 for heating and 600 for cooling hours.

3. *Duct Sealing and Repair with Central Air Conditioning*

   All duct sealing and repair with central air conditioning protocols were calculated in accordance with the formulas summarized below. In most cases, the gas seasonal use was estimated by subtracting 300 ccf from gas usage as shown below. However, in a few cases, the seasonal gas usage was included in the database and used in the calculation.

   - Electricity Savings = Pre-Treatment Electric Space Consumption * .10

- Gas Savings = Pre-Treatment Gas Space Consumption * .0.02

  Pre-Treatment Gas Space Consumption = Pre Gas Consumption – 300 ccf (if seasonal use is not available.)

4. *Duct Sealing and Repair without Central Air Conditioning*
   All duct sealing and repair without central air conditioning protocols were calculated in accordance with the formulas summarized below. In most cases, the gas seasonal use was estimated by subtracting 300 ccf from gas usage as shown below. However, in a few cases, the seasonal gas usage was included in the database and used in the calculation.

   - Electricity Savings = Pre-Treatment Electric Space Consumption * .02
   - Gas Savings = Pre-Treatment Gas Space Consumption * .02

     Pre-Treatment Gas Space Consumption = Pre Gas Consumption – 300 ccf (if seasonal use is not available.)

5. *Insulation Upgrades*
   All insulation protocols were calculated in accordance with the formulas summarized below. In most cases, the gas seasonal use was estimated by subtracting 300 ccf from gas usage as shown below. However, in a few cases, the seasonal gas usage was included in the database and used in the calculation.

   - Electricity Savings = Pre-Treatment Electric Space Consumption * .08
   - Gas Savings = Pre-Treatment Gas Space Consumption * .13

     Pre-Treatment Gas Space Consumption = Pre Gas Consumption – 300 ccf (if seasonal use is not available.)

6. *Thermostat Replacement*
   All thermostat replacement protocols were calculated in accordance with the formulas summarized below. In most cases, the gas seasonal use was estimated by subtracting 300 ccf from gas usage as shown below. However, in a few cases, the seasonal gas usage was included in the database and used in the calculation.

   - Electricity Savings = Pre-Treatment Electric Space Consumption * .03
   - Gas Savings = Pre-Treatment Gas Space Consumption * .03

     Pre-Treatment Gas Space Consumption = Pre Gas Consumption – 300 ccf (if seasonal use is not available.)

7. *Heating and Cooling Equipment Maintenance Repair/Replacement*
   All electric replacement protocols were calculated in accordance with the formulas summarized below.

   - Electricity Savings = Pre-Treatment Electric Space Consumption * .17
   - Gas Savings – No protocol provided

III. Recommended Changes to Current Protocols

We recommend the following changes to existing protocols.

- *Refrigerator Removal* – Refrigerator removal savings are not included in the NJ Comfort Partners Energy Saving Protocols. The refrigerator removal savings should be estimated as the annual metered usage of the refrigerator that was removed. NJ Comfort Partners should encourage extra refrigerator removal or two-for-one swaps and take credit for the savings from these removals.

- *Hot Water Measures* – Currently a fixed kWh or ccf savings amount is applied for a "standard package" of hot water measures. We recommend instead that separate savings are applied for each of the following measures as specified in the following section.

  - Hot Water Heater Replacement
  - Hot Water Tank Wrap
  - Hot Water Pipe Insulation
  - Aerators
  - Showerheads

- *Shell Measures* – The protocols currently apply the following thresholds for spending on air sealing, duct sealing, insulation, and HVAC before the percentage savings is applied.

  - Air Sealing - $100
  - Duct Sealing - $100
  - Insulation - $100
  - HVAC (electric) - $100
  - HVAC (gas) - $2,000

  The utilities asked APPRISE to review these thresholds. Below we provide an analysis and recommendations.

  <u>Air Sealing</u>
  Tables III-1A and III-1B display the relationship between spending on air sealing, mean protocol saving estimates, and total job savings from the usage impact analysis. Table III-1A shows that for gas jobs, the protocol savings estimates from air sealing are greater than the home's total usage impact savings for jobs with spending on air sealing of less than $200, and the protocol savings are almost equal to total gas savings from the usage impact analysis for jobs with spending between $200 and $300. Therefore, we recommend a spending threshold of at least $300 on air sealing for gas heating jobs before the five percent savings is applied to gas space consumption.

  Table III-1B displays similar results for air sealing on electric heating jobs. A less detailed analysis is presented here because there are a smaller number of these jobs. However, these results also suggest that a $300 or $400 threshold should be applied.

Table III-1A
Air Sealing Spending and Savings – Gas Heating Jobs

Air Sealing Spending	# Obs.	Mean Protocol Gas Savings (ccf)	Mean Total Gas Savings from Usage Impact Analysis (ccf)
≤$100	3	20	9
$101-$200	263	28	18
$201-$300	305	31	34
$301-$400	287	33	61
$401-$500	262	37	34
$501-$600	224	38	71
$600+	1,576	48	86
Total	**2,920**	**41**	**68**

Table III-1B
Air Sealing Spending and Savings – Electric Heating Jobs

Air Sealing Spending	# Obs.	Mean Protocol Electric Savings (kWh)	Mean Total Electric Savings from Usage Impact Analysis (kWh)
≤ $200	42	321	203
$201-$400	57	406	1,479
$401-$600	44	336	1,399
$601-$800	31	373	821
$801+	130	443	2,115
Total	**304**	**396**	**1,538**

Duct Sealing

Table III-2 displays the relationship between spending on duct sealing, mean protocol saving estimates, and total job savings from the usage impact analysis for gas heating jobs. The table also shows the percent of these jobs that had air sealing and insulation work and the average dollars spent on these other measures. This analysis is not provided for electric heating jobs, as there were many fewer electric heating jobs in total, and only 56 electric heating jobs with data on this measure.

The table shows that mean protocol gas savings for duct sealing range from 15 ccf for jobs that had $101 to $150 in spending on duct sealing to 19 ccf for jobs that had over $400 spent on duct sealing. It appears that $100 is a good threshold to use for spending before the percentage savings is applied. However, given that most of these jobs had air sealing and about half had significant insulation work as well, the two percent of gas space consumption savings for duct sealing may be too high of an estimate.

Table III-2
Duct Sealing Spending and Savings – Gas Heating Jobs

Duct Sealing Spending	# Obs.	Mean Protocol Gas Savings (ccf)	Mean Total Gas Savings from Usage Impact Analysis (ccf)	Percent with Air Sealing	Mean Air Sealing Spending	Percent with Insulation	Mean Insulation Spending
≤$100	0	-	-				
$101-$150	213	15	48	90%	$907	51%	$1,355
$151-$200	163	15	91	88%	$1,139	55%	$1,437
$201-$250	104	16	58	96%	$1,011	54%	$1,774
$251-$300	66	14	46	92%	$1,092	58%	$1,399
$301-$350	42	16	101	100%	$1,150	55%	$1,379
$351-$400	38	17	66	97%	$971	63%	$1,913
$401+	132	19	125	91%	$1,318	61%	$2,185
Total	758	16	75	92%	$1,075	55%	$1,626

Insulation

Table III-3 displays the relationship between spending on insulation, mean protocol saving estimates, and total job savings from the usage impact analysis for gas heating jobs. This analysis is not provided for electric heating jobs, as there were many fewer electric heating jobs in total, and only 187 electric heating jobs with data on this measure.

Table III-3 shows that for gas jobs, the protocol savings estimates from insulation are greater than the home's total usage impact savings for all jobs with spending on insulation of less than $900 with the current protocol of 13 percent of gas space heating consumption.

We propose that a lower percentage savings be applied for this measure. For illustration purposes, we divide the protocol savings by 3, for an approximate percentage of 4.33 percent of gas heating consumption saved. If a lower percentage around this level is applied, we recommend applying this percentage savings to jobs with at least $300 in spending on insulation.

Table III-3
Insulation and Savings – Gas Heating Jobs

Insulation Spending	# Obs.	Mean Protocol Gas Savings (ccf)		Mean Total Gas Savings from Usage Impact Analysis (ccf)
		Current (13%)	Proposed (4.33%)	
≤$100	0	-		-
$101-$200	56	85	28	9
$201-$300	78	94	31	59
$301-$400	60	88	29	59
$401-$500	53	87	29	83
$501-$600	59	103	34	56

Insulation Spending	# Obs.	Mean Protocol Gas Savings (ccf)		Mean Total Gas Savings from Usage Impact Analysis (ccf)
		Current (13%)	Proposed (4.33%)	
$601-$700	79	97	32	35
$701-$800	63	109	36	74
$801-$900	66	109	36	58
$901-$1,000	70	107	36	127
$1,001+	947	134	45	134
Total	1,531	120	40	109

HVAC

The current spending thresholds for HVAC measures are as follows and are much higher for gas than for electric to aim to separate installations of new systems from repairs.

- HVAC (electric) - $100
- HVAC (gas) - $2,000

We recommend that the separate replacement protocol is used for replacement rather than the repair, as shown in the following section of this memo. The NJ CP Protocols did not provide savings protocols for gas heating repairs. Following this change, the lower spending threshold for gas HVAC repairs can be implemented. The energy saving factor shown below is five percent, but may need to be adjusted depending on the type and amount of repair work that is performed.

- *Gas Usage Disaggregation* – Under the current protocols, baseload gas usage is assumed to be 300 ccf in most cases. The system should be programmed to disaggregate both gas and electric usage. This information can increase the accuracy of the Protocol Savings estimates. More importantly, the information should be provided to the contractors to help them diagnose energy usage issues in the home. Once the disaggregation is done by the system, the system can also calculate seasonal spending guidelines for the contractors.

IV. Additional Protocols

This section provides recommendations for additional protocols for the measures that do not have protocols or are being considered for addition to the program. Some of these measures have protocols in the NJ Clean Energy Program, but not for the Comfort Partners program. Where this happens, both the NJ Clean Energy Program protocol and an alternate protocol are provided in this section.

A. Combined Gas Boiler and Water Heater

These units have become common to replace both a gas boiler and water heater where there were previously two separate units. However, there are no existing protocol savings formulas for this measure as they were not considered when the protocols were developed.

There is not currently a separate measure code for combination units in the CP System, so this code should be added if this protocol is adopted.

The formula below is from Connecticut's 2012 program savings document.[2]

$$ACCF = ACCF_H + ACCF_w$$

$$ACCF_H = \frac{ABTU_H}{102{,}900}$$

$$ABTU_H = SF \times HF \times \left(\frac{1}{AFUE_E} - \frac{1}{AFEU_I}\right)$$

$$ACCF_W = \frac{ABTU_W}{102{,}900}$$

$$ABTU_W = ADHW \times \left(\frac{1}{AFUE_E} - \frac{1}{AFEU_I}\right)$$

$$ADHW = GPY \times 8.3 \times (T_{dhw} - T_{aiw})$$

Table IV-1
Definitions and Values for Combined Boiler and Water Heater Protocol

Term	Definition	Value
ACCF	Annual natural gas savings (Ccf/year)	
$ACCF_H$	Annual natural gas savings – heating (Ccf/year)	
$ACCF_W$	Annual natural gas savings – water heating (Ccf/year)	
$ABTU_H$	Annual Btu savings – heating (Btu/year)	
SF	Heated area served by boiler (square feet)	
HF	Heating factor based on age of home (Btu/ft^2/year)	See Table IV-2
$AFUE_E$	Annual fuel utilization efficiency, existing	See Table IV-3
$AFUE_I$	Annual fuel utilization efficiency, installed	83%
ADHW	annual domestic water heating load (Btu)	11,197,132 Btu
GPY	Annual domestic home water usage (gallons)	19,839 gallons
T_{dhw}	Domestic hot water heater set point	125°F
T_{aiw}	Average annual incoming water temperature	57°F
102,900	Conversion factor: Btu per ccf natural gas	
8.3	Conversion factor: density of water	

Table IV-2
Heating Factor (HF) Based on Home Age

Year Built (YRh)	HF (Btu/ft^2/year)
Before 1940	45,000
1940 to 1949	41,400

[2]Connecticut Light and Power and United Illuminating. "Connecticut Program Savings Document, 8th Edition for 2013 Program Year." October 30, 2012. Pages 143-148, 241-242.

Year Built (YRh)	HF (Btu/ft²/year)
1950 to 1959	38,700
1960 to 1969	36,000
1970 to 1979	33,300
1980 to 1989	30,600
1990 to 1999	27,900
2000 to present	26,100

Table IV-3
Existing Boiler AFUE Based on Boiler Age

Year Boiler Installed (YRe)	Gas AFUE
Before 1960	60%
1960 to 1969	60%
1970 to 1974	65%
1975 to 1983	65%
1984 to 1987	70%
1988 to 1991	77%
1992 to present (baseline)	80%

B. HVAC Repair – Gas Savings

While the protocols included electric savings for HVAC repairs, they did not include gas savings. The formula below is for gas savings from New York's 2010 Technical Resource Manual.[3]

$$\Delta therms = units \times \left(\frac{kBtuh_{in}}{unit}\right) \times \left(\frac{EFLH}{100}\right) \times ESF$$

$$EFLH_{heat} = \frac{Annual\ Heating\ Energy}{Nameplate\ capacity}$$

Table IV-4
Definitions and Values for Gas HVAC Repairs

Term	Definition	Value
Δtherms	Gross annual gas savings	
Units	Number of units repaired	
kBtuh/unit	Nominal heating input capacity in kBtu/hour	
$EFLH_{heat}$	heating equivalent full-load hours (relative to nameplate)	
ESF	Energy savings factor	0.05

[3] "New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs (Technical Resource Manual – TRM) Record of Revision." November 26, 2013. Page 68.

C. Hot Water Heater Replacements

The gas savings for hot water heater replacements is calculated in the NJ Clean Energy Protocols as follows.

$$\text{Gas Savings} = [(EF_q - EF_b)/EF_q] * DHW_{use}$$

Table IV-5
Definitions and Values for Hot Water Gas Heater Replacements

Term	Definition	Value
EF_q	Energy factor of qualifying water heater	If not rated: 41,0942/(41,094/TE + Volume*SLratio*24hours)
TE	Thermal efficiency of the unit	
Volume	Volume of water heater in gallons	
SLratio	Average ratio of rated standby losses	9.73
EB_q	Energy factor of baseline heater	.67 – (.0019*Gallons of Capacity)
DHW_{use}	Annual baseline water heater usage	180 Therms

Savings for hot water heater replacements from New York's 2013 Technical Resource Manual are as follows[4,5]

$$\Delta kW_s = units \times \left[\frac{(UA_{base} - UA_{ee}) \times \Delta T_s}{3{,}413}\right] \times DF_s \times CF_s$$

$$\Delta kWh = units \times \left(\frac{GPD \times 365 \times 8.33 \times \overline{\Delta T_w}}{3{,}413}\right) \times \left(\frac{1}{EF_{base}} - \frac{1}{EF_{ee}}\right)$$

$$\Delta therm = units \times \left(\frac{GPD \times 365 \times 8.33 \times \overline{\Delta T_w}}{100{,}000}\right) \times \left(\frac{1}{EF_{base}} - \frac{1}{EF_{ee}}\right)$$

Table IV-6
Definitions and Values for Hot Water Heater Replacements

Term	Definition
ΔkW_s	Gross coincident demand savings
ΔkWh	Gross annual energy savings
$\Delta therm$	Gross annual gas savings
Units	Number of high efficiency water heaters installed under program
UA_{base}	Overall heat loss coefficient of base water heater (Btu/hour-°F)
UA_{ee}	Overall heat loss coefficient of efficient water heater (Btu/hour-°F)
ΔT_s	Temperature difference between the stored hot water and the surrounding air (°F)

[4] New York Evaluation Advisory Contractor Team and TecMarket Works. "New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs; Residential, Multi-Family, and Commercial/Industrial Measures." October 15, 2010. Page 79.

[5] "New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs (Technical Resource Manual – TRM) Record of Revision." November 26, 2013. Page 12.

Term	Definition
GPD	Average daily water consumption (gallons/day)
ΔT_w	Average difference between cold inlet temperature and hot water temperature (°F)
EF_{base}	Baseline water heater energy factor
EF_{ee}	Efficient water heater energy factor
365	Conversion factor: days per year
8.33	Conversion factor: Btu per gallon-°F
3,413	Conversion factor: Btu per kWh
100,000	Conversion factor: Btu per therm

Table IV-7
Average Annual Incoming Water Temperature in New York

City	Average Annual Outdoor Temperature (°F)	Temperature of Water Mains (°F)
Albany	48.2	54.2
Binghamton	46.9	52.9
Buffalo	48.3	54.3
Massena	44.7	50.7
Syracuse	48.6	54.6
Upstate Average	47.3	53.3
New York City	56.5	62.5

D. Drain Water Heat Recovery System (GFX) Installation

Contractors have not installed this measure, as it is difficult to find opportunities. However, the utilities would like to encourage contractors to install GFX.

The New Jersey Clean Energy Program has assumed a constant savings per installed drain water heat recovery unit in a household with an electric water heater and a percentage savings for drain water heat recovery installation in a home with a gas hot water heater.

- Electric Savings = 1,457 kWh
- Gas Savings = Baseline gas water heater usage * .30

The formula below is from the Minnesota Technical Reference Manual from 2014.[6]

$$\frac{Unit\ kWh\ savings}{year} = \left(\frac{Energy\ to\ heat\ water}{Eff}\right) \times \left(\frac{Savings\ factor}{Conversion\ factor}\right)$$

[6]Minnesota Department of Commerce. “State of Minnesota Technical Reference Manual for Energy Conservation Improvement Programs Version 1.0.” Effective January 1-December 31, 2014. Pages 212-213. Savings factor – Drain pipe heat exchange savings estimates are based on study findings reported in a communication from J. J. Tomlinson, Oak Ridge Buildings Technology Center, to Marc LaFrance, DOE Appliance and Emerging Technology Center, DOE, August 24, 2000, suggesting 25 to 30% of water heating consumption savings potential. The lower end of the savings scale was chosen for this report, assuming ideal installation for the study. From: Minnesota Department of Commerce. “State of Minnesota Technical Reference Manual for Energy Conservation Improvement Programs Version 1.0.” Effective January 1-December 31, 2014. Page 214.

$$\frac{Unit\ Dth\ savings}{year} = \left(\frac{Energy\ to\ heat\ water}{Eff}\right) \times \left(\frac{Savings\ factor}{Conversion\ factor}\right)$$

$$Energy\ to\ heat\ water = Specific\ heat \times Density \times \frac{Gal}{Day} \times \frac{365.25\ Days}{Year} \times (T_{set} - T_{cold})$$

Table IV-8
Definitions and Values for GFX Installation

Term	Definition
Gal/day	Average gallons per day of hot water (Table IV-9)
T_{set}	Water heater temperature setting
T_{cold}	Average groundwater temperature
0.25	Savings factor
Eff	Energy factor of water heater
1.0	Conversion factor: specific heat of water (Btu/lb.-°F)
8.34	Conversion factor: density of water (lbs./gallon)
365.25	Conversion factor: days per year
3,412	Conversion factor (electric) Btu per kWh
1,000,000	Conversion factor (gas) Btu per Dth

Table IV-9
Daily Hot Water Usage by Building Type

Building Type	Daily Gal/Person*	Number of People**	Total Daily Hot Water Use (Gal/day)
Single-family	20.4	2.59	52.7
Multi-family	18.7	2.17	40.5

*Interpolated values from Table 38, Ohio Technical Reference Manual. October 15, 2009. Page 52.
**U.S. Census Bureau, *Selected Housing Characteristics 2010 American Community Survey 1-Year Estimates* for the state of Minnesota.

E. Heat Pump Water Heaters[7]

The New Jersey Clean Energy Program has assumed a constant savings per installed heat pump water heater.

- Electric Savings = 2,662 kWh

[7] Assumption taken from: Residential Water Heaters Technical Support Document for the January 17, 2001, Finale Rule Table 9.3.9, pp. 9-34, http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/09.pdf. Consistent with FEMP study: Field Testing of Pre-Production Prototype Residential Heat Pump Water Heaters, http://www1.eere.energy.gov/femp/pdfs/tir_heatpump.pdf.

Savings from New York's 2013 Technical Resource Manual are as follows[8,9]

$$\Delta kWh = units \times \left(\frac{GPD \times 365 \times 8.33 \times \overline{\Delta T_w}}{3{,}413}\right) \times \left(\frac{1}{EF_{base}} - \frac{1}{EF_{ee}}\right)$$

For electric water heaters:

$$EF_{base} = 0.93 - (0.00132 \times Volume)$$

For gas water heaters:

$$EF_{base} = 0.62 - (0.0019 \times Volume)$$

Table IV-10
Definitions and Values for Heat Pump Water Heaters

Term	Definition	Value
ΔkWh	Gross annual energy savings	
GPD	Gallons hot water per day	78 (see Table IV-11)
Units	Number of high efficiency water heaters installed under the program	
ΔT_w	Average difference between cold inlet temperature and hot water delivery temperature ($T_{set} - T_{main}$) (°F)	65°F
T_{set}	Hot water delivery temperature (°F)	130°F
T_{main}	Water mains temperature (cold inlet) (°F)	65°F (see Table IV-12)
EF_{base}	Baseline water heater energy factor	
EF_{ee}	Efficient water heater energy factor	2.2
365	Conversion factor: days per year	
8.33	Conversion factor: Btu per gallon-°F	
3,413	Conversion factor: Btu per kWH	

*Default value for family of four.
**Default value.

Table IV-11
Hot Water Use by Family Size in New York[10]

Number of people	Gal/person-day	Gal/day-household
1	29.4	29
2	22.8	46
3	20.6	62

[8]New York Evaluation Advisory Contractor Team and TecMarket Works. "New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs; Residential, Multi-Family, and Commercial/Industrial Measures." October 15, 2010. Pages 89-91.
[9]"New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs (Technical Resource Manual – TRM) Record of Revision." November 26, 2013. Pages 17-18.
[10] Average hot water use per person were taken from: Lutz, James D., Liu, Xiaomin, McMahan, James E., Dunham, Camilla, Shown, Leslie J., McCure, Quandra T; "Modeling patterns of hot water use in households;" LBL-37805 Rev. Lawrence Berkeley Laboratory, 1996.

Number of people	Gal/person-day	Gal/day-household
4	19.5	78
5	18.9	94
6	18.5	111

Table IV-12
Average Annual Incoming Water Temperature in New York[11,12]

City	Annual average outdoor temperature (°F)*	T mains (°F)**
Albany	48.2	54.2
Binghamton	46.9	52.9
Buffalo	48.3	54.3
Massena	44.7	50.7
Syracuse	48.6	54.6
Upstate average	47.3	53.5
NYC	56.5	62.5
Cold water entering temperatures (T mains) are approximately equal to the annual average outdoor temperature plus 6°F.		
Water heater set point for residential buildings is usually in the range of 120°F to 140°F.		

*Average annual outdoor temperatures were taken from the National Renewable Energy Laboratory TMY 3 long-term average weather data sets, processed with the DOE 2.2 weather data statistics package. www.nrel.gov
**Water mains temperatures were estimated from annual average temperature taken from: Burch, Jay and Craig Christensen; "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory.

F. Indirect Hot Water Heater

Savings from Wisconsin's 2013 Focus on Energy Deemed Savings are as follows.[13]

$$\Delta Therm = Therm_{Std} - Therm_{Eff}$$

$$Therm_{Out} = EF_{Std} \times Therm_{StdTank}$$

$$Therm_{Std} = Standby_{Std} \times 8{,}760 \times 1/100{,}000/AFUE_{Std} + Therm_{Out} \times 1/AFUE_{std}$$

$$Therm_{Eff} = Standby_{Eff} \times 8{,}760 \times 1/100{,}000/AFUE_{Eff} + Therm_{Out} \times 1/AFUE_{Eff}$$

$$Standby_{Std} = Vol_{Std} \times \left(\frac{°\mathrm{F}}{hr_{Std}}\right) \times 8.33$$

$$Standby_{Eff} = Vol_{Eff} \times \left(\frac{°\mathrm{F}}{hr_{Eff}}\right) \times 8.33$$

[11] Average annual outdoor temperatures were taken from the National Renewable Energy Laboratory TMY 3 long-term average weather data sets, processed with the DOE 2.2 weather data statistics package. www.nrel.gov
[12] Water mains temperatures were estimated from annual average temperature taken from: Burch, Jay and Craig Christensen; "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory.
[13] The Cadmus Group, Inc. "Final Report Focus on Energy Evaluated Deemed Savings Changes." *Prepared for the Public Service Commission of Wisconsin.* November 26, 2013. Pages 15-16.

Table IV-13
Definitions and Values for Indirect Hot Water Heaters

Term	Definition	Value
∆Therm	Gas Savings	
$Therm_{Std}$	Calculated therms standard tank	206
$Therm_{Eff}$	Calculated therms replacement tank	177.52
$Therm_{Out}$		
EF_{Std}	Federal standard energy factor	(.67 – (.0019xvolume))=.58
$Therm_{StdTank}$	Therms used by standard tank	223
$Standby_{Std}$	Standby loss from standard water heater	434 BTU/hr*
$AFUE_{Std}$	Efficiency (AFUE) of standard water heater	80%
$Standby_{Eff}$	Standby loss from efficient water heater	397 BTU/hr**
$AFUE_{Eff}$	Efficiency (AFUE) of efficient water heater	93%
Vol_{Std}	Volume of standard water heater (gallons)	63.50
Vol_{Eff}	Volume of efficient water heater (gallons)	51.20
$°F/hr_{Std}$	Heat lost per hour from standard water heater tank	0.8
$°F/hr_{Eff}$	Heat lost per hour from efficient water heater tank	0.93
	Conversion factor: density of water (lbs./gallon)	8.33

*AHRI Database. **Data model look-ups of AHRI Certifications.

G. Solar Hot Water Heater

The New Jersey Clean Energy Program has assumed a constant savings per installed solar hot water heater augmenting electric resistance DHW.

- Electric Savings = 3,100 kWh

The Pennsylvania calculation from Pennsylvania Public Utilities Commission's 2013 Technical Reference Manual is as follows.[14]

$$\Delta kWh = \frac{\left\{\left(\frac{1}{EF_{base}} - \frac{1}{EF_{proposed}}\right) \times [HW \times 365 \times 8.3 \times 1 \times (T_{hot} - T_{cold})]\right\}}{3{,}413}$$

Table IV-14
Definitions and Values for Solar Hot Water Heaters

Term	Definition	Value
EF_{Base}	Energy factor of baseline water heater	.904
$EF_{Proposed}$	Energy factor of proposed solar water heater	1.84
HW	Gallons of hot water used per day	50 gallons/day

[14]Pennsylvania Public Utility Commission. "Technical Reference Manual, State of Pennsylvania." June 2013. Pages 60-62.

Term	Definition	Value
T_{hot}	Hot water temperature	
T_{cold}	Cold water temperature	*55°F*
	Days per year	365
	Water density	8.3
	Specific heat of water (Btu/lb.*°F)	1
	Btu/kWh	3,413

H. Water Heater Pipe Insulation

The formula below is from Connecticut's 2012 program savings document.[15]

$$AKWH_W = AKW_W \times L$$

$$ACCF = ACCF_W \times L$$

Table IV-15
Definitions and Values for Water Heater Pipe Insulation

Term	Definition	Value
$AKWH_W$	Annual electric domestic hot water savings	
AKW_W	Annual electric savings per linear foot of heating	See Table IV-16
ACCF	Annual gas domestic hot water savings	
$ACCF_W$	Annual gas savings per linear foot of heating pipe insulation	See Table IV-16
L	Length of heating pipe insulation	

Table IV-16
Pipe Diameter and Energy Savings

Pipe Diameter	AKW_H (kWh/ft)	$ACCF_W$ (Ccf/ft)
0.50	10.4	0.55
0.75	15.9	0.85

I. Water Heater Tank Wrap

The formula below for electric water heaters is from Delaware's 2012 program savings document.[16]

$$\Delta kWh = KWH_{base} \times \left(\frac{EF_{new} - EF_{base}}{EF_{new}}\right)$$

[15]Connecticut Light and Power and United Illuminating. "Connecticut Program Savings Document, 8th Edition for 2013 Program Year." October 30, 2012. Pages 143-148, 241-242.
[16]Opinion Dynamics Corporation. "Delaware Technical Resource Manual, An Update to the Mid Atlantic TRM." April 30, 2012. Page 79-80.

Table IV-17
Definitions and Values for Electric Water Heater Tank Wrap

Term	Definition	Value
KWH_{base}	Average kWh consumption of electric domestic hot water tank[i]	3,460 kWh
EF_{new}	Assumed efficiency of electric tank with tank wrap installed**	0.88
EF_{base}	Assumed efficiency of electric tank without tank wrap installed**	0.86
ΔkWh	Change in kWh from installed measure	79 kWh

**The Oak Ride study predicted that wrapping a 40 gallon water heater would increase Energy Factor of a 0.86 electric DHW tank by 0.02 (to 0.88).

The formula below for electric water heaters is from Connecticut's 2012 program savings document.[17] We apply this formula to gas savings using the parameters shown in Table IV-18.

$$ABTU_W = ADHW \times \left(\frac{1}{EF_B} - \frac{1}{EF_I}\right)$$

$$ADHW = GPY \times 8.3 \times (T_{dhw} - T_{aiw})$$

Table IV-18
Definitions and Values for Gas Water Heater Tank Wrap

Term	Definition	Value
ADHW	Annual domestic hot water load	
$ABTU_W$	Annual Btu savings – water heating	
EF_B	Energy factor – baseline	0.54*
EF_I	Energy factor – insulated unit	0.56*
GPY	Annual domestic hot water usage in gallons	19,839
T_{dhw}	Domestic hot water heater set point	
T_{aiw}	Average annual incoming water temperature	
8.3	Conversion factor: lbs. per gallon of water	
ABTUw/100,000	Conversion factor to therms	

*Oak Ridge National Laboratory. "Meeting the Challenge: The Prospect of Achieving 30 Percent Energy Savings Through the Weatherization Assistance Program," May 2002. Page 25.

J. Showerheads

The following protocol is from the Ohio 2010 Technical Reference Manual.[18]

$$\Delta kWh = ISR \times (GPM_{base} - GPM_{low}) \times \left(\frac{kWh}{GPM_{reduced}}\right)$$

[17] Connecticut Light and Power and United Illuminating. "Connecticut Program Savings Document, 8th Edition for 2013 Program Year." October 30, 2012. Pages 143-148, 241-242.
[18] Vermont Energy Investment Corporation. "State of Ohio Energy Efficiency Technical Reference Manual, Including Predetermined Savings Values and Protocols for Determining Energy and Demand Savings." August 6, 2010. Pages 93-96.

$$\Delta MMBtu = ISR \times (GPM_{base} - GPM_{low}) \times \left(\frac{MMBtu}{GPM_{reduced}}\right)$$

Table IV-19
Definitions and Values for Showerheads

Term	Definition	Value
ISR	In Service Rate – Fraction of Units Installed	1.0
GPM_{base}	Gallons Per Minute of baseline showerhead	2.87
GPM_{low}	Gallons Per Minute of low flow showerhead	1.75
$kWh/GPM_{reduced}$	Assumed kWh savings per GPM reduction	149
MMBtu/GPM Reduced	Assumed MMBtu savings per GPM of reduction	0.66

K. Aerators

The following protocols are from the New York 2010 Technical Reference Manual.[19]

$$kWh\ savings = \frac{\left[water\ savings \times (temp\ faucet - temp\ to\ heater) \times \left(\frac{8.3}{3{,}413}\right)\right]}{water\ heater\ efficiency_{elec}}$$

$$therm\ savings = \frac{\left[water\ savings \times (temp\ faucet - temp\ to\ heater) \times \left(\frac{8.3}{100{,}000}\right)\right]}{water\ heater\ efficiency_{gas}}$$

$$Water\ savings = (Std_{aero} - LF_{aero}) \times \frac{duration}{use} \times \frac{\#\ uses}{day} \times \frac{days}{year}$$

Table IV-20
Definitions and Values for Aerators

Term	Definition	Value
Std_{aero}	Standard aerator GPM	2.2
LF_{aero}	Low flow aerator GPM	1.5
	Duration/use	0.5 minutes
	# uses/day	30
	Days/year	365
	Temp faucet	80°F
	Temp to heater	variable
8.3	Conversion factor: lbs. per gallon	
3,413	Conversion factor (electric): Btu per kWh	
100,000	Conversion factor (gas): Btu per Therm	

[19]New York Evaluation Advisory Contractor Team and TecMarket Works. "New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs; Residential, Multi-Family, and Commercial/Industrial Measures." October 15, 2010. Pages 94-96..

Term	Definition	Value
	Water heater $efficiency_{elec}$	0.97
	Water heater efficiencygas	0.75

L. Window Air Conditioners

The New Jersey Clean Energy Program has assumed a constant savings per replaced window air conditioner.

- Electric Savings = 56.4 kWh

The formula below is from Connecticut's 2012 program savings document.[20]

$$AKWH_{C,Retire} = EFLH \times CAP_{C,e} \times \frac{\left(\frac{1}{EER_e} - \frac{1}{EER_b}\right)}{1{,}000}$$

Table IV-21
Definitions and Values for Window Air Conditioners

Term	Definition	Value
$AKWH_{C, Retire}$	Annual electric energy savings from retiring a room a/c unit	
EFLH	Annual equivalent full load hours	272
$CAP_{C, e}$	Rated cooling capacity of (old) existing unit	
EER_e	Energy efficiency ratio of existing unit	
EER_b	Energy efficiency ratio, representing baseline NEW model	
1,000	Conversion factor: watts per KW	

M. LED Lighting (Replacement of Incandescent)

The savings from LED replacements would follow the same formula as the CFL replacement, with a different assumption for LED wattage.

Project Savings = ∆ Watts/1,000 * Hours/day *365

Fixed Values
- ∆ Watts = 52
- Hours/day = 2.5

Projected savings = 47.45 kWh

N. LED Night Light

The savings from LED replacements would follow the same formula as the CFL replacement, with a different assumption for LED wattage and hours of use.

Project Savings = ∆ Watts/1,000 * Hours/day *365

[20]Connecticut Light and Power and United Illuminating. "Connecticut Program Savings Document, 8th Edition for 2013 Program Year." October 30, 2012. Pages 143-148, 241-242.

Fixed Values

- Standard night light = 7 watts
- LED night light = .25 watts
- Δ Watts = 6.75
- Hours/day = 24

Projected savings = 59.13 kWh

O. Smart Strips

The New Jersey Clean Energy Program has assumed a constant savings per replaced smart strip.

- Electric Savings = 102.8 kWh

The formula below is from Pennsylvania's 2013 Technical Reference Manual.[21]

$$\Delta kWh = \frac{\left[\left(kW_{comp} \times Hr_{comp}\right) + \left(kW_{TV} \times Hr_{TV}\right)\right]}{2} \times 365$$

Table IV-22
Definitions and Values for Smart Strips

Term	Definition
kW_{comp}	Idle kW of computer system
Hr_{comp}	Daily hours of computer idle time
kW_{TV}	Idle kW of TV system
Hr_{TV}	Daily hours of TV idle time

P. Solar Panels

The NJ Clean Energy Program formerly used a deemed value method for estimating savings from solar panels. This deemed value was approximately 1200 kWh/year per kW of installed capacity.

While solar photovoltaic (PV) manufacturers provide ratings for direct current (DC) power production, installers and program evaluators rely on modeling software and online calculators to provide production estimates for solar PV technology. A list of models used to estimate energy production is available in the report "Models Used to Assess the Performance of Photovoltaic Systems," by Geoffrey Klise and Joshua Stein.[22] These models include National Renewable Energy Laboratory's (NREL) PVWatts calculator[23] and RETScreen International's software suite[24].

[21] Pennsylvania Public Utility Commission. "Technical Reference Manual, State of Pennsylvania." June 2013. Pages 58-59
[22] Klise, Geoffrey T. and Joshua S. Stein. "Models Used to Assess the Performance of Photovoltaic Systems." December 2009.
[23] National Renewable Energy Laboratory. "PVWatts." 18 November 2013. Web. 14 February 2014. http://www.nrel.gov/rredc/pvwatts/.
[24] RETScreen International. "RETScreen International Home." 23 May 2014. http://www.retscreen.net/ang/home.php.

The NJ Clean Energy Program uses PVWATTS Version 1 to estimate the energy generated by photovoltaic systems. PVWATTS v.1 is available at:
http://rredc.nrel.gov/solar/calculators/PVWATTS/version1/

$$Summer\ Peak\ Impact\ (kW) = Rating \times ELCC$$

$$Winter\ Peak\ Impact\ (kW) = Rating \times WELCC$$

Table IV-23
Definitions and Values for Solar Panels

Term	Definition	Value
Rating	System rated output (AC output based on DC output at Standard Rating Conditions and default DC/AC ratings)	
ELCC*	Summer effective load carrying capacity	65%
WELCC**	Winter effective load carrying capacity	8%

*Summer and winter peak impacts in PVWATTS v.1 are based on research conducted by Richard Perez of SUNY Albany (http://www.nrel.gov/ncpv/documents/pv_util.html). The estimated summer effective load carrying capacity (ELCC) for New Jersey is 60% to 70%. A value of 65% was adopted in New Jersey's protocols.
** WELCC = 8% is from monitored system data from White Plains, NY.

Data is collected for the following:

- Fixed, single or double axis tracking
- Array tilt angle (for fixed axis only)
- Array azimuth (for fixed axis only)
- Weather Data – based on closest weather station data for v.1. Four sites are used:
  1. Wilkes Barre, PA
  2. Newark, NJ
  3. Philadelphia, PA
  4. Atlantic City, NJ

The following protocol is from the National American Board of Certified Energy Practitioners.[25]

$$\frac{Production}{Year} = \frac{Peak\ Sun\ Hours}{Year} \times Total\ STC\ Rating \times System\ Factor$$

$$\frac{Peak\ Sun\ Hours}{Year} \equiv Annual\ Solar\ Irradiation$$

$$Annual\ Solar\ Irradiation = Avg.Daily\ Irradiation \times 365$$

$$Total\ STC\ Rating = \frac{W_{STC} \times Modules}{1{,}000}$$

[25] National American Board of Certified Energy Practitioners. "Photovoltaic (PV) Installer Resource Guide." March 2012. http://www.nabcep.org/wp-content/uploads/2012/08/NABCEP-PV-Installer-Resource-Guide-August-2012-v.5.3.pdf

Table IV-24
Definitions and Values for Solar Panels

Term	Definition
Peak Sun Hours	Equivalent number of hours producing power of 1,000W/m
Average Daily Irradiation	Amount of solar irradiation on panel in average day
W_{STC}	Maximum power rating of module in Watts
365	Conversion factor: days/year
1,000	Conversion factor: W/kW
System Factor	Adjustments made to the energy produced due to system

Q. Cool Roofs

An EPA article regarding cool roof technology recommends online calculators to estimate savings from this technology. The two calculators mentioned in this article are an Energy Star® Calculator and a calculator developed by the Oak Ridge National Laboratory (ORNL). Inputs for the ORNL calculator include building location, roof insulation, solar reflectance and thermal emittance.[26]

This technology was mentioned in technical reference manuals for New York, Ohio and Connecticut, but detailed equations for savings estimates were not included. A very basic equation found in New York's technical reference manual is shown below along with actual savings estimates from this manual's appendix.[27]

$$\Delta kWh = kSF_{coolroof} \times \left(\frac{\Delta kWh}{kSF}\right)$$

$$\Delta therm = kSF_{coolroof} \times \left(\frac{\Delta therm}{kSF}\right)$$

Table IV-25
Definitions and Values for Cool Roofs

Term	Definition
ΔkWh	Gross annual energy savings
kSF cool roof	Thousand square feet of cool roof installed over a cooled space
ΔkWh/kSF	Electricity consumption savings per square foot of cool roof
Δtherm/kSF	Gas consumption impact per thousand square foot of cool roof

[26]U.S. Environmental Protection Agency. "Reducing Urban Heat Islands: Compendium of Strategies, Cool Roofs." October 2008. Pages 22-24.
[27]New York Evaluation Advisory Contractor Team and TecMarket Works. "New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs; Residential, Multi-Family, and Commercial/Industrial Measures." October 15, 2010. Pages 127-128.

Table IV-26
Savings Estimates for a Small Office Building in New York State

City	kWh/1000 Sq ft. Roof	kW/unit	Therm/unit
Albany	151	0.128	12.0
Binghamton	128	0.128	11.5
Buffalo	130	0.128	11.0
Massena	152	0.128	14.0
NYC	169	0.128	8.0
Poughkeepsie	164	0.128	10.0
Syracuse	157	0.128	14.0

V. Engineering Estimates

This section provides engineering estimates for new protocols when participants have implemented these measures and input data are available.

Table V-1
Engineering Estimates for Electric Savings

Measure	Observations	NJ Protocol Savings	Other Protocol Savings
Hot Water Heater Replacement*	59	--	1,001 kWh
GFX**	0	1,457 kWh	817 kWh
Heat Pump Water Heater***	0	2,662 kWh	2,943 kWh
Solar Water Heater****	0	3,100 kWh	1,748 kWh
Water Heater Pipe Insulation[#]	84	--	73 kWh
Water Heater Tank Wrap	53	--	79 kWh
Showerheads	125	--	167 kWh
Aerators[##]	7	--	168 kWh
Window Air Conditioners[###]	28	56 kWh	68 kWh
LED Lighting	0	--	47 kWh
LED Night Lights	0	--	59 kWh
Smart Strips	0	--	--
Solar Panels	0	--	--

Measure	Observations	NJ Protocol Savings	Other Protocol Savings
Cool Roofs	0	--	--

*Hot Water Heater Replacement Efficiency fixed at 95%, hot water temperature fixed at 130° F, cold water temperature fixed at 62.5° F. (NYC water main temperature from Table IV-7). GPD fixed at 78 (per table IV-11)
**GFX: GPD calculated as 0.7*(Single Family Value) + 0.3*(Multi Family Value) = 46.6 (per table IV-9) 70% of treatment group was Single Family. Energy Factor of Water Heater fixed at 0.904
***Heat Pump Water Heater: Baseline Water Heater Energy Factor fixed at 0.904.
****Solar Water Heater: hot water temperature fixed at 130° F.
#Water Heater Pipe Insulation: averaged electric savings per foot of pipe insulation between values for pipe diameter of 0.5 and 0.75 inches. Feet of insulation installed capped at 6 feet.
##Aerator: temp to heater fixed at 62.5° F (NYC water main temperature from Table IV-7)
###Window AC: EER of old unit fixed at 8 & EER of new unit fixed at 10. Capacity fixed at 10,000 Btu

Table V-2
Engineering Estimates for Gas Savings

Measure	Observations	NJ Protocol Savings	Other Protocol Savings
Combined Gas Boiler and Water Heater*	0	--	25.94 therms
HVAC Repairs	2	--	0.56 therms
Hot Water Heater Replacement**	315	8.55 therms	12.63 therms
GFX***	0	--	31.51 therms
Indirect Water Heater	0	--	32 therms
Water Heater Pipe Insulation#	1,032	--	3.88 therms
Water Heater Tank Wrap##	492	--	7.35 therms
Showerheads	1,036	--	7.39 therms
Aerators###	19	--	7.42 therms
Solar Panels	0	--	--
Cool Roofs	0	--	--

*Combined Gas Boiler & Water Heater: SF fixed at median for treatment group square footage (1,200). HF fixed at 38,700, based on median home age of 55. Existing efficiency fixed at 80%.
**Hot Water Heater Replacement Efficiency fixed at 65%. Maximum of 65% efficiency imposed for old unit. Hot water temperature fixed at 130° F. Cold water temperature fixed at 62.5° F. (NYC water main temperature from Table IV-7). GPD fixed at 78 (per table IV-11).
***GFX: GPD calculated as 0.7*(Single Family Value) + 0.3*(Multi Family Value) = 46.6 (per table IV-9). 70% of treatment group was Single Family. Energy Factor of Water Heater fixed at 0.8.
****Water Heater Pipe Insulation: averaged gas savings per foot of pipe insulation between values for pipe diameter of 0.5 and 0.75 inches
#Water Heater Pipe Insulation: Feet of insulation installed capped at 6.
##Hot Water Heater Tank Wrap: hot water temperature fixed at 130° F. Cold water temperature fixed at 62.5° F. (NYC water main temperature from Table IV-7)
###Aerator: temp to heater fixed at 62.5° F (NYC water main temperature from Table IV-7).

VI. Summary

This memo provided an analysis of current NJ Comfort Partners Energy Saving Protocols, made recommendations for changes to some of the protocols, and provided additional protocols for measures that are not currently included or are being considered for addition.

Checks of the Energy Saving Protocol calculations found that almost all of the savings data in the NJ CP Tracking database matched the specifications provided in the documentation. The one exception was the furnace and boiler replacements.

The following key changes were recommended.

- Refrigerator Removal – The savings from additional refrigerator removal should be calculated.

- Hot Water Measures – The savings from individual measures should be calculated rather than including savings for a standard package of measures.

- Shell Measures – The spending thresholds for applying percentage savings should be increased for air sealing and insulation. The percentage savings applied should be lowered for duct sealing and insulation.

- HVAC Replacement and Repairs – Savings for replacement and repairs should be calculated separately.

Additional protocols were recommended for the following measures.

- Combined Gas Boiler and Water Heater
- Gas Heating System Repair
- Hot Water Heater Replacements
- Drain Water Heat Recovery System (GFX)
- Heat Pump Water Heaters
- Indirect Hot Water Heaters
- Solar Hot Water Heaters
- Water Heater Pipe Insulation
- Water Heater Tank Wrap
- Showerheads
- Aerators
- Window Air Conditioners
- LED Lighting (Incandescent Replacement)
- LED Night Lights
- Smart Strips
- Solar Panels
- Cool Roofs

Engineering estimates were provided for these protocols where input data were available or default values could be used.