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December 30, 2015

Via Hand Delivery
Rosemary Chiavetta, Secretary
PA Public Utility Commission
PO Box 3265
Harrisburg, PA 17105-3265

Re: Pennsylvania Public Utility Commission v. Philadelphia Gas Works,
Docket Nos. R-2009-2139884; P-2009-2097639

Dear Secretary Chiavetta:

In accordance with Paragraph 24 of the Joint Petition For Settlement of the above proceeding, which was approved by the Commission by Order entered July 29, 2010, enclosed for filing please find the original of Philadelphia Gas Works' ("PGW") FY 2015 Demand Side Management ("DSM") Program Annual Report. Copies are being served in accordance with the attached Certificate of Service.

Please contact me if you have any questions

Very truly yours,

Deanne M. O'Dell

Deanne M. O'Dell

DMO/lww
Enclosure

cc: Cert. of Service w/enc.
Joseph Magee w/enc. via email only jmagee@pa.gov
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Demand Side Management Program Annual Report

FY 2015 Results

December 30, 2015

Prepared by Philadelphia Gas Works (PGW) with assistance from Green Energy Economics Group, Inc. (GEEG)

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1. Portfolio Overview

1.1. Introduction

This report presents and discusses the results from PGW's implementation of its Demand Side Management (DSM) portfolio of energy-efficiency programs in Fiscal Year 2015 ("FY 2015").[1]

PGW's DSM portfolio was approved by the Pennsylvania Public Utility Commission ("PUC") by order entered on July 29, 2010. PGW committed to filing its annual report four months after the end of the program year to report on program outcomes to date. This report is the fifth such Annual Fiscal Year Report.

This report provides quantitative tables of portfolio operations and outcomes for all six DSM programs:

- Enhanced-Low Income Retrofit Program ("ELIRP");
- Residential Heating Efficiency Rebate Program ("RHER");
- Commercial and Industrial Retrofit Program, now Efficient Building Grants;
- Commercial and Industrial Equipment Rebates Program ("CIER");
- High Efficiency Construction Incentives Program, now Efficient Construction Grants; and
- Comprehensive Residential Retrofit Incentives program ("CRRI"), now "Home Rebates".

1.2. *Summary of Results*

In FY 2015, all six DSM programs authorized by the July 29, 2010 PUC order were implemented and PGW's management was focused on growing participation. PGW spent $10.6 million on DSM programming, approximately 83 percent of the FY 2015 budget filed by PGW in its FY 2015 Implementation Plan. PGW achieved estimated first year gas savings of nearly 105 Billion Btu ("BBtu") and 2,161 BBtu over the lifetime of the measures installed. From portfolio inception in January, 2011 through the end of FY 2015, overall DSM activities have resulted in projected $7.9 million in net resource benefits and a benefit-cost-ratio ("BCR") of 1. 21 under the Total Resource Cost ("TRC") cost-effectiveness test.

[1] September 1, 2012 through August 31, 2013

TABLE 1. DSM COSTS AND BUDGETS BY PROGRAM (NOMINAL)[2]

Program	FY 2015		
	Actual	Goal	%
Enhanced Low Income Retrofit	$7,505,428	$7,600,000	99%
Residential Heating Equipment Rebates	$774,391	$1,145,520	68%
Home Rebates	$409,735	$1,400,000	29%
Efficient Construction Grants (Residential)	$177,227	$297,791	60%
Residential Total	**$8,866,781**	**$10,443,311**	**85%**
Efficient Building Grants	$215,811	$536,558	40%
Commercial and Industrial Equipment Rebates	$358,448	$337,792	106%
Efficient Construction Grants (Nonresidential)	$-	$-	
Non-residential Total	**$574,260**	**$874,351**	**64%**
Portfolio-wide Costs	$1,120,342	$1,390,000	81%
UTILITY TOTAL	**$10,561,382**	**$12,707,662**	**83%**
Participant Costs	$1,732,941	$3,768,659	46%
Total	**$12,294,323**	**$16,476,321**	**75%**

TABLE 2. DSM COSTS AND BUDGETS BY CATEGORY (NOMINAL)

Category	FY 2015		
	Actual	Goal	%
Customer Incentives	$7,231,326	$8,890,090	81%
Administration and Management	$687,948	$940,000	73%
Marketing and Business Development	$432,394	$480,000	90%
Contractor Costs	$1,985,803	$1,911,978	104%
Inspection and Verification	$66,784	$175,593	38%
On-site Technical Assessment	$-	$-	
Evaluation	$157,127	$310,000	51%
UTILITY TOTAL	**$10,561,382**	**$12,707,662**	**83%**
Participant Costs	$1,732,941	$3,768,659	46%
Total	**$12,294,323**	**$16,476,321**	**75%**

[2] All PGW Efficiency Cost Recovery Surcharge collections are shown in Appendix A. FY 2014 over-collections were refunded to the appropriate customer classes in FY 2015.

TABLE 3. PORTFOLIO-WIDE INCREMENTAL FIRST YEAR GAS SAVINGS (MMBTU)

Program	FY 2015		
	Actual	Goal	%
Enhanced Low Income Retrofit	64,307.7	55,315.7	116%
Residential Heating Equipment Rebates	13,031.4	20,125.3	65%
Home Rebates	2,581.2	17,665.1	15%
Efficient Construction Grants (Residential)	5,745.7	3,729.4	154%
Residential Total	**85,665.9**	**96,835.5**	**88%**
Efficient Building Grants	4,783.9	8,169.2	59%
Commercial and Industrial Equipment Rebates	14,461.1	10,055.6	144%
Efficient Construction Grants (Nonresidential)	-	-	
Non-residential Total	**19,245.1**	**18,224.8**	**106%**
Portfolio-wide Costs	-	-	
PORTFOLIO TOTAL	**104,911**	**115,060.4**	**91%**

TABLE 4. PORTFOLIO-WIDE INCREMENTAL LIFETIME GAS SAVINGS (MMBTU)

Program	FY 2015		
	Actual	Goal	%
Enhanced Low Income Retrofit	1,321,965.8	1,106,313.8	119%
Residential Heating Equipment Rebates	278,317.4	431,725.9	64%
Home Rebates	75,774.6	453,687.4	17%
Efficient Construction Grants (Residential)	92,845.2	68,456.6	136%
Residential Total	**1,768,903.1**	**2,060,183.6**	**86%**
Efficient Building Grants	111,445.1	150,985.6	74%
Commercial and Industrial Equipment Rebates	281,112.3	156,424.3	180%
Efficient Construction Grants (Nonresidential)	-	-	
Non-residential Total	**392,557.4**	**307,409.9**	**128%**
Portfolio-wide Costs	-	-	
PORTFOLIO TOTAL	**2,161,460.5**	**2,367,593.5**	**91%**

TABLE 5. NON-GAS BENEFITS

Program	FY 2015		
	Actual	Goal	%
First Year Energy Savings Installed (kWh)	921,266.7	1,148,243.8	80%
Lifetime Energy Savings Installed (kWh)	19,635,601.8	24,642,881.3	80%
Summer Peak Demand Savings Installed (kW)	211	211	100%
First Year Water Savings Installed (million gallons)	7.4		
Lifetime Water Savings Installed (million gallons)	74.0		

TABLE 6. TOTAL RESOURCE COST TEST RESULTS FROM INCEPTION THROUGH THE END OF FY 2015 (2009$)

Program	Launch Year	Inception through FY 2015			
		PV of Benefits	PV of Costs	PV of Net Benefits	BCR
Enhanced Low Income Retrofit	FY 2011	$34,110,010	$26,318,553	$7,791,457	1.30
Residential Heating Equipment Rebates	FY 2011	$6,745,039	$4,331,175	$2,413,864	1.56
Home Rebates	FY 2014	$1,235,658	$1,708,724	$(473,066)	0.72
Efficient Construction Grants (Residential)	FY 2012	$632,194	$313,707	$318,487	2.02
Residential Total		**$42,722,902**	**$32,672,161**	**$10,050,741**	**1.31**
Efficient Building Grants	FY 2012	$1,316,198	$947,247	$368,951	1.39
Commercial and Industrial Equipment Rebates	FY 2013	$1,771,242	$643,039	$1,128,203	2.75
Efficient Construction Grants (Nonresidential)	FY 2013	$-	$-	$-	
Non-residential Total		**$3,087,440**	**$1,590,286**	**$1,497,154**	**1.94**
Portfolio-wide Costs		$-	$3,659,322	$(3,659,322)	-
PORTFOLIO TOTAL		**$45,810,342**	**$37,921,768**	**$7,888,574**	**1.21**

2. Enhanced Low-Income Retrofit Program

The Enhanced Low-Income Retrofit Program seeks to obtain cost-effective energy savings for low-income customers who participate in PGW's Customer Responsibility Program ("CRP"). A secondary goal of the program is to reduce the overall long-term cost of CRP as paid by all firm customers. The program seeks to achieve these goals and make customers' homes more energy efficient and comfortable by:

- Repairing or replacing older and less efficient heating systems.
- Providing comprehensive weatherization services.
- Educating customers on ways to reduce their energy use along with basic health and safety information.
- Raising awareness of energy conservation and encouraging the incorporation of energy saving behavior.
- Targeting high-use customers to maximize impact and increase cost-effectiveness.
- Streamlining the delivery mechanism through the use of implementation contractors.

TABLE 7. ELIRP RESULTS FOR FY 2015

	FY 2015		
	Actual	**Goal**	**%**
PARTICIPATION			
Closed Cases	**2,601**	**1,795**	**144%**
Comprehensively Closed	1,300		
Closed, Limited Measures	1,301		
COSTS (Nominal)			
Non-Incentive Spending	**$1,662,440**	**$1,672,600**	**99%**
Administration and Management	$-	$30,000	
Marketing and Business Development	$-		
Contractor Costs[3]	$1,567,219	$1,482,000	
Inspection and Verification	$55,962	$75,000	
On-site Technical Assessment	$-		
Evaluation	$39,259	$85,000	
Measure Installation	**$5,842,988**	**$5,928,000**	**99%**
Total Program Spending	**$7,505,428**	**$7,600,000**	**99%**
Participant Costs	$-	$-	
Total Cost	**$7,505,428**	**$7,600,000**	**99%**

[3] Includes annual administrative expenses (costs not directly related to the provision of program services, such as office overhead) and also includes non-administrative costs (for variable program support expenses that are directly related to the provision of program services) but does not include PGW's own overhead.

SAVINGS[4]			
First Year BBtu	64.3	55.3	116%
Lifetime BBtu	1,322	1,106	119%
First Year kWh	583,243		
Lifetime kWh	12,785,662		

TABLE 8. TRC COST-EFFECTIVENESS RESULTS FOR ELIRP FROM INCEPTION THROUGH FY 2015

PRESENT VALUE (2009$)	Actual
Benefits	$34,110,010
Costs	$26,318,553
Net Benefits	$7,791,457
BCR	1.30

2.1. Notable Program Activities in FY 2015

ELIRP has continued to show year over year improvement in FY 2015. The program reached its highest level of spending and resultant energy savings during FY 2015, as it achieved $7.8 million present value of benefits (2009$) since inception. The program's cost *effectiveness continued to trend upwards from* 1.26 BCR *at the end of* FY 2014 *and reached* a cumulative BCR of 1.30 by the end of FY 2015.

Closed Limited Cases[5]

In FY 2015, ELIRP experienced a rise in closed limited cases, growing from 43 percent in FY 2014 to 50 percent in FY 2015. This high proportion of closed limited cases is responsible for the greater number of total projects closed than originally projected, as closed limited cases cost less on average than comprehensively closed cases. PGW attributes the rise to an increased focus by Conservation Service Providers ("CSP") to seek greater cost-effectiveness by installing only core measures when the price of comprehensive weatherization was cost ineffective. There were two main causes for the increase of cost ineffective projects.

First, health, safety or structural issues required costly pre-treatments in many homes before weatherization could occur, thereby driving up the project cost. Although many of the issues are common to the Philadelphia housing stock, in FY 2015 CSPs continued their commitment to using cost effectiveness as a deciding factor when planning projects. The second – related - reason is that many of the highest usage cases have already been treated

[5] The Closed Limited status is a designation for cases that receive only core measures (thermostat, low-flow devices, pipe wrap) at the time of the audit, as comprehensive measures can not be performed due to health and safety issues, and/or work is not cost-effective, though some savings are still possible through the identified low-cost measures.

in ELIRP. The average pre-heat usage for cases treated in 2015 was 138 MMBtu, compared to 160 MMBtu in 2011. While there are still many savings opportunities available, some measures, particularly heater installations, are not as cost-effective on lower-usage homes.

These CSP decisions have been guided by PGW's bi-annual evaluations which allocate funding based on CSP performance on various metrics including cost-effectiveness. Overall, this practice has improved CSP performance and produced a greater return on investment for ratepayer funds.

Quality Assurance

PGW had 149 cases inspected by a third-party inspector in FY 2015. Two different inspection companies performed this work in 2015, as PGW issued a Request for Proposals ("RFP") mid-year and selected a new firm. The scope of work for the current inspection firm includes several items that PGW feels are important in ensuring work quality, which are influenced by the 3rd party program evaluation. These include:

- Shadowing of energy audits to ensure testing is done correctly and CSPs are communicating effectively with customers. Nine audits were shadowed.
- Enhanced QA activities performed on a sample of all inspections, including blower *door test and zonal pressure diagnostics, and infrared scans to evaluate insulation.* 11 of the 140 inspections were enhanced QA.
- In-field and classroom mentoring and training

In 2015, cases were targeted for inspection randomly based on certain criteria:

- high and low percentage savings;
- small and large air sealing blower door reductions; and
- specific measure combinations.

PGW has updated its inspection protocols to be more stringent and deduct more points for *infractions, encouraging* CSPs to capture all cost-effective savings opportunities, reduce health and safety issues, and improve work quality. The average inspection score was 91 percent. This is a decrease from last year's average of 97 percent, due in part to the newer more stringent standards. The inspection score average since program inception is 94 percent.

The new inspection process reflects a shift in using inspections as a tool for improving CSP performance. In past years, inspections had been more concerned about "what" went wrong. There is now more focus on the "how" and "why," as well as steps to improve in future. There is more discussion among all stakeholders about inspection findings, and these trends inform trainings and program updates.

Table 9 details the types of inspections performed by fiscal year. As mentioned above, PGW refined its inspection strategy to conduct two new types of quality assurance practices, enhanced inspections, and shadowed audits and jobs. In previous years, the inspector counted mentoring as the amount of time that he or she instructed a CSP during the in-home inspection. Since this instruction is woven more comprehensively into shadowed and enhanced inspections, as well as follow-up from inspections, PGW discontinued its practice of tracking mentoring hours as a standalone metric as was previously done.

TABLE 9. ELIRP ANNUAL AUDITS AND ON-SITE MENTORING

Fiscal Year	Standard Inspections	Enhanced Inspections	Shadowed Audits & Jobs	Hours of Mentoring
2011	44	N/A	N/A	22.5
2012	140	N/A	N/A	28.5
2013	131	N/A	N/A	23
2014	268	N/A	N/A	9
2015	129	11	9	N/A
Inception to Date	**712**	**11**	**9**	**83**

Database Updates and Savings Validation

PGW has continued to improve its database to address issues identified, introduce new controls to ensure accurate data input, and develop new modules to make the tool more useful. In FY 2015, PGW completed several projects to identify and make improvements in its tracking system. The changes resulted in an increase of 88,236 lifetime MMBtu savings, approximately two percent of lifetime savings to-date. The projects included the following changes:

- Re-calculating savings for cases that were opened to indicate the ELIRP project has begun more than once in PGW's database, causing complications with cases' pre-usage data. For example, the same home assigned as multiple cases at different periods may have had the incorrect pre-usage data-point applied to the project performed. Similarly, a separate database design issue that allowed CSPs to open a case twice by double-clicking fast.
- CSP data entry errors identified as anomalies and corrected with revised inputs from the CSPs. Examples of these issues include: reversed pre and post values for measures, missing digits (e.g., AFUE of 9 percent instead of 90 percent), savings incorrectly claimed for the energy audit blower door when actual air sealing wasn't performed, and heater repair measures that incorrectly claimed savings as heater replacements.
- Corrected a savings calculation error that undercounted the lifetime savings for boiler replacements due to an incorrect measure lifetime entry. The error had reduced the boiler measure to a lifetime of 20 instead of 25.

PGW has established a new protocol to identify and correct data anomalies on a regular basis, and will continue to quality-check the program data to improve accuracy going forward.

Through the process of updating the DSM database, PGW identified the need to update its assumptions for the heater repair measure. Heater repairs are primarily performed for health and safety reasons to lower carbon monoxide and enable CSPs to perform air sealing.

From inception to date, PGW has assigned a measure lifetime of 15 years to the heater repair measure, the furnace replacement measure. After conducting a best-practice analysis, PGW determined that this measure lifetime exceeds the lifetime used in other jurisdictions. Effective for all new cases opened after January 1, 2016, PGW will update the measure lifetime for this measure to two years (See Appendix B in Section 9 for the updated TRM entry). This measure does not contribute a significant portion of program savings, so the change is expected to only have a minor impact on the program's cost-effectiveness.

3. Residential Heating Efficiency Rebate Program

The Residential Heating Equipment Rebates program offers prescriptive rebates on premium efficiency heating equipment to increase the penetration of these technologies in the homes of PGW's customers. The program has the following objectives:

- Promote the selection of premium efficiency furnaces and boilers at the time of purchase of residentially-sized gas heating equipment.
- Increase consumers' awareness of the breadth of energy efficiency opportunities in their homes.
- Strengthen PGW's relationship with customers as a partner in energy efficiency.
- Encourage market actors throughout the supply chain to provide and promote high efficiency options.
- Align incentives with other programs.
- Aid in market transformation towards highest-efficiency options.

TABLE 10. RHER RESULTS FOR FY 2015

	FY 2015		
	Actual	**Goal**	**%**
PARTICIPATION			
Rejected Applications	84		
Approved Applications	**1,018**	**1,352**	**75%**
Total Applications	1,102		
COSTS (Nominal)			
Non-Incentive Spending	**$58,543**	**$91,000**	**64%**
Administration and Management	$-		
Marketing and Business Development	$-		
Contractor Costs	$53,854	$48,000	
Inspection and Verification	$4,580	$8,000	
On-site Technical Assessment	$-		
Evaluation	$109	$35,000	
Customer Incentives	**$715,848**	**$1,054,520**	**68%**
Total Program Spending	**$774,391**	**$1,145,520**	**68%**
Participant Costs	$928,670		
Total Costs	**$1,703,061**		
SAVINGS			
First Year BBtu	13.0	20.1	65%
Lifetime BBtu	278.3	431.7	64%
First Year kWh	165,900		
Lifetime kWh	3,318,000		
MEASURES			
Furnaces	829		
Boilers	189		
Programmable Thermostats	436		

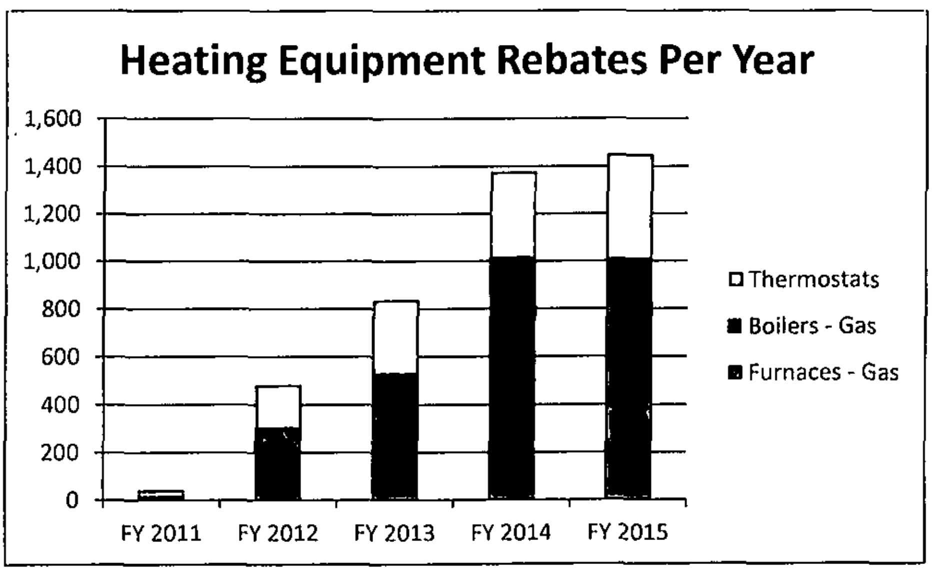
TABLE 11. TRC COST-EFFECTIVENESS RESULTS FOR RHER FROM INCEPTION THROUGH FY 2015

Present Value (2009$)	Actual
Benefits	$6,745,039
Costs	$4,331,175
Net Benefits	$2,413,864
BCR	1.56

3.1. Notable Program Activities in FY 2015

In FY 2015, applications from landlords and developers continued to be a large part of the program, consisting of 42 percent of all heater rebates. The projects ranged in sizes from the largest project, a 100-unit housing complex, to small and medium sized buildings between 5 and 20 units. PGW attributes this trend to increased marketing activity and engagement with this audience through other programs. In some cases, the landlord or developer sought grants under EnergySense Efficient Construction Grant or Efficient Building Grant programs, but did not meet the programs' savings requirements despite installing high efficiency heaters. Rebate activity since inception by month is detailed further in Figure 1.

FIGURE 1. REBATE ACTIVITY SINCE INCEPTION



In FY 2015, the greatest sources of applications continued to be HVAC technicians and plumbers, as shown in Table 12. PGW continued its outreach to these trade allies through activities similar to those conducted in previous program years, and as a result more than half of applications were referrals from this source.

TABLE 12. SOURCE OF RHER REFERRALS FROM INCEPTION THROUGH FY 2015

Source	Percentage
Community Event	1%
Family / Friend	11%
Contractor / Supply House	60%
Internet / PGW website	13%
Newspaper Ad / Article	1%
PGW Rep	3%
PGW Gas Bill	10%
TV & Radio Ads	1%

Quality Assurance and Verifications

There were 45 on-site rebate verifications performed in 2015, accounting for four percent of all rebate projects, exceeding our program goal of three percent. Projects were selected at random for verification. Multifamily projects with more than six submissions were also flagged to receive on-site verifications for a small sample of units. No discrepancies were found through verifications.

PGW's quality assurance policy of cross-checking RHER applicants with those who received HVAC upgrades in the Home Rebates Program identified that one customer received funds *through both programs. PGW contacted the customer and successfully had the funds* returned. PGW is working to automate this process to allow the rebate processor to more easily cross-check grant and rebate recipients.

Revised Incentive Design

PGW developed a revised incentive tier that went into effect at the beginning of FY 2015 on September 1, 2014. This was done to make projects cost-effective under the updated EFLH assumptions (revised in the most recent TRM update, informed by the 3rd-party RHER impact evaluations) that reduced projected gas savings per unit installed. PGW also defined rebates based on "project," as installations at a single building address by the property owner, manager or developer. This revision was intended to better align RHER with the incentive levels of other EnergySense programs.

Measure	First Rebate Per-Project	Additional Rebates Per-Project
Natural Gas Furnace 94% AFUE	$500	$250
Natural Gas Furnace 94% AFUE, BFM Fan	$500	$250
Natural Gas Water Boiler 94% AFUE	$1,500	$800

The incentive changes did not result in a reduction in participation, as the program continued to exhibit year over year growth in FY 2015. The changes did, however, successfully reduce potential negative gas administrator cost effectiveness impact of the smaller units found in multifamily buildings. Furthermore, the changes facilitated better incentive alignment with PGW's Efficient Construction Grant and Efficient Building Grant programs for the purpose of fostering comprehensive projects with greater savings over single equipment replacements. The alignment offers customers the RHER incentives as a minimum award, which can be increased by proceeding with a more comprehensive project in the grant programs. PGW will continue to track these issues and consider further changes if warranted.

4. Efficient Building Grants Program

The Efficient Building Grants program promotes natural gas energy efficiency retrofit investments by PGW's multi-family residential, commercial, and industrial customers. The program provides technical assistance and customized financial incentives of up to $75,000 for cost-effective gas-saving investments including high-efficiency heating system replacements, improved system controls, and building thermal performance enhancements. The program also helps participants arrange financing for the balance of project costs through partnerships with third-party lenders. The program has the following objectives:

- Save natural gas through cost-effective energy efficiency retrofit projects.
- Make comprehensive energy-efficiency retrofits affordable by combining customized financial incentives with third-party financing to provide participating customers with immediate positive cash flow.
- Promote a better understanding of energy efficiency options available to PGW's nonresidential customers.

TABLE 13. EFFICIENT BUILDING GRANTS PROGRAM ACTIVITY FOR FY 2015

	FY 2015		
	Actual	**Goal**	**%**
PARTICIPATION			
Applications	21		
Incentive Agreements Issued	6		
Customer with Installations	**10**	**18**	**56%**
COSTS (Nominal)			
Non-Incentive Spending	**$53,011**	**$190,969**	**28%**
Administration and Management	$-	$-	
Marketing and Business Development	$-	$-	
Contractor Costs	$18,657	$120,831	
On-site Technical Assessment	$-	$20,138	
Evaluation	$34,354	$50,000	
Customer Incentives	**$162,801**	**$345,589**	**47%**
Total Program Spending	**$215,811**	**$536,558**	**40%**
Participant Costs	$339,896	$275,222	
Total Cost	**$555,707**	**$811,780**	**69%**
SAVINGS			
First Year BBtu	4.8	8.2	59%
Lifetime BBtu[6]	111.4	151.0	74%
First Year kWh	109,513		
Lifetime kWh	2,035,203		
Summer Peak Demand kW	721		

[6] Projected lifetime gas savings was closer to the goal than first-year gas savings because the project mix included tended towards measures with lifetimes longer than originally projected.

First Year Water (Million Gallons)	0.30		
Lifetime Water (Million Gallons)	2.82		

TABLE 14. COST-EFFECTIVENESS RESULTS FOR EFFICIENT BUILDING GRANTS FROM INCEPTION THROUGH FY 2015

Present Value (2009$)	Actual
Benefits	$1,316,198
Costs	$947,247
Net Benefits	$368,951
BCR	1.39

4.1. Notable Program Activities in FY 2015

Project Timelines

PGW received 21 applications from landlords, business owners, and trade allies, nearly two-thirds of which came during the first half of the fiscal year. Ten Efficient Building Grant projects were completed during the year, including several that were initially applied for during previous fiscal years.

PGW has previously reported on long lead times for Efficient Building Grant projects to proceed from an application to a completed project ready for payment. In FY 2015, the *average time elapsed between application date and grant payment date increased even* further due to several projects completing that originally applied for the grant as much as two and a half years prior to completion. From inception through August 2015, the Efficient Building Grants project lifecycle from time of application to time of grant payment ranged from 4 months to 25 months, with the average project taking about 8.9 months.

The timing is notable with respect to PGW's Phase II extension proceeding. As PGW neared the end of FY2015, applications tapered off because customers were uncertain whether their project would be completed in time to receive an Efficient Building Grant. Efficient Building Grant projects are typically discretionary and as discussed above, can take a significant amount of lead time for the customer to plan the project and obtain all necessary approvals and are frequently dependent on the PGW grant to proceed. This contrasts to projects in the Efficient Construction Grant program, which are not dependent on the PGW grant to proceed, but use it to improve the efficiency of projects already underway. The DSM Bridge Order eased some of the concerns about grant availability for projects slated to close later in the year, but customers were often unwilling to risk applying for the program with project timelines that could potentially extend beyond the approval horizon.

Multifamily Trend

In 2015, PGW continued to see strong participation in Efficient Building Grants program from multifamily property owners, as shown in Table 15, likely due to the early program targeting. These multifamily projects were relatively small compared to the program's targeted average commercial and industrial project savings and incentive sizes, resulting in a decreased amount of incentive funds issued and savings achieved as compared with initial projections. Although these projects were comprehensive and cost-effective, the net benefits were relatively low due to the relatively low natural gas consumption at the properties.

TABLE 15. EFFICIENT BUILDING GRANTS PARTICIPANT SUMMARY

Customer Type	FY 2015	Total To-Date	Percent To-Date
Multi-family	8	23	92%
Commercial	2	2	8%
Industrial	0	0	0%
Total	**10**	**25**	

A review of the program's application activity in Table 16 shows a far greater diversity in building types than the program participants. PGW believes this to be due to hurdles experienced by small business owners and commercial buildings when planning an energy efficiency retrofit project. Some common hurdles to converting commercial applications include owner access to financing, and competing priorities of building owners.

TABLE 16. EFFICIENT BUILDING GRANTS APPLICANT SUMMARY

Customer Type	FY 2015	Total To-Date	Percent To-Date
Multi-family	13	37	54%
Commercial	5	26	38%
Industrial	0	3	4%
Other	3	3	4%
Total	**21**	**69**	

Evaluation Findings

PGW has completed the third-party impact evaluation on the Efficient Building Grant program's activities from its inception in September 2011 through February 2014 including analysis of actual gas usage reductions. The evaluation found significant project-level savings among the eight projects reviewed, averaging 53 percent of pre-treatment gas usage. Individual project savings ranged from six to 62 percent of pre-treatment usage, and most projects had at least 30 percent savings. At the measure-level, the evaluator found HVAC, hot water and low-flow fixtures to contribute the most to the total estimated savings, a combined 76 percent. Other measures such as insulation and air sealing contributed only marginally to the total estimated savings.

Although the impact evaluation showed that projects in the Efficient Building Grants program achieved high savings, the levels were slightly less on average than PGW's initial projections. Overall, the projects achieved 93 percent of the calculated savings that were projected using PGW's TRM assumptions. The realization rates ranged from 21 percent to 123 percent. Differences in realization rates across projects did not appear to be explained by differences in the types of measures installed or the percent of projected savings from certain measures. However, a quantitative analysis of the differences could not be implemented due to the small sample sizes and so the Evaluator did not recommend making any updates to the TRM assumptions due to the small sample size of just eight projects reviewed. PGW will continue performing biennial impact evaluations on all DSM programs, including Efficient Building Grants. In future evaluations, PGW will have a larger sample size and more closely analyze the impact of individual measures to determine what modifications to PGW's TRM may be necessary to align actual savings with the projected savings.

Despite the lower savings than expected, the Efficient Building Grants program was found to be highly cost-effective. According to the savings estimated by the evaluator through its billing analysis, all but one project was cost-effective, with project cost-effectiveness ranging from 0.68 to 7.42 BCR. Overall, the cost-effectiveness ratio weighted by total project cost was projected to be 2.27.

The impact evaluation found PGW to be very proactive in reaching out to customers and successfully recruiting multifamily building owners to participate in the program. Although the program did not reach original participation goals, the Evaluator recognized PGW's success in meeting the program design goal of targeting comprehensive projects. The Evaluator recommended that PGW continue to work with customers who are discussing single-measure upgrades to expand their project into a comprehensive approach, a tactic PGW employed during FY 2015 in its business development activities.

5. Commercial and Industrial Equipment Rebates

The Commercial and Industrial Equipment Rebates Program ("CIER") issues prescriptive rebates on premium efficiency gas appliances and heating equipment to increase the penetration of these measures in the facilities of PGW nonresidential customers. The program has the following objectives:

- Promote the selection of premium efficiency models at the time of purchase of commercial- and industrial-sized gas heating equipment.
- Increase business customers' awareness of the breadth of energy efficiency opportunities in their properties.
- Strengthen PGW's relationship with business customers as partners in energy efficiency.
- Encourage market actors throughout the supply chain to provide and promote high efficiency options.
- Align incentives with other programs.
- Aid in market transformation towards highest-efficiency options.

Eligible customers use certified contractors to install the premium efficiency equipment and receive cash rebates to offset most of the incremental cost of the higher efficiency equipment.

TABLE 17. CIER RESULTS FOR FY 2015

	FY 2015		
	Actual	**Goal**	**%**
PARTICIPATION[7]			
Rejected Claims	19		
Completed Claims	**71**	**144**	**49%**
Total Claims	90		
COSTS (Nominal)			
Non-Incentive Spending[8]	**$107,533**	**$101,200**	**106%**
Administration and Management	$-	$-	
Marketing and Business Development	$-	$-	
Contractor Costs	$48,493	$60,000	
Inspection and Verification	$1,284	$1,200	
On-site Technical Assessment	$-	$-	
Evaluation	$57,756	$40,000	
Customer Incentives	**$250,915**	**$236,592**	**106%**
Total Program Spending	**$358,448**	**$337,792**	**106%**
Participant Costs	$111,912	$91,614	
Total Costs	**$470,360**	**$429,406**	**110%**

[7] *A claim is a rebate request for one piece of equipment. Because applications can have claims for multiple pieces of equipment, metrics for this section are based on claims.*

[8] The CIER non-incentive costs exceeded projected costs due to PGW's decision to gather additional data through the program evaluation than originally anticipated. The study will inform future program design decisions.

SAVINGS[9]			
First Year BBtu	14.5	10.1	144%
Lifetime BBtu	281.1	156.4	180%
First Year kWh	28,598		
Lifetime kWh	428,970		
Summer Peak Demand kW	8.9		
First Year Water (Million Gallons)	1.64		
Lifetime Water (Million Gallons)	16.84		
MEASURES			
Commercial Heating Boilers	33		
Commercial Hot Water Heaters	13		
Commercial Gas Convection Oven	3		
Commercial Fryer	8		
Commercial Gas Steam Cooker	1		
Custom Equipment	13		

TABLE 18. COST-EFFECTIVENESS RESULTS FOR CIER FROM INCEPTION THROUGH FY 2015

Present Value (2009$)	Actual
Benefits	$1,771,242
Costs	$643,039
Net Benefits	$1,128,203
BCR	2.75

5.1. Notable Program Activities in FY 2015

The CIER program had its most successful year to-date in FY 2015 with 71 installations, resulting in PGW exceeding its customer incentive budget by $14,323.[10] Although participation was below program goals, the projects that were incentivized received larger rebates than projected so PGW's goals were achieved by incentivizing fewer participants.

The rise in CIER spending was largely due to the nearly $95,000 spent on custom rebates in FY2015, 38 percent of the total CIER customer incentive expenditures. The custom rebate projects consisted of nine low-flow fixture projects in multifamily facilities, one commercial energy management system project, and an infrared heater installation. The infrared heater project, which received a $75,000 rebate, was PGW's largest custom rebate project to-date. Due to the success of this project, PGW plans to explore promoting infrared heating equipment in future program years.

[9] PGW's CIER program savings tracking has been expanded to include kWh and kW savings resulting from a custom equipment rebate project.

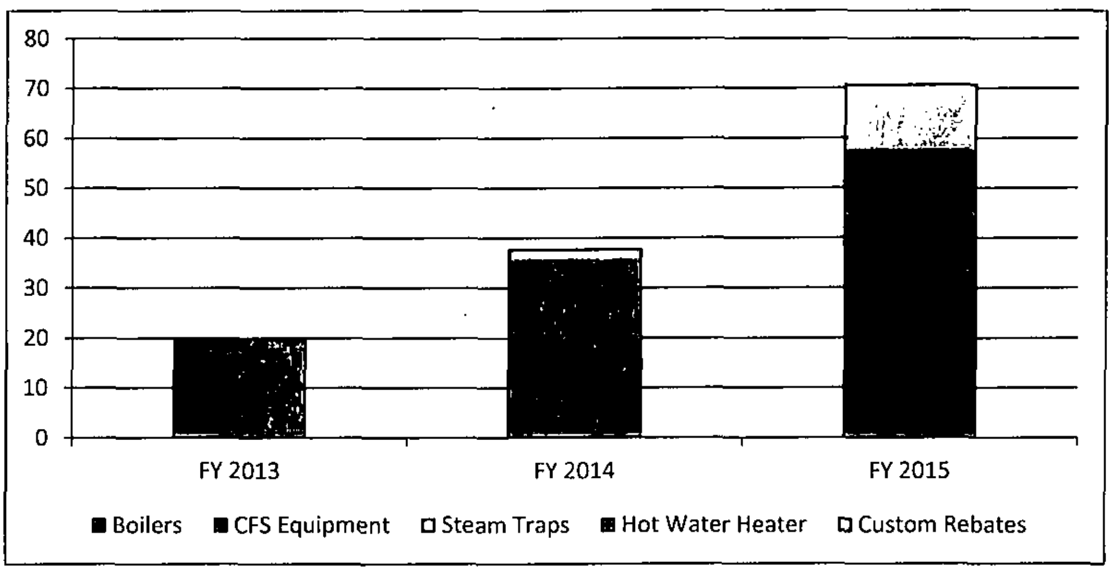
[10] As PGW maintains the ability to reallocate funds between programs as long as the overall portfolio budget remains within the budget cap approved by the Commission, other incentive funding was shifted

The CIER boiler rebates offer also had its most successful year to-date, with $122,800 in rebates issued for 33 boiler installations. This trend resulted in gas savings exceeding projections, as commercial boilers achieve greater savings than other measures in CIER. In FY 2015, the gas savings achieved 144% of the first-year savings goal and 180% of the lifetime savings goal.

In prior program years the majority of boiler installations occurred in multifamily buildings. In FY 2015 only 30 percent of installations took place in multifamily buildings, while 52 percent occurred in office buildings. This shift confirms PGW's strategy of improved targeting of the business community in FY 2014 and FY 2015 to expand the participant base to other commercial building types beyond multifamily.

In FY 2015, PGW launched a new offer for ENERGY STAR® certified commercial hot water heaters, which resulted in 13 rebates over the course of the year. Program participation continued to grow in FY2015 due to an increase in boiler rebates, custom rebates, and the new hot water heater rebate product category. The commercial food service category experienced a decline in rebates issued due to elimination of the ENERGY STAR® commercial gas convection oven category, which was previously the most popular equipment in this rebate category. Figure 2 provides a summary of annual rebate issuance activity for the CIER program.

FIGURE 2. CIER REBATE ISSUANCE ANNUAL ACTIVITY



Evaluation Findings and TRM Update

PGW has completed the third-party CIER impact evaluation on the program's activities from its first rebate in February 2013 through April 2014, including analysis of actual gas usage reductions. The evaluation reviewed the savings of 13 customers that installed high efficiency natural gas commercial boilers and six customers that installed high efficiency natural gas commercial convection ovens. The evaluator noted that the precision of the findings was not high, especially in the case of the convection oven savings, due to this small sample size. PGW will continue performing biennial impact evaluations on all DSM programs, including CIER. In future evaluations, PGW will have a larger sample size and more closely analyze the impact of individual measures to determine what modifications to PGW's TRM may be necessary to align actual savings with the projected savings.

The program was found to have been popular with both customers and contractors. Further evaluation findings and conclusions are discussed in greater detail below.

A. Energy Savings

The impact evaluation found that the commercial boilers were estimated to achieve an estimated 13.3 percent savings on average, or 4,194 Ccf. The estimated savings for *commercial boilers exceeded PGW's savings projections by 166 to 317 percent, depending* on the weather normalization method used. The disparity has been diagnosed as resulting from under-estimating average equipment sizes and the Equivalent Full Load Hours ("EFLH"). PGW *is filing a TRM update with this FY 2015 Annual Report to revise EFLH* assumptions upwards for commercial-sized boilers, which will make future projections much closer to the estimated gas savings found through this impact evaluation.

Convection ovens were found to have no apparent savings, possibly due to the participating customers sizing up equipment at the time of the upgrade, or the equipment going into facilities that were recently converted for restaurant use. PGW discontinued its rebate offer for convection ovens at the start of FY 2015 due to cost effectiveness concerns.

B. Program Design

The impact evaluation found incremental costs for both commercial food service equipment and commercial-sized boilers to vary widely between the responses provided by installers and suppliers. The majority of participants, installers and suppliers found the rebate amounts to be sufficient for boilers, though not large enough for food service equipment. The evaluator recommended continuing to research incremental costs to ensure that the program is covering the projected 80 percent goal.

In FY 2015, PGW revised its food service rebate levels based on a review of incremental costs. Rebate levels for several products were increased to cover the 80 percent target. This change may have been a factor in the increase in rebates for natural gas fryers in FY 2015.

The Evaluation also recommended considering additional rebate offerings, given the barriers facing the existing high-efficiency. PGW agrees and is using its custom rebate category to examine additional offerings for future program years. This rebate category experienced significant growth in FY 2015, confirming the evaluation's findings.

C. Marketing and Participation

CIER program participation was low during the period of this valuation. Activity trends have improved to date, however participation still remains short of annual participation goals. Based on their research, interview, and analysis within this impact evaluation, several recommendations were offered for additional marketing opportunities to pursue. Some of those recommendations are:

- Reach out to commercial and industrial contractors and sales staff so that they are aware of the rebate programs available and can share the information with consumers.
- Provide printed materials or electronic advertisements that installers and suppliers can forward to their customers.
- Link the PGW rebate website to a list of high efficiency installers and contractors in the area.
- Contact building management companies directly.
- Build relationships with local trade and housing associations to personally keep in touch about programs.
- Advertise through monthly equipment publications or trade magazines.
- Send out bill inserts, email advertising, or other media.

PGW agrees with many of the Evaluation's conclusions, and is planning to move forward in implementing several specific recommendations, such as online applications as part of its DSM Phase II proposal.

D. Market Impact

The evaluator performed interviews with participants who received rebates, non-participants who were interested in the program but did not proceed with a project, and contractors who installed CIER equipment for customers. The survey results both helped PGW assess effective marketing activities and identify opportunities for improvement. Relevant survey results include:

- Overall, customers and trade allies alike were satisfied with the program. Seventy five percent of suppliers surveyed were satisfied with the products covered by the rebates. All participants found it very or somewhat easy to participate and were very or somewhat satisfied with their new equipment. Fifty percent of participants surveyed received direct assistance from PGW and reported that PGW was very helpful.
- The program needs to increase participation to have an impact on the market. Suppliers stated that the program did not have an impact on their stocking options because stocking is only based on demand. Currently, participation is too low to have such an impact.
- The program needs to increase outreach to impact customers who were not otherwise focusing on the high-efficiency option. A number of participants surveyed reported that they would have installed the high-efficiency option regardless of the incentive. This troubling statistic suggests that PGW is not reaching a broad enough swath of the market to drive participation among customers who would otherwise not install high efficiency equipment. The program needs to reach a broader audience and educate them about the benefits of the high-efficiency alternative to move the unlikely high efficiency buyers into the program.

PGW agrees with many of the Evaluation's conclusions, and is exploring specific program changes for its DSM Phase II programming that will address the findings.

6. Efficient Construction Grants Program

The Efficient Construction Grants program promotes natural gas energy efficiency in the construction and gut rehab markets, both for residential and non-residential construction projects. The program provides technical assistance and prescriptive financial incentives for projects that exceed energy code design requirements. Incentives increase based on the relative and actual amount of gas a project saves. The program has the following objectives:

- Save natural gas through cost-effective energy efficiency new construction and gut rehabilitation projects.
- Promote a better understanding of energy efficiency options available in the new construction and gut rehabilitation markets.
- Aid in market transformation towards highest-efficiency building and equipment options.

TABLE 19. EFFICIENT CONSTRUCTION GRANTS PROGRAM RESULTS FOR FY 2015

	FY 2015		
	Actual	**Goal**	**%**
PARTICIPATION			
Residential Applications	27		
Commercial Applications	22		
Applications Rejected or Withdrawn	16		
Customers with Installations	**14**	65	22%
Residential	12		
Commercial	2		
COSTS (Nominal)			
Non-Incentive Spending	**$67,765**	**$83,402**	**81%**
Administration and Management	$-		
Marketing and Business Development	$-		
Contractor Costs	$40,770	$23,148	
Inspection and Verification	$1,346	$10,255	
On-site Technical Assessment	$-		
Evaluation	$25,649	$50,000	
Customer Incentives	**$109,462**	**$214,389**	**51%**
Total Program Spending	**$177,227**	**$297,791**	**60%**
Participant Costs	$-	$106,887	0%
Total Cost	**$177,227**	**$404,679**	**44%**
SAVINGS			
Net Annual BBtu	5.7	3.7	154%
Net Lifetime BBtu	92.8	68.5	136%

TABLE 20. COST-EFFECTIVENESS RESULTS FOR EFFICIENT CONSTRUCTION GRANTS FROM INCEPTION THROUGH FY 2015

PRESENT VALUE (2009$)	Actual
Benefits	$632,194
Costs	$313,707
Net Benefits	$318,487
BCR	2.02

6.1. Notable Program Activities in FY 2015

The Efficient Construction Grant program received 49 applications, had 16 applications withdrawn or rejected, and issued $109,462 in grants for 14 projects during FY 2015. The program showed a significant increase in cost-effectiveness, ending the year with a 2.02 TRC BCR from inception through FY 2015.

FIGURE 3. EFFICIENT CONSTRUCTION GRANT PROGRAM APPLICATION ACTIVITY

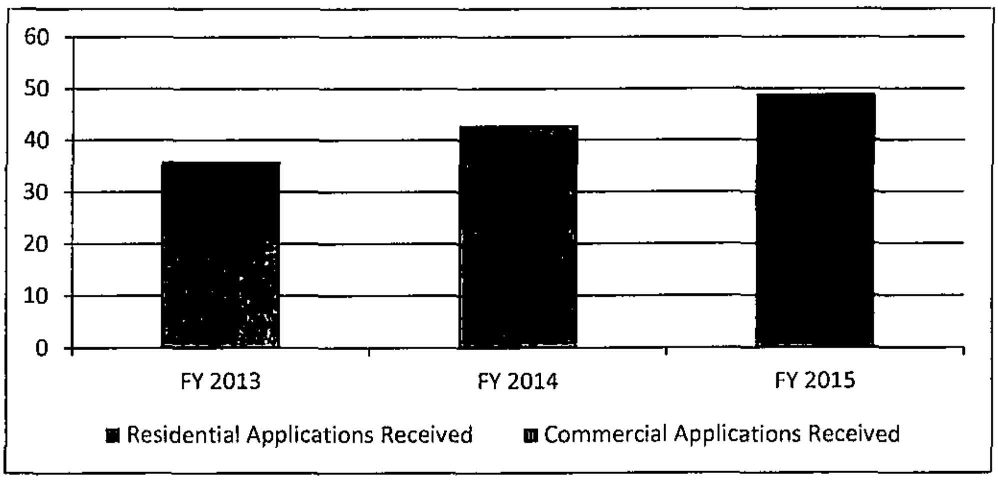
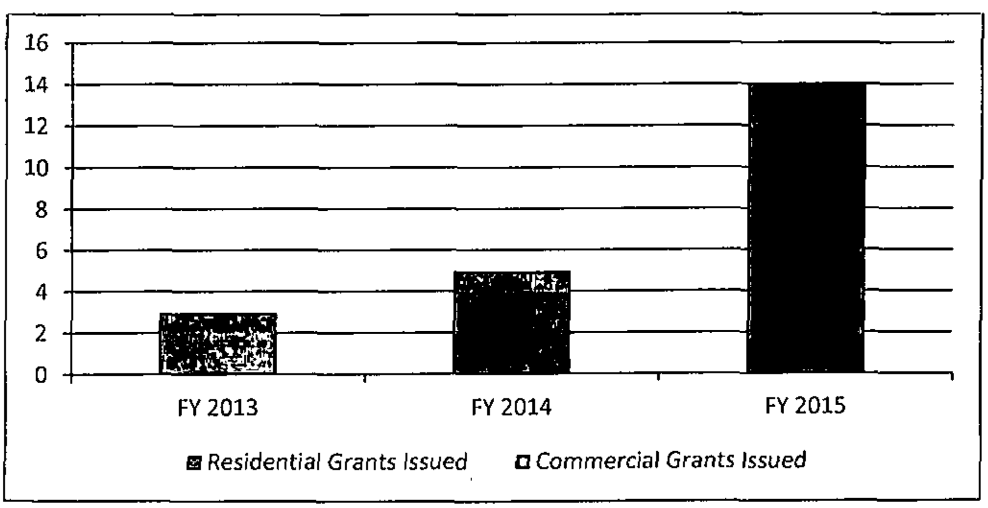


FIGURE 4. EFFICIENT CONSTRUCTION GRANT PROGRAM ISSUANCE ACTIVITY



As Figure 3 above shows, the number of applications received increased slightly in FY 2015, while the number of grants issued increased significantly due to projects applied for in prior years being completed. Figure 4 above shows that participation in FY2015 was the highest than in each of the previous two fiscal years combined. Much of this activity came from customers who applied in prior program years, but whose projects weren't completed until FY 2015.

Two factors were critical to the program's success in FY 2015. First, large commercial multifamily project closed, which received an $84,300 incentive through a combination of prescriptive rebates and the Efficient Construction Grant custom incentive award. This project contributed to 88 percent of the FY15 first-year gas savings for PGW. The second factor was the rise in single-family home participants. The improvements to the HECI application process in FY 2014 resulted in many more single-family home developers to provide the necessary documentation for their projects, and follow-through to receive the Efficient Construction Grant.

Incentive Changes

Two changes to the grant calculation took effect for FY 2015 to improve cost-effectiveness while maintaining a streamlined program delivery. First, in June 2014 just before the start of FY 2015, the Efficient Construction Grant incentive calculation for single family homes was updated. Customers continue to receive a minimum grant equal to the value of the prescriptive rebate for all eligible heating equipment, aligned with RHER. In these instances, the construction grant is scaled down based on the percentage of savings attributed to equipment not covered by the prescriptive rebate. This prevents customers from receiving double incentives for the same efficiency measure in a project.

The second change to grant calculations was the reduction to Residential Equipment Rebates program rebates, adjusted to reflect smaller-capacity equipment in multifamily buildings and homes with multiple pieces of heating equipment. Participants received a reduced rebate amount for each additional piece of equipment installed after the first.

The combined effect of these changes was to protect and improve program cost-effectiveness, while increasing participation to a greater number of projects than if the grant funds were committed to fewer projects with larger incentives. PGW is currently reviewing its grant calculation protocols to determine if further changes are necessary to ensure that the grant levels are aligned with the estimated incremental cost of each project.

7. Home Rebates

The Home Rebates program offers performance-based incentives to PGW's residential customers who implement whole-home energy efficiency retrofits. The program has the following objectives:

- *Save natural gas through cost-effective residential retrofits.*
- Achieve reductions of 20 percent or more in annual gas heating consumption on average among all participants.
- Promote better understanding of energy efficiency options available for the residential market.

TABLE 21. HOME REBATES RESULTS FOR FY 2015

	FY 2015		
	Actual	Goal	%
PARTICIPATION			
Audits	273		
Completed Jobs	**118**	**652**	**18%**
COSTS (Nominal)[11]			
Non-Incentive Spending	**$260,423**	**$289,000**	**90%**
Administration and Management	$-		
Marketing and Business Development	$-		
Contractor Costs	$260,423	$239,000	109%
On-site Technical Assessment	$-		
Evaluation	$-	$50,000	0%
Incentives	**$149,312**	**$1,111,000**	**13%**
Total Program Spending	**$409,735**	**$1,400,000**	**29%**
Participant Costs	$328,490	$2,226,823	
Total Cost	**$738,225**	**$3,626,823**	**20%**
SAVINGS			
First Year BBtu	2.6	17.7	15%
Lifetime BBtu	75.8	453.7	17%
First Year kWh	33,308		
Lifetime kWh	1,048,806		

[11] Due to a low program participation rates during the first program year, PGW has postponed the planned evaluation to a future program year to ensure an adequate sample size for the impact evaluation.

TABLE 22. COST-EFFECTIVENESS RESULTS FOR HOME REBATES FROM INCEPTION THROUGH FY 2015

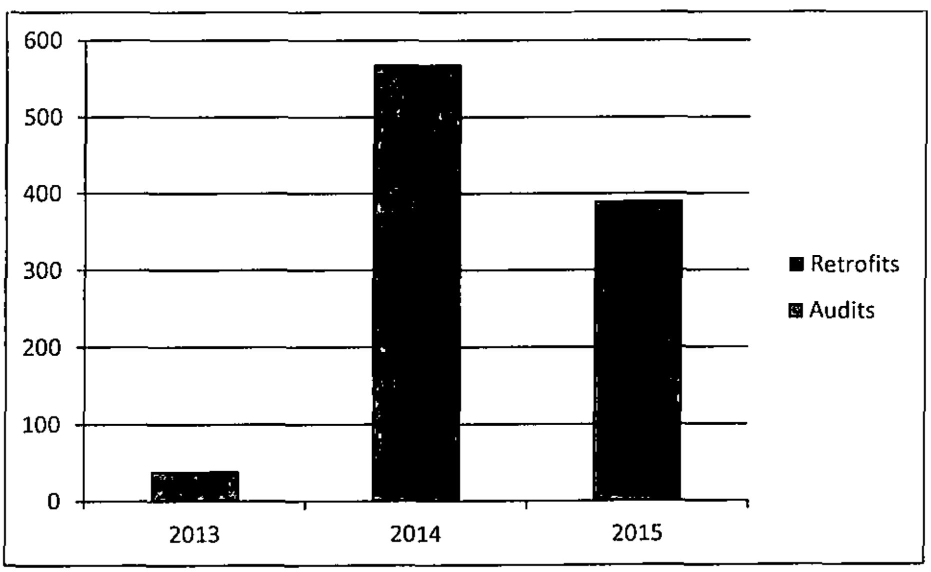
PRESENT VALUE (2009$)	Actual
Benefits	$1,235,658
Costs	$1,708,724
Net Benefits	$(473,066)
BCR	0.72

7.1. Notable Program Activities in FY 2015

The Home Rebates program was not cost-effective in 2015, though it continues to make incremental positive trending as shown by the fact that the program BCR improved from 0.70 in FY 2014 to 0.72. Individual customer projects are cost-effective, demonstrating net benefits since inception of $165,000, with a BCR of 1.14. The primary issues affecting overall program cost-effectiveness continues to be high overhead costs necessary in administering the program, combined with low participation levels.

Participation decreased in 2015 compared to 2014 levels, in part because the highest performing contractor withdrew from the program in mid-FY 2015, as discussed below. Although the overall participation dropped mid-year, activity trended upward at the end of the year due to marketing activities discussed below. PGW aims to reach cost-effective levels given sufficient program activity. However, these levels have not yet been reached, and future forecasts will be dependent upon program continuation past FY 2015, currently under review within the PGW DSM Phase II petition to the PUC.

FIGURE 5. HOME REBATES PARTICIPATION BY FISCAL YEAR



PGW's updates in FY 2015 were related to increasing proactive lead generation and new marketing initiatives, changes in participating CSPs, and efforts to increase customer participation.

Conservation Service Provider Changes

PGW added two new CSPs to the program mid-year, chosen through a competitive RFP, with the goal of increasing program participation. While participation and savings figures did not exceed 2014 levels for other reasons explained below, the addition of these two firms was positive for the program. Both firms added proactive lead generation activities. It also increased competition among CSPs and allowed PGW to assign more program-generated leads to those with the greatest capacity and ability to perform work.

The program faced a significant challenge when the largest and most active CSP closed operations and ceased participating in the program in FY 2015. The CSP was responsible for the majority of Home Rebates projects from inception until it closed operations in January 2015. The loss resulted in reduced program activity of CSP-generated leads, and led to increased program administrative costs in addressing customer concerns and working with other active CSPs in reassigning work.

Program Updates

PGW and its Program Administrator made several improvements throughout the year to streamline program delivery, improve CSP performance, and increase customer participation. Notable program management activities included:

- Implementing an online Rebate Tracker tool, allowing customers to view the status of their rebate and estimated payment time
- Identifying entities that finance energy and home repair projects, for CSPs to refer to customers in hopes of attracting more customers that couldn't otherwise afford projects
- Program trainings and improved documentation processes regarding multi-point blower door use, and health and safety issues

Marketing Activities

PGW's FY 2015 marketing activities consisted of a strategic multi-layer approach consisting of the following activities:

- A $500 Limited Time Offer ("LTO") to create a sense of urgency in marketing the program to new leads and help CSPs convert old leads.
- A pilot thermal imaging campaign that offered a custom thermal analysis report to PGW's customers identified as the best candidates for Home Rebates projects.
- A press event to build awareness of the innovative thermal imaging campaign and highlight the innovative technology.
- Advertisements and promotion through to build awareness of the program.
- Neighborhood blitzes consisting of localized marketing activities and presentation to generate quality leads and have one-on-one conversations.

The most successful new marketing tactic PGW employed in FY 2015 was the launch of the LTO for an increased rebate amount. The LTO offered an additional rebate of $500 to customers who signed contracts between July 1 and August 31, 2015 to have over $2,500 worth of energy savings measures and complete the project within 45 days. This effort was successful, with 26 contracts signed during this period, though most projects will be *completed in FY 2016.*

PGW launched its pilot thermal imaging campaign in summer 2015 that offered customized thermal reports to 2,500 targeted customers. Letters were mailed to leads explaining the program and giving customers the opportunity to opt-in to receive a custom thermal image report showing the air leakage and insulation deficiency of the home, and an estimated dollar figure for how much they could save through a Home Rebates Project. The customers were also offered to have this report delivered by a program CSP who would perform a free walk-through assessment. Although initial response rates were lower than anticipated, PGW plans to continue outreach to these customers in through letters, outbound calls and door-to-door canvassing.

In addition to the new initiatives discussed above, PGW continued its neighborhood blitz campaign in four targeted neighborhoods. This campaign included posting flyers at businesses on local "main streets," making presentations at community meetings and enrolling leads, canvassing homeowners, targeted advertising and earned media. The goal of this effort is to create market awareness so to generate customer familiarity with the program at the same time that CSPs and program representatives are directly targeting neighborhoods with active lead generation activities.

8. Appendix A. Cost Recovery Reconciliation

TABLE 23. USC COST RECOVERY (SEPTEMBER 2014 THROUGH AUGUST 2015)

Month		Applicable Volumes	USC Charge	USC Revenue Billed	USC Expenses	Monthly Over/(Under) Recovery	Cumulative Over/(Under) Recovery
FY 14 Reconciliation							$1,338,927
September 2014	Actual	1,120,161	$1.6753	$1,876,606	$(1,754,620)	$3,631,226	$4,970,153
October	Actual	1,410,747	$1.4642	$2,065,616	$(942,460)	$3,008,076	$7,978,229
November	Actual	3,310,333	$1.4642	$4,846,990	$4,575,714	$271,276	$8,249,505
December	Actual	6,897,688	$1.2795	$8,825,247	$12,729,386	$(3,904,139)	$4,345,366
January 2015	Actual	8,801,725	$1.0947	$9,635,248	$17,122,367	$(7,487,119)	($3,141,753)
February	Actual	10,263,513	$1.0947	$11,235,468	$17,584,237	$(6,348,769)	($9,490,521)
March	Actual	9,449,687	$1.1688	$11,044,321	$15,870,152	$(4,825,831)	($14,316,352)
April	Actual	5,403,643	$1.2428	$6,715,647	$8,761,072	$(2,045,425)	($16,361,777)
May	Actual	2,187,690	$1.2428	$2,718,861	$2,525,245	$193,616	($16,168,161)
June	Actual	1,308,732	$1.3665	$1,788,382	$(650,004)	$2,438,386	($13,729,775)
July	Actual	1,125,749	$1.4902	$1,677,591	$(1,321,068)	$2,998,660	($10,731,116)
August	Actual	1,060,296	$1.4902	$1,580,053	$144,845	$1,435,209	($9,295,907)

TABLE 24. USC EXPENSES (SEPTEMBER 2014 THROUGH AUGUST 2015)

USC Expenses	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15
ELIRP Expense	$48,393	$51,212	$455,885	$585,451	$973,868	$41,296
ELIRP Labor	$12,683	$16,517	$19,264	$19,228	$24,220	$18,865
CRP Discount	$(2,424,508)	$(1,659,774)	$3,235,642	$10,852,045	$14,662,334	$16,019,680
CRP Forgiveness	$469,489	$478,214	$456,177	$498,830	$515,397	$493,063
Senior Citizen Discount	$139,322	$171,372	$408,745	$773,832	$946,548	$1,011,334
Bad Debt Expense Offset*	$-	$-	$-	$-	$-	$-
Total	**$(1,754,620)**	**$(942,460)**	**$4,575,714**	**$12,729,386**	**$17,122,367**	**$17,584,237**

USC Expenses	Mar-15	Apr-15 (Revised)	May-15	Jun-15	Jul-15	Aug-15
ELIRP Expense	$1,124,411	$826,183	$823,808	$618,920	$538,229	$2,038,095
ELIRP Labor	$16,049	$10,287	$12,857	$10,318	$12,555	$11,198
CRP Discount	$13,316,092	$6,842,300	$825,635	$(2,030,043)	$(2,566,295)	$(2,588,072)
CRP Forgiveness	$560,325	$562,347	$607,513	$615,562	$585,316	$574,178
Senior Citizen Discount	$853,275	$519,955	$255,432	$135,241	$109,127	$109,446
Bad Debt Expense Offset*	$-	$-	$-	$-	$-	$-
Total	**$15,870,152**	**$8,761,072**	**$2,525,245**	**$(650,004)**	**$(1,321,068)**	**$144,845**

USC Expenses	Total
ELIRP Expense	$8,125,752
ELIRP Labor	$184,041
CRP Discount	$54,485,035
CRP Forgiveness	$6,416,409
Senior Citizen Discount	$5,433,628
Bad Debt Expense Offset*	$-
Total	$74,644,866

**Bad Debt Expense Offset Applicable When Actual CRP Participation Exceeds 84,000*

TABLE 25. EFFICIENCY COST RECOVERY SURCHARGE (SEPTEMBER 2014 THROUGH AUGUST 2015)

Residential & PHA GS

		Actual Sep-14	Actual Oct-14	Actual Nov-14	Actual Dec-14	Actual Jan-15	Actual Feb-15	Actual Mar-15	Actual Apr-15	Actual May-15	Actual Jun-15	Actual Jul-15	Actual Aug-15
FY 2014 Over-Collection	$3,664,920												
Volume Billed		716,465	891,401	2,334,361	5,215,559	6,705,574	7,855,404	7,311,790	4,146,356	1,602,303	878,834	731,782	684,924
ECR Surcharge		$(0.0154)	$(0.0040)	$(0.0040)	$(0.0086)	$(0.0131)	$(0.0131)	$(0.0136)	$(0.0141)	$(0.0141)	$(0.0061)	$0.0019	$0.0019
Revenue Billed		$(11,034)	$(3,566)	$(9,337)	$(44,593)	$(87,843)	$(102,906)	$(99,440)	$(58,464)	$(22,592)	$(5,361)	$1,390	$1,301
RHER[12]	Expense	28,249	7,302	80,490	91,172	137,874	(13,912)	91,278	24,868	42,712	95,823	29,614	177,747
RHER	Labor	1,714	2,232	3,096	2,598	3,273	765	2,169	1,390	1,659	1,394	1,697	2,316
HECI[13]	Expense	1,330	1,408	104	10,920	3,705	13,499	11,475	11,021	22,948	7,655	7,739	(31,716)
HECI	Labor	349	454	687	529	666	2,376	441	283	2,951	284	345	(2,050)
CRRI[14]	Expense	8,915	9,434	54,628	23,504	152,405	52,720	54,603	66,375	47,150	50,700	54,943	108,908
CRRI	Labor	2,336	3,043	3,584	3,542	4,462	3,520	2,957	1,895	2,397	1,901	2,313	79
CIRI[15]	Expense	1,352	1,431	(992)	2,471	2,126	(9,183)	40,924	7,766	(35,681)	10,042	412	33,897
CIRI	Labor	354	461	224	537	677	(3,572)	448	287	(3,957)	288	351	(2,799)
CIER[16]	Expense	263	141	(213)	252	3,088	931	2,264	549	(562)	2,224	191	(2,924)
CIER	Labor	24	32	-	37	46	207	31	20	232	20	24	96
Total		$44,887	$25,937	$141,608	$135,562	$308,322	$47,352	$206,589	$114,454	$79,848	$170,330	$97,628	$283,553
Monthly Over/(Under)		$(55,921)	$(29,502)	$(150,946)	$(180,155)	$(396,165)	$(150,258)	$(306,029)	$(172,918)	$(102,441)	$(175,691)	$(96,237)	$(282,252)
Cumulative Over/(Under)		$3,609,000	$3,579,497	$3,428,551	$3,248,396	$2,852,232	$2,701,973	$2,395,944	$2,223,027	$2,120,586	$1,944,895	$1,848,658	$1,566,406

12 Residential Equipment Rebate Program
13 Efficient Construction Grant Program
14 Home Rebates Program
15 Efficient Building Grants Program
16 Commercial and Industrial Equipment Rebates Program

Table 26. Efficiency Cost Recovery Surcharge (September 2014 through February 2015)

Commercial & PHA

COMMERCIAL & PHA			Actual	Actual	Actual	Actual	Actual	Actual	Actual	Actual	Actual	Actual	Actual	Actual
FY 2014 Over-Collection		$1,029,904	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15	Jul-15	Aug-15
Volume Billed			364,948	470,450	856,762	1,461,168	1,822,979	2,080,859	1,838,729	1,090,870	527,118	383,611	354,968	337,149
ECR Surcharge			$(0.0058)	$(0.0013)	$(0.0013)	$(0.0040)	$(0.0066)	$(0.0066)	$(0.0070)	$(0.0074)	$(0.0074)	$0.0062	$0.0198	$0.0198
Revenue Billed			(2,098)	(612)	(1,114)	(5,772)	(12,032)	(13,734)	(12,871)	(8,072)	(3,901)	2,378	7,028	6,676
RHER	Expense		3,200	827	3,232	10,327	15,616	71,075	10,339	2,817	(35,386)	10,853	3,354	467
RHER	Labor		194	253	(155)	294	371	2,128	246	157	310	158	192	(676)
CIRI	Expense		2,069	2,190	1,222	3,782	3,254	14,919	62,637	11,886	59,275	15,370	631	27,903
CIRI	Labor		542	706	1,147	822	1,036	4,917	686	440	4,873	441	537	3,597
CIER	Expense		5,915	3,161	3,943	5,669	69,417	5,988	50,899	12,332	2,239	50,003	4,284	49,927
CIER	Labor		546	711	851	827	1,042	621	690	443	334	444	540	(2,088)
HECI	Expense		591	625	(792)	4,851	1,646	(8,415)	5,098	4,896	(14,322)	3,401	3,438	144,940
HECI	Labor		155	202	60	235	296	(1,650)	196	126	(2,455)	126	153	2,482
CRRI	Expense		-	-	-	-	-	-	-	-	-	-	-	42,923
CRRI	Labor		-	-	-	-	-	-	-	-	-	-	-	2,009
Total			$13,212	$8,674	$9,507	$26,808	$92,678	$89,584	$130,790	$33,097	$14,867	$80,796	$13,130	$271,483
Monthly Over/(Under)			$(15,311)	$(9,286)	$(10,621)	$(32,579)	$(104,710)	$(103,318)	$(143,661)	$(41,169)	$(18,768)	$(78,417)	$(6,101)	$(264,808)
Cumulative Over/(Under)			$1,014,594	$1,005,308	$994,687	$962,108	$857,399	$754,081	$610,419	$569,250	$550,482	$472,064	$465,963	$201,155

TABLE 27. EFFICIENCY COST RECOVERY SURCHARGE (SEPTEMBER 2014 THROUGH FEBRUARY 2015)

Industrial

INDUSTRIAL			Actual	Actual	Actual	Actual	Actual	Actual	Actual	Actual	Actual	Actual	Actual	Actual
FY 2013 Over-Collection		$121,604	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15	Jul-15	Aug-15
Volume Billed			31,238	37,156	59,645	113,165	146,265	169,038	151,272	76,711	36,376	32,820	27,829	28,578
ECR Surcharge			$(0.1374)	$(0.1307)	$(0.1307)	$(0.1310)	$(0.1312)	$(0.1312)	$(0.1362)	$(0.1411)	$(0.1411)	$(0.0762)	$(0.0113)	$(0.0113)
Revenue Billed			$(4,292)	$(4,856)	$(7,796)	$(14,819)	$(19,190)	$(22,178)	$(20,596)	$(10,824)	$(5,133)	$(2,501)	$(314)	$(323)
RHER	Expense		-	-	-	-	-	-	-	-	-	-	-	2,413
RHER	Labor		-	-	-	-	-	-	-	-	-	-	-	75
CIRI	Expense		-	-	-	-	-	-	-	-	-	-	-	-
CIRI	Labor		-	-	-	-	-	-	-	-	-	-	-	-
CIER	Expense		-	-	-	-	-	-	-	-	-	-	-	117,101
CIER	Labor		-	-	-	-	-	-	-	-	-	-	-	2,484
Total			$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$122,074
Monthly Over/(Under)			$(4,292)	$(4,856)	$(7,796)	$(14,819)	$(19,190)	$(22,178)	$(20,596)	$(10,824)	$(5,133)	$(2,501)	$(314)	$(122,397)
Cumulative Over/(Under)			$117,312	$112,456	$104,660	$89,841	$70,651	$48,473	$27,878	$17,054	$11,921	$9,420	$9,106	$(113,291)

9. Appendix B. PGW TRM January 1, 2016

See attached document titled "Technical Reference Manual Measure Savings Algorithms January 1, 2016."

Technical Reference Manual
Measure Savings Algorithms

ENERGYSENSE
Your building, your savings.

PGW

January 1, 2016

Table of Contents

Prepared by: GreenEnergy EconomicsGroup

I. Residential Time of Replacement Market

A. Space Heating End Use

1) Efficient Space Heating System

Unique Measure Code(s): TBD
Draft date: 2/17/11
Effective date: TBD
End date: TBD

Measure Description
This measure applies to residential-sized gas furnaces and boilers purchased at the time of natural replacement. A qualifying furnace or boiler must meet minimum efficiency requirements (AFUE).

Definition of Baseline Condition
The efficiency levels of the gas-fired furnaces or boilers that would have been purchased absent this or another DSM program are shown in the following table.

Equipment Type	***Baseline AFUE***
Gas Furnace	80%
Gas Boiler	80%

Definition of Efficient Condition
The installed gas furnace or boiler must have an AFUE greater than that shown in the table below. Efficient model minimum AFUE requirements are detailed below.

Equipment Type	**Minimum AFUE**
Gas Furnace	94%
Gas Furnace with ECM Fan	94%
Gas Boiler	94%

Gas Savings Algorithms
MMBtu savings are realized due to the increase in AFUE of the new equipment. MMBtu savings vary by equipment type due to differences in model specific baseline AFUE and high efficiency AFUE percentages. Savings are calculated from the baseline new unit to the installed efficient unit.

$$Annual\ Gas\ Savings\ (MMBtu) = \frac{Capacity_{Out}}{1{,}000} \times \left(\frac{1}{AFUE_{Base}} - \frac{1}{AFUE_{Eff}}\right) \times EFLH_{Heat}$$

Where:

$Capacity_{Out}$	= Output capacity of equipment to be installed (kBtu/hr)
1,000	= Conversion from kBtu to MMBtu
$AFUE_{Base}$	= Efficiency of new baseline equipment (Annual Fuel Utilization Efficiency)

$AFUE_{EFF}$	= Efficiency of new equipment
$EFLH_{Heat}$	= Equivalent Full Load Heating Hours (730 hours for furnaces, 854 for boilers)[1]

Electric Savings Algorithms

Electric energy savings result from efficient furnace fans (ECM) that may be included with efficient furnaces. Electrical savings from fan motor efficiency does not apply to boilers.

Energy Savings
$\Delta kWh = 700$ kWh

Demand Savings
$\Delta kW = 0$ kW

Where:

ΔkWh	=	Gross customer annual kWh savings for the measure. Based on 500 kWh heating season plus 200 kWh cooling season.
ΔkW	=	Gross customer summer load kW savings for the measure.

Freeridership/Spillover
Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

Equipment Type	Free Ridership	Spillover
Gas Furnace	0%	0%
Gas Furnace with ECM Fan	0%	0%
Gas Boiler	0%	0%

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes

Equipment Type	Measure Lifetime
Gas Furnaces	20
Gas Boilers	25

Source: Lifetime estimates used by Efficiency Vermont.

Water Savings
There are no water savings for this measure.

[1] EFLH based on adjustments applied based on 2014 evaluation by APPRISE.

2) Programmable Thermostat

Unique Measure Code(s): TBD
Draft date: 2/17/11
Effective date: TBD
End date: TBD

Measure Description
This is a programmable thermostat controlling a residential-sized gas furnace or boiler.

Definition of Baseline Condition
The baseline is a manual thermostat where each temperature setting change requires human intervention.

Definition of Efficient Condition
The efficient thermostat is one that can be programmed to automatically increase or lower the temperature setting at different times of the day and week.

Gas Savings Algorithms

$$Annual\ Gas\ Savings\ (MMBtu) = SH_{pre} \times 5.3\% = (81 - 30) \times 5.3\% = 1.53\ MMBtu$$

Where:

SH_{pre}	=	*Space Heat MMBtu gas usage with manual thermostat*
5.3%	=	Percentage savings from programmable thermostat compared to manual thermostat[2]
81	=	Typical PGW residential heating customer total gas usage in MMBtu.
30	=	Non-space-heat gas usage in typical residence.[3]

Electric Savings Algorithms

If the type of air conditioning is known, then use the appropriate algorithm below. If the type or existence of air-conditioning is not known, then assume that 83% have air-conditioning and estimate the cooling savings as 83% of a house with central air conditioning.[4]

Reduced furnace fan or boiler circulator pump usage is also likely to occur and provide electricity savings during both the heating and cooling seasons, but these auxiliary savings are not accounted for in the following algorithms.

Energy Savings

$\Delta kWh = \Delta kWh_{Aux} + \Delta kWh_{Cool}$

$\Delta kWh_{Aux} = Annual\ Gas\ Savings\ (MMBtu) \times Auxiliary$

ΔkWh_{Cool} = 0 kWh if house has no air conditioning
= ΔkWh_{CAC} if house has central air conditioning
= 0 if house has room air conditioning
= 83% × ΔkWh_{CAC} *if no information about air conditioner*

[2] Percent savings from CWP evaluations of ECA thermostat installations.
[3] Non-space-heat usage assumption in New Jersey Clean Energy Program Protocols (December 2009).
[4] Percentage of houses with air-conditioning from EIA Table AC1.xls for Middle Atlantic region (PA, NY, NJ). From: http://www.eia.doe.gov/emeu/recs/recs2005/hc2005_tables/detailed_tables2005.html

$$\Delta \mathrm{kWh}_{CAC} = CAP_{COOL} \times \left(\frac{12{,}000 \frac{Btu}{ton} \times \frac{1}{1{,}000} \frac{kWh}{Wh}}{EER_{COOL} \times Eff_{duct}} \right) \times EFLH \times ESF_{COOL}$$

Deemed Savings:
$\Delta \mathrm{kWh} = \Delta \mathrm{kWh}_{aux} + \Delta \mathrm{kWh}_{CAC}\ (missing) = 7.7 + 77.1 = 84.8\ kWh$

$\Delta \mathrm{kWh}_{aux} = 1.53 \times 5.02 = 7.7$

$$\begin{aligned} \Delta \mathrm{kWh}_{CAC}\ (missing) &= 83\% \times \Delta \mathrm{kWh}_{CAC} \\ &= 83\% \times 3 \times \left(\frac{12}{10 \times 0.8}\right) \times 1032 \times 0.02 = 77.1 \end{aligned}$$

Demand Savings
$\Delta \mathrm{kW} = 0\ \mathrm{kW}$

Where:

ΔkWh = gross customer annual kWh savings for the measure.
ΔkW = gross customer summer load kW savings for the measure.
CAP_{COOL} = *capacity of the air conditioning unit in tons, based on nameplate capacity (see table below)*

EER_{COOL} = *Seasonally averaged efficiency rating of the baseline unit. (see table below)*

Eff_{duct} = *duct system efficiency (see table below)*

ESF_{COOL} = *energy savings factor for cooling and heating, respectively (see table below)*

EFLH = *equivalent full load hours*

Residential Electric HVAC Calculation Assumptions

Component	Type	Value	Sources
CAP_{COOL}	Variable	Nameplate data	Contractor Data Gathering
		Default: 3 tons	1
EER_{COOL}	Variable	Nameplate data	Contractor Data Gathering
		Default: Cooling = 10 SEER Default: Heating = 1.0 (electric furnace COP)	2
Eff_{duct}	Fixed	0.8	3
ESF_{COOL}	Fixed	2%	4
EFLH	Fixed	Philadelphia Cooling = 1,032 Hours	5

Sources:

1. Average size of residential air conditioner.
2. Minimum Federal Standard for new Central Air Conditioners/Heat Pumps between 1990 and 2006.
3. New York Standard Approach for Estimating Energy Savings from Energy Efficiency Measures in Commercial and Industrial Programs, September 1, 2009.
4. DEER 2005 cooling savings for climate zone 16, assumes a variety of thermostat usage patterns.
5. US Department of Energy, ENERGY STAR Calculator. Accessed 3/16/2009.

Freeridership/Spillover

Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

Equipment Type	Free Ridership	Spillover
Programmable Thermostat	0%	0%

Persistence

The persistence factor is assumed to be one.

Measure Lifetimes

Equipment Type	Measure Lifetime
Programmable Thermostat	15

Source: New Jersey Clean Energy Program Protocols (December 2009).

Water Savings

There are no water savings for this measure.

B. Water Heating End Use

1) Tankless Water Heater

Unique Measure Code(s): TBD
Draft date: 5/28/15
Effective date: TBD
End date: TBD

Measure Description

This measure is an on-demand gas water heater.

Definition of Baseline Condition

The efficiency levels of the gas-fired stand-alone storage water heater that would have been purchased absent this or another DSM program are shown in the following table.

Equipment Type	Baseline EF
Gas Stand-alone Storage Water Heater	0.615[5]

Definition of Efficient Condition
The installed tankless water heater must have an EF greater than that shown in the table below. Efficient model minimum EF requirements are detailed below.

Equipment Type	Minimum EF
Gas Tankless Water Heater	0.82

Gas Savings Algorithms
The following formula for gas savings is based on the DOE test procedure for water heaters.

$$Annual\ Gas\ Savings\ (MMBtu) = \frac{\left(\frac{1}{EF_{Base}} - \frac{1}{EF_{Eff}}\right) \times 41{,}045 \times 365}{1{,}000{,}000}$$

Where:

EF_{Base} = Energy Factor of baseline water heater = 0.615
EF_{Eff} = Energy Factor of efficient water heater

Electric Savings Algorithms

There are no electric savings from this measure.

Energy Savings
ΔkWh = 0 kWh

Demand Savings
ΔkW = 0 kW

Where:

ΔkWh = gross customer annual kWh savings for the measure.
ΔkW = gross customer summer load kW savings for the measure.

Freeridership/Spillover
Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

Equipment Type	Free Ridership	Spillover
Tankless Water Heater	0%	0%

[5] Based on the federal standard for residential gas-fired water heater as of April 16, 2015 and assumed typical 40 gallon storage.

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes

Equipment Type	Measure Lifetime
Tankless Water Heater	20

Source: Energy Star Residential Water Heaters: Final Criteria Analysis, April 1, 2008, p. 10.

Water Savings
There are no water savings for this measure.

C.Combined Space and Domestic Hot Water Usage

1) Combination Boiler - Space Heating and DHW

Unique Measure Code(s): TBD
Draft date: 1/1/16
Effective date: TBD
End date: TBD

Measure Description
This measure applies to residential-sized combination boilers purchased at the time of natural replacement. These are integrated boilers that provide hot water for space heating and on-demand domestic hot water and have minimal or no hot water storage. A qualifying combination boiler (combi boiler) must meet minimum efficiency requirements (AFUE).

Definition of Baseline Condition
The efficiency levels of the gas-fired boiler and stand-alone storage water heater that would have been purchased absent this or another DSM program are shown in the following table.

Equipment Type	Baseline
Gas Boiler	80% AFUE
Gas DHW tank	0.615 EF[6]

Definition of Efficient Condition
The installed gas furnace or boiler must have an AFUE greater than that shown in the table below. Efficient model minimum AFUE requirements are detailed below.

Equipment Type	Minimum AFUE
Gas Combi Boiler	94% AFUE 0.94 EF

[6] Based on the federal standard for residential gas-fired water heater as of April 16, 2015 and assumed typical 40 gallon storage.

Gas Savings Algorithms
MMBtu savings are realized due to the increase in AFUE of the new equipment. MMBtu savings vary by equipment type due to differences in model specific baseline AFUE and high efficiency AFUE percentages. Savings are calculated from the baseline new unit to the installed efficient unit.

$$Annual\ Gas\ Savings\ (MMBtu) = Annual\ Gas\ Savings_{SH} + Annual\ Gas\ Savings_{DHW}$$

$$Annual\ Gas\ Savings_{SH} = \frac{Capacity_{Out}}{1{,}000} \times \left(\frac{1}{AFUE_{Base}} - \frac{1}{AFUE_{Eff}}\right) \times EFLH_{Heat}$$

Where:

Annual Gas Savings$_{SH}$	= Space heating annual gas savings (MMBtu)
Annual Gas Savings$_{DHW}$	= Domestic Hot Water annual gas savings (MMBtu)
$Capacity_{Out}$	= Output capacity of equipment to be installed (kBtu/hr)
1,000	= Conversion from kBtu to MMBtu
$AFUE_{Base}$	= Efficiency of new baseline equipment (Annual Fuel Utilization Efficiency)
$AFUE_{Eff}$	= Efficiency of new equipment
$EFLH_{Heat}$	= Equivalent Full Load Heating Hours (854 hours)[7]

The following formula for DHW gas savings is based on the DOE test procedure for water heaters.

$$Annual\ Gas\ Savings_{DHW} = \frac{\left(\frac{1}{EF_{Base}} - \frac{1}{EF_{Eff}}\right) \times 41{,}045 \times 365}{1{,}000{,}000}$$

Where:

EF_{Base} = Energy Factor of baseline water heater = 0.594

EF_{Eff} = Energy Factor of efficient combi boiler. Since the combi boiler has no or little storage, standby losses are assumed to be negligible and the EF is assumed to be the same as the AFUE.

Electric Savings Algorithms

Energy Savings
$\Delta kWh = 0\ kWh$

Demand Savings
$\Delta kW = 0\ kW$

Where:

ΔkWh	=	Gross customer annual kWh savings for the measure.
ΔkW	=	*Gross customer summer load kW savings for the measure.*

Freeridership/Spillover
Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

[7] Based on 2014 APPRISE evaluation for boilers.

Equipment Type	Free Ridership	Spillover
Gas Combi Boiler	0%	0%

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes

Equipment Type	Measure Lifetime
Gas Combi Boiler	20

Source: Same as lifetime estimate used for tankless water heater.

Water Savings
There are no water savings for this measure.

D.All End Uses

1) Custom Measure

Unique Measure Code(s): TBD
Draft date: 7/22/13
Effective date: TBD
End date: TBD

Measure Description
This measure applies to all custom measures, not otherwise specified in this TRM.

Definition of Baseline Condition
The baseline represents the typical equipment that is installed without a DSM program. The efficiency level is based on the current Federal standards, or state and local building codes that are applicable.

Definition of Efficient Condition
The efficient measure is any equipment that uses less energy than the baseline equipment.

Gas Savings Algorithms
The generalized equation for a custom measure compares the baseline usage to the efficient usage.

$$Annual\ Gas\ Savings\ (MMBtu) = BaselineUse - EfficientUse$$

Where:

BaselineUse = The gas usage of baseline equipment or building.

EfficientUse = The gas usage of efficient equipment or building.

Electric Savings Algorithms

Energy Savings
$\Delta kWh = BaselinekWh - EfficientkWh$

Demand Savings
$\Delta kW = BaselinekW - EfficientkW$

Where:

ΔkWh	=	*Gross customer annual kWh savings for the measure.*
ΔkW	=	Gross customer summer load kW savings for the measure.
BaselinekWh	=	The electric kWh usage of baseline equipment or building.
EfficientkWh	=	The electric kWh usage of efficient equipment or building.
BaselinekW	=	The electric kW usage of baseline equipment or building.
EfficientkW	=	The electric kW usage of efficient equipment or building.

Freeridership/Spillover
Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

Equipment Type	Free Ridership	Spillover
Custom Measure	0%	0%

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes
Where available, custom measure lifetimes should be based on similar measures defined elsewhere in this TRM.

Water Savings
The water savings are the difference between the baseline and efficient equipment annual water usage in gallons.

II. Residential New Construction

A.All End Uses

1) Custom Measures

Unique Measure Code(s): TBD
Draft date: 4/30/12
Effective date: TBD
End date: TBD

Measure Description
This measure applies to all custom measures, not otherwise specified in this TRM.

Definition of Baseline Condition
The baseline represents the typical equipment that is installed without a DSM program. The efficiency level is based on the current Federal standards, or state and local building codes that are applicable.

Definition of Efficient Condition
The efficient measure is any equipment that uses less energy than the baseline equipment.

Gas Savings Algorithms
The generalized equation for a custom measure compares the baseline usage to the efficient usage.

$$Annual\ Gas\ Savings\ (MMBtu) = BaselineUse - EfficientUse$$

Where:

BaselineUse = The gas usage of baseline equipment or building.

EfficientUse = The gas usage of efficient equipment or building.

Electric Savings Algorithms

Energy Savings
ΔkWh = *BaselinekWh* - *EfficientkWh*

Demand Savings
ΔkW = *BaselinekW* - *EfficientkW*

Where:

ΔkWh = Gross customer annual kWh savings for the measure.

ΔkW = Gross customer summer load kW savings for the measure.

BaselinekWh = The electric kWh usage of baseline equipment or building.

EfficientkWh = The electric kWh usage of efficient equipment or building.

BaselinekW	=	The electric kW usage of baseline equipment or building.
EfficientkW	=	The electric kW usage of efficient equipment or building.

Freeridership/Spillover
Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

Equipment Type	Free Ridership	Spillover
Custom Measure	0%	0%

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes
Where available, custom measure lifetimes should be based on similar measures defined elsewhere in this TRM.

Water Savings
The water savings are the difference between the baseline and efficient equipment annual water usage in gallons.

III. Residential Retrofit Market (Non-Low Income)

A. Space Heating End Use

1) Efficient Space Heating System

Unique Measure Code(s): TBD
Draft date: 4/30/12
Effective date: TBD
End date: TBD

Measure Description
This measure applies to residential-sized high-efficiency gas furnaces and boilers replacing an existing and functioning furnace or boiler of lower efficiency.

Definition of Baseline Condition
The efficiency levels (AFUE) of existing and functioning gas-fired furnaces or boilers. If the manufacturer's rated AFUE is available use it in the savings calculations. If the manufacturer's rated AFUE is not available, then calculate the existing heating system AFUE by multiplying the measured Steady State Efficiency by the appropriate multipliers in the following table:

Distribution Type	System Type	Default Multiplier
Air	Forced Air	1.0
	Gravity Feed	0.8
	Freestanding Heater	0.95
	Floor Furnace	0.9
	Wall Furnace	0.85
Water	Force Circulation (high mass)	0.85
	Force Circulation (low mass)	0.9
	Gravity Feed	0.85
	Steam	0.75

Source: Building Performance Institute, Technical Standards for the Heating Professional, Revision 11/20/07, p.6.

Definition of Efficient Condition
The installed gas furnace or boiler must have an AFUE greater than the baseline condition.

Gas Savings Algorithms
MMBtu savings are realized due to the increase in AFUE of the new equipment. MMBtu savings vary by equipment type due to differences in model-specific baseline AFUE and high efficiency AFUE percentages. Savings are calculated from the baseline existing unit to the installed efficient unit.

$$Annual\ Gas\ Savings\ (MMBtu) = HeatingUse \times \left(1 - \frac{AFUE_{Base}}{AFUE_{Eff}}\right)$$

Where:

HeatingUse = Annual heating use (MMBtu/yr) from weather normalized usage analysis of customer billing data from pre-treatment period. See description below.

$AFUE_{Base}$ = Efficiency of existing baseline equipment (Annual Fuel Utilization Efficiency)

$AFUE_{Eff}$ = Efficiency of new efficient equipment

Heating Use weather normalization methods (HeatingUse):

Method 1: Use a linear regression model of use/day as a function of HDD63[8]/day to estimate heating slope (MMbtu/HDD63) and baseload daily use (MMBtu/day) with an annual HDD63 of 4033[9] to calculate annual heating load.

Method 2: Calculate baseload (MMBtu/day) as the third lowest MMBtu/day bill for the analysis year. Then calculate raw heating use as the sum of monthly billed use minus the – baseload * sum(monthly bill elapsed days), then calculate weather adjusted heating use as raw heating use * (4033/HDD63actual).

Electric Savings Algorithms

Electric energy savings result from efficient furnace fans (ECM) that may be included with efficient furnaces. Electrical savings from fan motor efficiency does not apply to boilers.

Energy Savings
ΔkWh = 700 kWh

Demand Savings
$\Delta kW = 0$ kW

Where:

ΔkWh = Gross customer annual kWh savings for the measure. Based on 500 kWh heating season plus 200 kWh cooling season.

ΔkW = Gross customer summer load kW savings for the measure.

Freeridership/Spillover
Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

Equipment Type	Free Ridership	Spillover
Gas Furnace	0%	0%
Gas Furnace with ECM Fan	0%	0%
Gas Boiler	0%	0%

[8] Heating degree days are calculated using base 63°F, which was selected, based on variable-base degree day regressions of billing data from CWP participants over the past several years. This value is higher than found for many non-low income populations in similar climates and likely reflects the low efficiency of the low income housing stock and also the targeting of high users by CWP. The use of this HDD base eliminates the need for the degree day correction factor found in some similar calculations that use HDD65.

[9] This value of 4033 HDD63 is the average from NWS data for PHL for the years 2002 through 2009.

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes

Equipment Type	*Measure Lifetime*
Gas Furnaces	20
Gas Boilers	25

Source: Lifetime estimates used by Efficiency Vermont.

Water Savings
There are no water savings for this measure.

2) Space Heating System Tune-Up

Unique Measure Code(s): TBD
Draft date: 1/1/16
Effective date: 1/1/16
End date: TBD

Measure Description
This measure applies to existing residential-sized gas furnaces and boilers. The tune-up is to improve the overall efficiency of the furnace or boiler by checking, cleaning and adjusting parts relevant to the heating equipment's combustion and heat transfer efficiency.

Definition of Baseline Condition
The efficiency levels (AFUE) of existing gas-fired furnaces or boilers. Calculate the existing heating system AFUE by multiplying the measured Steady State Efficiency by the appropriate multipliers in the following table:

Distribution Type	System Type	Default Multiplier
Air	Forced Air	1.0
	Gravity Feed	0.8
	Freestanding Heater	0.95
	Floor Furnace	0.9
	Wall Furnace	0.85
Water	Force Circulation (high mass)	0.85
	Force Circulation (low mass)	0.9
	Gravity Feed	0.85
	Steam	0.75

Source: Building Performance Institute, Technical Standards for the Heating Professional, Revision 11/20/07, p.6.

Definition of Efficient Condition
The efficiency levels (AFUE) of the gas-fired furnaces or boilers after the tune-up. Calculate the heating system AFUE by multiplying the measured Steady State Efficiency by the appropriate multipliers in the preceding table.

Gas Savings Algorithms

MMBtu savings are realized due to the increase in AFUE of the heating equipment. MMBtu savings vary by equipment type due to differences in model-specific baseline AFUE and high efficiency AFUE percentages. Savings are calculated from the baseline existing unit to the unit after the tune-up.

$$Annual\ Gas\ Savings\ (MMBtu) = HeatingUse \times \left(1 - \frac{AFUE_{Base}}{AFUE_{Eff}}\right)$$

Where:

HeatingUse	=	Annual heating use (MMBtu/yr) from weather normalized usage analysis of customer billing data from pre-treatment period. See description below.
$AFUE_{Base}$	=	Efficiency of existing space heating equipment (Annual Fuel Utilization Efficiency)
$AFUE_{Eff}$	=	Efficiency of heating equipment after tune-up

Heating Use weather normalization methods (HeatingUse):

Method 1: Use a linear regression model of use/day as a function of HDD63[10]/day to estimate heating slope (MMbtu/HDD63) and baseload daily use (MMBtu/day) with an annual HDD63 of 4033[11] to calculate annual heating load.

Method 2: Calculate baseload (MMBtu/day) as the third lowest MMBtu/day bill for the analysis year. Then calculate raw heating use as the sum of monthly billed use minus the – baseload * sum(monthly bill elapsed days), then calculate weather adjusted heating use as raw heating use * (4033/HDD63actual).

Electric Savings Algorithms

There are no electricity savings for this measure.

Energy Savings

$\Delta kWh = 0\ kWh$

Demand Savings

$\Delta kW = 0\ kW$

Where:

ΔkWh	=	Gross customer annual kWh savings for the measure.
ΔkW	=	Gross customer summer load kW savings for the measure.

Freeridership/Spillover

Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

[10] Heating degree days are calculated using base 63°F, which was selected, based on variable-base degree day regressions of billing data from CWP participants over the past several years. This value is higher than found for many non-low income populations in similar climates and likely reflects the low efficiency of the low income housing stock and also the targeting of high users by CWP. The use of this HDD base eliminates the need for the degree day correction factor found in some similar calculations that use HDD65.

[11] This value of 4033 HDD63 is the average from NWS data for PHL for the years 2002 through 2009.

Equipment Type	Free Ridership	Spillover
Gas Furnace or Boiler Tune-up	0%	0%

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes

Equipment Type	Measure Lifetime
Gas Furnace or Boiler Tune-up	2

Source: Lifetime estimate used by Illinois, Minnesota and New York TRMs.

Water Savings
There are no water savings for this measure.

3) Infiltration Reduction

Unique Measure Code(s): TBD
Draft date: 4/30/12
Effective date: TBD
End date: TBD

Measure Description
This involves decreasing the amount of air exchange between the inside of the house or unit and the outdoors without buffering from any adjacent unit(s) by sealing the sources of leaks, while maintaining minimum air exchange for air quality.

Definition of Baseline Condition
The baseline is the house in its pre-treatment condition, with opportunities for infiltration reductions.

Definition of Efficient Condition
Any decrease in infiltration will reduce energy consumption compared to the pre-treated house.

Gas Savings Algorithms

$$Annual\ Gas\ Savings\ (MMBtu) = \frac{HDD_t \times 24 \times (CFM50_{pre} - CFM50_{post})}{(21.5 \times AFUE \times 1{,}000{,}000)}$$

Where:

HDD_t = Heating degree days at temperature t, where t=63°F if no programmable thermostat has been installed and t=62°F if a programmable thermostat has been installed. From NWS data for PHL from 2002-2009, HDD63=4033 and HDD62 = 3820.

24 = hours/day

$CFM50_{pre}$ = CFM50 of building shell leakage as measured by a blower door test before treatment.
$CFM50_{post}$ = CFM50 of building shell leakage as measured by a blower door test after treatment.

21.5 = factor to convert CFM50 value to Btu/hrF heat loss rate, calculated from hourly infiltration modeling[12]

AFUE = rated AFUE of heating system. If no rating is available then use the method described in the Efficient Space Heating System section for calculating the AFUE. The AFUE of replacement equipment should be used if the heating system replacement precedes the air sealing work.

Electric Savings Algorithms

If the type of air conditioning is known, then use the appropriate algorithm below. If the type or existence of air-conditioning is not known, then assume that 83% have air-conditioning and estimate the cooling savings as 83% of a house with central air conditioning.[13]

Reduced furnace fan or boiler circulator pump usage is also likely to occur and provide electricity savings during both the heating and cooling seasons.

Energy Savings

$\Delta kWh = \Delta kWh_{Aux} + \Delta kWh_{Cool}$

$\Delta kWh_{Aux} = \textit{Annual Gas Savings (MMBtu)} \times \textit{Auxiliary}$

ΔkWh_{Cool} = 0 kWh if house has no air conditioning
= ΔkWh_{CAC} if house has central air conditioning
= ΔkWh_{RAC} if house has room air conditioning
= 83% × ΔkWh_{CAC} if no information about air conditioner

$$\Delta kWh_{CAC} = \frac{CDD \times 24 \times DUA \times (CFM50_{pre} - CFM50_{post})}{\left(21.5 \times SEER_{CAC} \times 1000\frac{W}{kW}\right)}$$

$$\Delta kWh_{RAC} = \frac{CDD \times 24 \times DUA \times F_{Room\ AC} \times (CFM50_{pre} - CFM50_{post})}{\left(21.5 \times \overline{EER}_{RAC} \times 1000\frac{W}{kW}\right)}$$

Demand Savings

ΔkW = 0 kW if house has no air conditioning
= ΔkW_{CAC} if house has central air conditioning
= ΔkW_{RAC} if house has room air conditioning

$$\Delta kW_{CAC} = \frac{\Delta kWh_{CAC}}{EFLH_{cool}} \times CF_{CAC}$$

$$\Delta kW_{RAC} = \frac{\Delta kWh_{RAC}}{EFLH_{cool\ RAC}} \times CF_{RAC}$$

Where:

ΔkWh = gross customer annual kWh savings for the measure.
ΔkW = gross customer summer load kW savings for the measure.

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[12] An hourly infiltration was calculated using a modified version of the LBL (a.k.a. Sherman-Grimsrud) infiltration model with a wind effect modification (EPRI RP 2034-40, Palmiter and Bond 1991) using Philadelphia TMY2 hourly weather data. This analysis result was then adjusted to account for an assumed party wall leakage fraction of 12% and an estimated 10% thermal regain from infiltration/exfiltratiom. The resulting value of 21.5 is consistent with statistical analyses of empirical data using CFM50 values and actual gas use and savings from CWP evaluations.

[13] Percentage of houses with air-conditioning from EIA Table AC1.xls for Middle Atlantic region (PA, NY, NJ). From: http://www.eia.doe.gov/emeu/recs/recs2005/hc2005_tables/detailed_tables2005.html

Auxiliary	= *Heating system auxiliary usage per MMBTU consumption (5.02 From Vermont Technical Reference Manual)*
CDD	= *Cooling Degree Days (Degrees F * Days)HDD*
DUA	= *Discretionary Use Adjustment to account for the fact that people do not always operate their air conditioning system when the outside temperature is greater than 65F.*
$SEER_{CAC}$	= *Seasonal Energy Efficiency Ratio of existing home central air conditioner (Btu/W•hr) (See table below for default values if actual values are not available)*
$\overline{EER}_{RAC}$	= *Average Energy Efficiency Ratio of existing room air conditioner (Btu/W•hr) (See table below for default values if actual values are not available)*
CF_{CAC}	= *Demand Coincidence Factor for central AC systems (See table below)*
CF_{RAC}	= *Demand Coincidence Factor for Room AC systems (See table below)*
$EFLH_{cool}$	= *Equivalent Full Load Cooling hours for Central AC and ASHP (See table below)*
$EFLH_{cool\ RAC}$	= *Equivalent Full Load Cooling hours for Room AC (See table below)*
$F_{Room\ AC}$	= *Adjustment factor to relate insulated area to area served by Room AC units*

The default values for each term are shown in the table below.

Default values for algorithm terms, Ceiling/Attic and Wall Insulation

Term	Type	Value	Source
DUA	Fixed	0.75	OH TRM[14]
$SEER_{CAC}$	Variable	Default values: *Early Replacement* = 10 Replace on Burnout = 13	PUC Technical Reference Manual
		Nameplate	Contractor Data Gathering
$\overline{EER}_{RAC}$	Variable	Default = 9.8	DOE Federal Test Procedure 10 CFR 430, Appendix F (Used in ES Calculator for baseline)
		Nameplate	Contractor Data Gathering
CF_{CAC}	Fixed	0.70	PUC Technical Reference Manual
CF_{RAC}	Fixed	0.58	PUC Technical Reference Manual
$F_{Room,AC}$	Fixed	0.38	Calculated[15]

[14] "State of Ohio Energy Efficiency Technical Reference Manual," prepared for the Public Utilities Commission of Ohio by Vermont Energy Investment Corporation. August 6, 2010.

EFLH, CDD and HDD by City

City	$EFLH_{cool}$ (Hours)[16]	$EFLH_{cool\ RAC}$ (Hours)[17]	CDD (Base 65)[18]	HDD (Base 65)[19]
Philadelphia	1032	320	1235	4759

Freeridership/Spillover
Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

Measure	Free Ridership	Spillover
Infiltration Reduction	0%	0%

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes

Measure	Measure Lifetime
Infiltration Reduction	20

Source: NYSERDA Home Performance with Energy Star.

Water Savings
There are no water savings for this measure.

4) Roof and Cavity Insulation

Unique Measure Code(s): TBD
Draft date: 4/30/12
Effective date: TBD
End date: TBD

Measure Description
This involves increasing the insulation levels in either the attic or walls which directly define the boundary between the house or unit and the outdoors.

Definition of Baseline Condition
The baseline is amount of insulation in the house in its pre-treatment condition.

[15] From PECO baseline study, average home size = 2323 ft^2, average number of room AC units per home = 2.1. Average Room AC capacity = 10,000 BtuH per ENERGY STAR Room AC Calculator, which serves 425 ft^2 (average between 400 and 450 ft^2 for 10,000 BtuH unit per ENERGY STAR Room AC sizing chart). $F_{Room,AC} = (425\ ft^2 * 2.1)/(2323\ ft^2) = 0.38$
[16] PA 2010 TRM Table 2-1.
[17] PA SWE Interim Approved TRM Protocol – Residential Room AC Retirement
[18] Climatography of the United States No. 81. Monthly Station Normals of Temperature, Precipitation, and Heating and Cooling Degree Days 1971-2000, 36 Pennsylvania. NOAA. http://cdo.ncdc.noaa.gov/climatenormals/clim81/PAnorm.pdf
[19] Ibid.

Definition of Efficient Condition
Any increase in insulation will reduce energy consumption compared to the pre-treated house.

Gas Savings Algorithms

$$Annual\ Gas\ Savings\ (MMBtu) = \frac{HDD_t \times 24 \times AREA \times \left(1/_{R_{pre}} - 1/_{R_{post}}\right)}{(AFUE \times 1{,}000{,}000)}$$

Where:

HDD_t	=	Heating degree days at temperature t, where t=63°F if no programmable thermostat has been installed and t=62°F if a programmable thermostat has been installed[20].
24	=	Hours per day
AREA	=	Net insulated area in square feet. Estimated at 85% of gross area for cavities.
R_{pre}	=	R value of roof/cavity pre-treatment. R_{pre}= 5 unless there is existing insulation.
R_{post}	=	R value of roof/ cavity after insulation is installed.
AFUE	=	Rated AFUE of heating system. If no rating is available then use the method described in the Efficient Space Heating System section for calculating the AFUE. The AFUE of replacement equipment should be used if the heating system replacement precedes the air sealing work.

Electric Savings Algorithms
*If the type of air conditioning is known, then use the appropriate algorithm below. If the type or existence of air-*conditioning is not known, then assume that 83% have air-conditioning and estimate the cooling savings as 83% of a house with central air conditioning.[21]

Reduced furnace fan or boiler circulator pump usage is also likely to occur and provide electricity savings during both the heating and cooling seasons.

Energy Savings
$\Delta kWh = \Delta kWh_{Aux} + \Delta kWh_{Cool}$

ΔkWh_{Aux} $= Annual\ Gas\ Savings\ (MMBtu) \times Auxiliary$

ΔkWh_{Cool} = 0 kWh if house has no air conditioning
= ΔkWh_{CAC} if house has central air conditioning
= ΔkWh_{RAC} *if house has room air conditioning*
= 83% × ΔkWh_{CAC} if no information about air conditioner

$$\Delta kWh_{CAC} = \frac{CDD \times 24\frac{hr}{day} \times DUA}{SEER_{CAC} \times 1000\frac{W}{kW}} \times \left[AREA \times \left(\frac{1}{R_{pre}} - \frac{1}{R_{post}}\right)\right]$$

[20] From NWS data for PHL from 2002-2009, HDD63=4033 and HDD62 = 3820
[21] Percentage of houses with air-conditioning from EIA Table AC1.xls for Middle Atlantic region (PA, NY, NJ). From: http://www.eia.doe.gov/emeu/recs/recs2005/hc2005_tables/detailed_tables2005.html

$$\Delta kWh_{RAC} = \frac{CDD \times 24\frac{hr}{day} \times DUA \times F_{Room\ AC}}{\overline{EER}_{RAC} \times 1000\frac{W}{kW}} \times \left[AREA \times \left(\frac{1}{R_{pre}} - \frac{1}{R_{post}}\right)\right]$$

Demand Savings

ΔkW = 0 kW if house has no air conditioning
= ΔkW_{CAC} if house has central air conditioning
= ΔkW_{RAC} *if house has room air conditioning*

$$\Delta kW_{CAC} = \frac{\Delta kWh_{CAC}}{EFLH_{cool}} \times CF_{CAC}$$

$$\Delta kW_{RAC} = \frac{\Delta kWh_{RAC}}{EFLH_{cool\ RAC}} \times CF_{RAC}$$

Where:

ΔkWh = gross customer annual kWh savings for the measure.

ΔkW = gross customer summer load kW savings for the measure.

Auxiliary = *Heating system auxiliary usage per MMBTU consumption (5.02 From Vermont Technical Reference Manual)*

CDD = *Cooling Degree Days (Degrees F * Days)HDD*

DUA = *Discretionary Use Adjustment to account for the fact that people do not always operate their air conditioning system when the outside temperature is greater than 65F.*

$SEER_{CAC}$ = *Seasonal Energy Efficiency Ratio of existing home central air conditioner (Btu/W•hr) (See table below for default values if actual values are not available)*

$\overline{EER}_{RAC}$ = *Average Energy Efficiency Ratio of existing room air conditioner (Btu/W•hr) (See table below for default values if actual values are not available)*

CF_{CAC} = *Demand Coincidence Factor for central AC systems (See table below)*

CF_{RAC} = *Demand Coincidence Factor for Room AC systems (See table below)*

$EFLH_{cool}$ = *Equivalent Full Load Cooling hours for Central AC and ASHP (See table below)*

$EFLH_{cool\ RAC}$ = *Equivalent Full Load Cooling hours for Room AC (See table below)*

$F_{Room\ AC}$ = *Adjustment factor to relate insulated area to area served by Room AC units*

The default values for each term are shown in the table below.

Default values for algorithm terms, Ceiling/Attic and Wall Insulation

Term	Type	Value	Source
DUA	Fixed	0.75	OH TRM[22]
$SEER_{CAC}$	Variable	Default values: Early Replacement = 10 Replace on Burnout = 13	PUC Technical Reference Manual
		Nameplate	Contractor Data Gathering
$\overline{EER}_{RAC}$	Variable	Default = 9.8	DOE Federal Test Procedure 10 CFR 430, *Appendix F (Used in ES Calculator for baseline)*
		Nameplate	Contractor Data Gathering
CF_{CAC}	Fixed	0.70	PUC Technical Reference Manual
CF_{RAC}	Fixed	0.58	PUC Technical Reference Manual
$F_{Room,AC}$	Fixed	0.38	Calculated[23]

EFLH, CDD and HDD by City

City	$EFLH_{cool}$ (Hours)[24]	$EFLH_{cool\,RAC}$ (Hours)[25]	CDD (Base 65)[26]	HDD (Base 65)[27]
Philadelphia	1032	320	1235	4759

Freeridership/Spillover

Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

Measure	Free Ridership	Spillover
Insulation	0%	0%

Persistence

The persistence factor is assumed to be one.

[22] "State of Ohio Energy Efficiency Technical Reference Manual," prepared for the Public Utilities Commission of Ohio by Vermont Energy Investment Corporation. August 6, 2010.

[23] From PECO baseline study, average home size = 2323 ft², average number of room AC units per home = 2.1. Average Room AC capacity = 10,000 BtuH per ENERGY STAR Room AC Calculator, which serves 425 ft² (average between 400 and 450 ft² for 10,000 BtuH unit per ENERGY STAR Room AC sizing chart). $F_{Room,AC} = (425\ ft^2 * 2.1)/(2323\ ft^2) = 0.38$

[24] PA 2010 TRM Table 2-1.

[25] PA SWE Interim Approved TRM Protocol – Residential Room AC Retirement

[26] Climatography of the United States No. 81. Monthly Station Normals of Temperature, Precipitation, and Heating and Cooling Degree Days 1971-2000, 36 Pennsylvania. NOAA. http://cdo.ncdc.noaa.gov/climatenormals/clim81/PAnorm.pdf

[27] Ibid.

Measure Lifetimes

Measure	Measure Lifetime
Roof Insulation	40
Cavity Insulation	40

Source: NYSERDA Home Performance with Energy Star.

Water Savings
There are no water savings for this measure.

5) Programmable Thermostat

Unique Measure Code(s): TBD
Draft date: 4/30/12
Effective date: TBD
End date: TBD

Measure Description
This is a programmable thermostat controlling a residential-sized gas furnace or boiler.

Definition of Baseline Condition
The baseline is a manual thermostat where each temperature setting change requires human intervention.

Definition of Efficient Condition
The efficient thermostat is one that can be programmed to automatically increase or lower the temperature setting at different times of the day and week.

Gas Savings Algorithms

$$Annual\ Gas\ Savings\ (MMBtu) = HeatingUse \times \left(1 - {HDD_{62}}/{HDD_{63}}\right) = HeatingUse \times 0.053$$
$$= 1.53\ MMBtu$$

Where:

HeatingUse = Annual heating use (MMBtu/yr) from weather normalized usage analysis of customer billing data from pre-treatment period (see description under heating system replacement). If thermostat measure is performed after shell measures of insulation or air sealing, then subtract the projected savings from those measures from the pre retrofit heating use.

HDD_{62} = 3820

The annual heating degree days based on 62°F, representing the estimated balance point temperature of the home with the programmable thermostat.

HDD_{63} = 4033

The annual heating degree days based on 63°F, representing the estimated balance point temperature of the home with the programmable thermostat.

An analysis of variable base degree day billing data from the CWP has found an average net reduction in balance point temperature of about 1.0°F for thermostat installations. Multiple impact evaluations have also found heating savings averaging about 5%-6% from thermostat installations. These two findings are consistent with each other and indicate an estimated average impact based on employing the approach from past CWP contractors to targeting customers and selecting homes to receive thermostats and the savings opportunities and compliance rates achieved. The savings may not be accurate when applied to different populations in different ways.

Electric Savings Algorithms

If the type of air conditioning is known, then use the appropriate algorithm below. If the type or existence of air-conditioning is not known, then assume that 83% have air-conditioning and estimate the cooling savings as 83% of a house with central air conditioning.[28]

Reduced furnace fan or boiler circulator pump usage is also likely to occur and provide electricity savings during both the heating and cooling seasons, but these auxiliary savings are not accounted for in the following algorithms.

Energy Savings

$\Delta kWh = \Delta kWh_{Aux} + \Delta kWh_{Cool}$

$\Delta kWh_{Aux} = Annual\ Gas\ Savings\ (MMBtu) \times Auxiliary$

ΔkWh_{Cool} = 0 kWh if house has no air conditioning
= ΔkWh_{CAC} if house has central air conditioning
= 0 if house has room air conditioning
= 83% × ΔkWh_{CAC} if no information about air conditioner

$$\Delta kWh_{CAC} = CAP_{COOL} \times \left(\frac{12{,}000 \frac{Btu}{ton} \times \frac{1}{1{,}000} \frac{kWh}{Wh}}{EER_{COOL} \times Eff_{duct}} \right) \times EFLH \times ESF_{COOL}$$

Demand Savings

$\Delta kW = 0\ kW$

Where:

ΔkWh	= gross customer annual kWh savings for the measure.
ΔkW	= gross customer summer load kW savings for the measure.
CAP_{COOL}	= *capacity of the air conditioning unit in tons, based on nameplate capacity (see table below)*
EER_{COOL}	= *Seasonally averaged efficiency rating of the baseline unit . (see table below)*
Eff_{duct}	= *duct system efficiency (see table below)*
ESF_{COOL}	= *energy savings factor for cooling and heating, respectively (see table below)*
EFLH	= *equivalent full load hours*

[28] Percentage of houses with air-conditioning from EIA Table AC1.xls for Middle Atlantic region (PA, NY, NJ). From: http://www.eia.doe.gov/emeu/recs/recs2005/hc2005_tables/detailed_tables2005.html

Residential Electric HVAC Calculation Assumptions

Component	Type	Value	Sources
CAP_{COOL}	Variable	Nameplate data	Contractor Data Gathering
		Default: 3 tons	1
EER_{COOL}	Variable	Nameplate data	Contractor Data Gathering
		Default: Cooling = 10 SEER Default: Heating = 1.0 (electric furnace COP)	2
Eff_{duct}	Fixed	0.8	3
ESF_{COOL}	Fixed	2%	4
EFLH	Fixed	Philadelphia Cooling = 1,032 Hours	5

Sources:

1. Average size of residential air conditioner.
2. Minimum Federal Standard for new Central Air Conditioners/Heat Pumps between 1990 and 2006.
3. New York Standard Approach for Estimating Energy Savings from Energy Efficiency Measures in Commercial and Industrial Programs, September 1, 2009.
4. DEER 2005 cooling savings for climate zone 16, assumes a variety of thermostat usage patterns.
5. US Department of Energy, ENERGY STAR Calculator. Accessed 3/16/2009.

Freeridership/Spillover

Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

Equipment Type	Free Ridership	Spillover
Programmable Thermostat	0%	0%

Persistence

The persistence factor is assumed to be one.

Measure Lifetimes

Equipment Type	Measure Lifetime
Programmable Thermostat	15

Source: New Jersey Clean Energy Program Protocols (December 2009).

Water Savings

There are no water savings for this measure.

6) Duct Work Insulation

Unique Measure Code(s): TBD
Draft date: 4/30/12
Effective date: TBD
End date: TBD

Measure Description
This measure relates to installing insulation on ducts in unconditioned spaces.

Definition of Baseline Condition
The baseline condition is assumed to be an un-insulated duct.

Definition of Efficient Condition
The efficient condition is the duct with insulation installed.

Water Savings Algorithms
This measure has no water savings associated with it.

Natural Gas Savings Algorithms

$$Annual\ Gas\ Savings\ (MMBtu) = Length \times \frac{EFLH_{heat}}{24 \times 365} \times \frac{\left(HeatLoss(Th_{base}) - HeatLoss(Th_{eff})\right)}{AFUE \times 1{,}000{,}000}$$

Where:

Length	=	Number of linear feet of duct work insulated
$EFLH_{heat}$	=	Equivalent full load heating hours = 730
Th_{base}	=	Thickness of base condition insulation (inches)
Th_{eff}	=	Thickness of efficient condition insulation (inches)
HeatLoss(x)	=	Heat loss through duct work as a function of insulation thickness x (Btu/ft /yr)
AFUE	=	Rated AFUE of heating system. If no rating is available then use the method described in the Efficient Space Heating System section for calculating the AFUE. The AFUE of replacement equipment should be used if the heating system replacement precedes the duct work insulation.

"HeatLoss(x)" can be found using the following lookup table.

Insulation Thickness (inches)	*Heat Loss* (Btu/ft/yr)
Bare	1,120,000
0.25	339,500
0.5	205,300
0.75	190,700
1	128,300
1.5	93,970
2	74,370

Insulation Thickness (inches)	Heat Loss (Btu/ft/yr)
2.5	61,620
3	52,650
3.5	45,990
4	40,830

This table was calculated using the North American Insulation Manufacturers Association's (NAIMA) 3E Plus 4.0 Insulation Thickness Computer Program. The following assumptions were used.

Item Description	=	bare duct
Calculation Type	=	Heat Loss Per Year Report
Geometry Description	=	Steel Duct - Rectangular Horz.
System Units	=	ASTM C585
Bare Surface Emittance	=	0.8
Process Temperature	=	140 °F
Ave. Ambient Temperature	=	41.8 °F[29]
Ave. Wind Speed	=	0 mph
Relative Humidity	=	N/A
Dew Point	=	N/A
Condensation Control Thickness	=	N/A
Hours Per Year	=	2000[30]
Outer Jacket Material	=	Aluminum, oxidized, in service
Outer Surface Emittance	=	0.1
Insulation Layer 1	=	Duct Wrap, 1.0 pound per cubic foot, C1290,
Duct Horiz Dimension	=	12 in.
Duct Vert Dimension	=	8 in.

Electric Savings Algorithms
No electric savings are currently claimed for this measure.

Freeridership/Spillover
Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes
The measure life is assumed to 18 years[31].

[29] Average winter temperature for Philadelphia from "Cost Savings and Comfort for Existing Buildings", 3rd Edition, by John Krigger, Saturn Resource Management. Page 255.
[30] Low end of 2,000 – 2,500 winter heating load hours from Air-conditioning and Refrigeration Institute. http://www.waterfurnace.ca/Engineer/Misc%20References/ARI%20Cooling%20&%20Heating%20Load%20Hours%20Map.pdf
[31] NYSERDA Home Performance with Energy Star

7) Heating Pipe Insulation

Unique Measure Code(s): TBD
Draft date: 4/30/12
Effective date: TBD
End date: TBD

Measure Description
This measure relates to installing insulation on space heating pipes in unconditioned spaces.

Definition of Baseline Condition
The baseline condition is the current insulation thickness on a space heating hot water or steam pipe.

Definition of Efficient Condition
The efficient condition is any insulation thicker than that already on the pipe.

Water Savings Algorithms
This measure has no water savings associated with it.

Natural Gas Savings Algorithms

$$Annual\ Gas\ Savings\ (MMBtu) = Length \times H_{heat} \times \frac{\left(HeatLoss(Th_{base}) - HeatLoss(Th_{eff})\right)}{AFUE \times 1{,}000{,}000}$$

$$H_{Heat} = \frac{HDD \times 24}{Dt} = \frac{4{,}033 \times 24}{59} = 1{,}640$$

Where:

Length	=	Number of linear feet of heating pipe insulated
H_{heat}	=	Heating hours for a properly sized boiler. Used as an estimate of the hours in which the space-heating pipe would be hotter than the ambient temperature and would therefore experience heat loss.
Th_{base}	=	Thickness of base condition insulation (inches)
Th_{eff}	=	Thickness of efficient condition insulation (inches)
HeatLoss(x)	=	Heat loss through pipe as a function of insulation thickness x (Btu/ft /hr)
AFUE	=	Rated AFUE of heating system. If no rating is available then use the method described in the Efficient Space Heating System section for calculating the AFUE. The AFUE of replacement equipment should be used if the heating system replacement precedes the pipe insulation.
HDD	=	Base 63° F Heating Degree Days for Philadelphia = 4,033[32]
Dt	=	Design temperature difference (assume from 11° F to 70° F for properly sized boiler)[33] = 59° F

"HeatLoss(x)" can be found using the following lookup table.

[32] Based on NCDC ASOS temperature data for PHL from 2002 through 2009.
[33] 11 degree design temperature source: 5th Edition Residential Energy, Cost Savings and Comfort for Existing Buildings. John *Krigger and Chris Dorsi, 2009, Saturn Resource Management, Appendix A-8, p. 280.*

Insulation Thickness (inches)	Steam Heat Loss (Btu/ft/hr)	Hot Water Heat Loss (Btu/ft/hr)
Bare	201.4	72.12
0.5	47.75	15.24
1.0	31.15	11.2
1.5	24.09	8.67
2.0	20.28	7.51
2.5	17.98	6.42
3.0	16.35	5.98
3.5	15.13	5.64
4.0	14.06	5.37
4.5	13.31	5.12

This table was calculated using the North American Insulation Manufacturers Association's (NAIMA) 3E Plus 4.0 Insulation Thickness Computer Program. The following assumptions were used.

Item Description	=	steam piping
System Application	=	Pipe - Horizontal
Dimensional Standard	=	ASTM C 585 Rigid
Calculation Type	=	Heat Loss Per Hour Report
Process Temperature	=	212
Ambient Temperature	=	60
Wind Speed	=	0
Nominal Pipe Size	=	2
Bare Metal	=	Copper
Bare Surface Emittance	=	0.6
Insulation Layer 1	=	850F Mineral Fiber PIPE, Type I, C547-11
Outer Jacket Material	=	All Service Jacket
Outer Surface Emittance	=	0.9

Item Description	=	hot water piping
System Application	=	Pipe - Horizontal
Dimensional Standard	=	ASTM C 585 Rigid
Calculation Type	=	Heat Loss Per Hour Report
Process Temperature	=	180
Ambient Temperature	=	60
Wind Speed	=	0
Nominal Pipe Size	=	0.75
Bare Metal	=	Copper
Bare Surface Emittance	=	0.6
Insulation Layer 1	=	Phenolic SHEET+TUBE,Type III, C1126-11
Outer Jacket Material	=	All Service Jacket
Outer Surface Emittance	=	0.9

Electric Savings Algorithms
There are no electric savings associated with this measure.

Freeridership/Spillover
Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes
The measure life is assumed to be 20 years[34].

8) Duct Work Sealing

Unique Measure Code(s): TBD
Draft date: 4/30/2013
Effective date: TBD
End date: TBD

Measure Description
This measure provides estimates for stand-along savings from sealing ducts in a retrofit project and preventing heated air from leaking into unconditioned spaces. In order to verify savings, a duct-leakage test must be used to *calculate a reduction in* CFM-25 *readings*.

Definition of Baseline Condition
The baseline condition is assumed to be a duct that has not been sealed.

Definition of Efficient Condition
The efficient condition is a duct that has been sealed to reduce outside leakage.

Water Savings Algorithms
This measure has no water savings associated with it.

Natural Gas Savings Algorithms

$$Annual\ Gas\ Savings\ (MMBtu) = (CFMpre - CFMpost)\ \times\ DSFgas$$

Where:

CFMpre	=	Reading from duct-blaster test at 25 pascals, before sealing performed
CFMpost	=	Reading from duct-blaster test at 25 pascals, after sealing performed
DSFgas	=	Dúct sealing factor for gas systems, 0.035 MMBtus/CFM-25[35]

Electric Savings Algorithms
Electric savings per 100 CFM-25 reduction:[36]

[34] NYSERDA Home Performance with Energy Star
[35] Based on 3.5 MMBtus savings per 100 CFM reduction for duct sealing from UI/CL&P Program Savings Documentation – 2011, page 131
[36] UI/CL&P Program Savigns Documentation, 2011, page 131

- 110.0 kWh in heating fan savings
- If a central air conditioner is present
    - o 105.9 kWh from cooling
    - 0.23 kW summer peak demand savings

Freeridership/Spillover
Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes
The measure life is assumed to 18 years[37].

9) High Efficiency Window

Unique Measure Code(s): TBD
Draft date: 7/29/13
Effective date: TBD
End date: TBD

Measure Description
This involves installing a window with a U-factor less than a baseline window.

Definition of Baseline Condition
The baseline is the minimum window required by code. IECC 2009 for Philadelphia requires a U-factor of 0.35 or less.

Definition of Efficient Condition
An efficient window is any window exceeding Energy Star® requirements for U-factor of 0.32 or less.

Gas Savings Algorithms

$$Annual\ Gas\ Savings\ (MMBtu) = \frac{HDD_t \times 24 \times AREA \times (U_{base} - U_{eff})}{(AFUE \times 1{,}000{,}000)}$$

Where:

HDD_t	=	Heating degree days at temperature t, where t=63°F if no programmable thermostat has been installed and t=62°F if a programmable thermostat has been installed[38].
24	=	Hours per day
AREA	=	Square feet of window area.
U_{base}	=	U-factor of new baseline window. U_{base}= 0.35 based on IECC 2009.
U_{eff}	=	U-factor of efficient window.
AFUE	=	Rated AFUE of heating system. If no rating is available then use the method described in the Efficient Space Heating System section for calculating the AFUE.

[37] California DEER estimage.
[38] From NWS data for PHL from 2002-2009, HDD63=4033 and HDD62 = 3820

The AFUE of replacement equipment should be used if the heating system replacement precedes the air sealing work. Use default AFUE of 80% if actual AFUE is not available.

Electric Savings Algorithms

If the type of air conditioning is known, then use the appropriate algorithm below. If the type or existence of air-conditioning is not known, then assume that 83% have air-conditioning and estimate the cooling savings as 83% of a house with central air conditioning.[39]

Reduced furnace fan or boiler circulator pump usage is also likely to occur and provide electricity savings during both the heating and cooling seasons.

Energy Savings

$\Delta kWh = \Delta kWh_{Aux} + \Delta kWh_{Cool}$

$\Delta kWh_{Aux} = Annual\ Gas\ Savings\ (MMBtu) \times Auxiliary$

ΔkWh_{Cool} = 0 kWh if house has no air conditioning
= ΔkWh_{CAC} if house has central air conditioning
= ΔkWh_{RAC} if house has room air conditioning
= 83% × ΔkWh_{CAC} *if no information about air conditioner*

$$\Delta kWh_{CAC} = \frac{CDD \times 24\frac{hr}{day} \times DUA}{SEER_{CAC} \times 1000\frac{W}{kW}} \times \left[AREA \times \left(\frac{1}{R_{pre}} - \frac{1}{R_{post}}\right)\right]$$

$$\Delta kWh_{RAC} = \frac{CDD \times 24\frac{hr}{day} \times DUA \times F_{Room\ AC}}{EER_{RAC} \times 1000\frac{W}{kW}} \times \left[AREA \times \left(\frac{1}{R_{pre}} - \frac{1}{R_{post}}\right)\right]$$

Demand Savings

ΔkW = 0 kW if house has no air conditioning
= ΔkW_{CAC} if house has central air conditioning
= ΔkW_{RAC} *if house has room air conditioning*

$$\Delta kW_{CAC} = \frac{\Delta kWh_{CAC}}{EFLH_{cool}} \times CF_{CAC}$$

$$\Delta kW_{RAC} = \frac{\Delta kWh_{RAC}}{EFLH_{cool\ RAC}} \times CF_{RAC}$$

Where:

ΔkWh = gross customer annual kWh savings for the measure.
ΔkW = gross customer summer load kW savings for the measure.
Auxiliary = *Heating system auxiliary usage per MMBTU consumption (5.02 From Vermont Technical Reference Manual)*

CDD = *Cooling Degree Days (Degrees F * Days)HDD*

[39] Percentage of houses with air-conditioning from EIA Table AC1.xls for Middle Atlantic region (PA, NY, NJ). From: http://www.eia.doe.gov/emeu/recs/recs2005/hc2005_tables/detailed_tables2005.html

DUA	*= Discretionary Use Adjustment to account for the fact that people do not always operate their air conditioning system when the outside temperature is greater than 65F.*
$SEER_{CAC}$	*= Seasonal Energy Efficiency Ratio of existing home central air conditioner (Btu/W•hr) (See table below for default values if actual values are not available)*
$\overline{EER}_{RAC}$	*= Average Energy Efficiency Ratio of existing room air conditioner (Btu/W•hr) (See table below for default values if actual values are not available)*
CF_{CAC}	*= Demand Coincidence Factor for central AC systems (See table below)*
CF_{RAC}	*= Demand Coincidence Factor for Room AC systems (See table below)*
$EFLH_{cool}$	*= Equivalent Full Load Cooling hours for Central AC and ASHP (See table below)*
$EFLH_{cool\ RAC}$	*= Equivalent Full Load Cooling hours for Room AC (See table below)*
$F_{Room\ AC}$	*= Adjustment factor to relate insulated area to area served by Room AC units*

The default values for each term are shown in the table below.

Default values for algorithm terms, Ceiling/Attic and Wall Insulation

Term	Type	Value	Source
DUA	Fixed	0.75	OH TRM[40]
$SEER_{CAC}$	Variable	Default values: Early Replacement = 10 Replace on Burnout = 13	PUC Technical Reference Manual
		Nameplate	Contractor Data Gathering
$\overline{EER}_{RAC}$	Variable	Default = 9.8	DOE Federal Test Procedure 10 CFR 430, Appendix F (Used in ES Calculator for baseline)
		Nameplate	Contractor Data Gathering
CF_{CAC}	Fixed	0.70	PUC Technical Reference Manual
CF_{RAC}	Fixed	0.58	PUC Technical Reference Manual
$F_{Room,AC}$	Fixed	0.38	Calculated[41]

[40] "State of Ohio Energy Efficiency Technical Reference Manual," prepared for the Public Utilities Commission of Ohio by Vermont Energy Investment Corporation. August 6, 2010.

[41] From PECO baseline study, average home size = 2323 ft^2, average number of room AC units per home = 2.1. Average Room AC capacity = 10,000 BtuH per ENERGY STAR Room AC Calculator, which serves 425 ft^2 (average between 400 and 450 ft^2 for 10,000 BtuH unit per ENERGY STAR Room AC sizing chart). $F_{Room,AC} = (425\ ft^2 * 2.1)/(2323\ ft^2) = 0.38$

EFLH, CDD and HDD by City

City	$EFLH_{cool}$ (Hours)[42]	$EFLH_{cool\ RAC}$ (Hours)[43]	CDD (Base 65)[44]	HDD (Base 65)[45]
Philadelphia	*1032*	*320*	*1235*	*4759*

Freeridership/Spillover
Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

Measure	Free Ridership	Spillover
Window	0%	0%

Persistence
The persistence factor is assumed to be one.

Measure Lifetime

Measure	Measure Lifetime
Window	30

Source: NREL Measure Database.

Water Savings
There are no water savings for this measure.

B. Domestic Hot Water End Use

1) Low Flow Showerhead

Unique Measure Code(s): TBD
Draft date: 4/30/12
Effective date: *TBD*
End date: TBD

Measure Description
This measure relates to the installation of a low flow showerhead in a home. This is a retrofit direct install measure.

Definition of Baseline Condition
The baseline is the flow rate of the showerhead being replaced. If this is not available a baseline value of 2.5 GPM will be used.

[42] PA 2010 TRM Table 2-1.
[43] *PA SWE Interim Approved TRM Protocol – Residential Room AC Retirement*
[44] Climatography of the United States No. 81. Monthly Station Normals of Temperature, Precipitation, and Heating and Cooling Degree Days 1971-2000, 36 Pennsylvania. NOAA. http://cdo.ncdc.noaa.gov/climatenormals/clim81/PAnorm.pdf
[45] Ibid.

Definition of Efficient Condition

The flow rate of the efficient showerhead should be greater than the flow rate of the baseline condition. If this value is not available it is assumed to be 1.5 GPM[46].

Water Savings Algorithms

The water savings for low flow showerheads are due to the reduced amount of water being used per shower.

$$\Delta Gallons = \frac{\left(\frac{GPM_{base} - GPM_{eff}}{GPM_{base}}\right) \times 2.48 \times 11.6 \times 365}{1.6}$$

Where:

$\Delta Gallons$	=	Gallons of water saved
GPM_{base}	=	Maximum gallons per minute of baseline showerhead. Default = 2.5 GPM if measured rate is not available[47]
GPM_{eff}	=	Maximum gallons per minute of the efficient showerhead
2.48	=	Average number of people per household[48]
11.6	=	Average gallons of water per person per day used for showering[49]
365	=	Days per year
1.6	=	Average number of showers per home[50]

Natural Gas Savings Algorithms

Gas energy savings result from avoiding having to heat the saved water due to the efficient showerhead.

$$\Delta MMBtu = \frac{\left[\Delta Gallons \times 8.3 \times c_p \times (105 - 55)\right] / 1{,}000{,}000}{RE_{DHW}}$$

Where:

$\Delta MMBtu$	=	MMBtu of saved natural gas
8.3	=	Constant to convert gallons to pounds (lbs.)
c_p	=	Average specific heat of water at temperature range (1.00 Btu/lb·°F)
105	=	Assumed temperature of water coming out of showerhead (degrees Fahrenheit)
55	=	Assumed temperature of water entering house (degrees Fahrenheit)[51]
RE_{DHW}	=	Recovery efficiency of the domestic hot water heater = 75%[52]

[46] Pennsylvania Public Utility Commission Act 129 Technical Reference Manual (June 2011)

[47] The Energy Policy Act of 1992 established the maximum flow rate for showerheads at 2.5 gallons per minute (GPM)

[48] Pennsylvania, Census of Population, 2000.

[49] Most commonly quoted value of gallons of water used per person per day (including in U.S. Environmental Protection Agency's "water sense" documents; http://www.epa.gov/watersense/docs/home_suppstat508.pdf)

[50] *Estimate based on review of a number of studies:*

a) Pacific Northwest Laboratory; "Energy Savings from Energy-Efficient Showerheads: REMP Case Study Results, Proposed Evaluation Algorithm, and Program Design Implications" http://www.osti.gov/bridge/purl.cover.jsp;jsessionid=80456EF00AAB94DB204E848BAE65F199?purl=/10185385-CEkZMk/native/

b) East Bay Municipal Utility District; "Water Conservation Market Penetration Study" http://www.ebmud.com/sites/default/files/pdfs/market_penetration_study_0.pdf

[51] A good approximation of annual average water main temperature is the average annual ambient air temperature. Average water main temperature = 55° F based on: http://lwf.ncdc.noaa.gov/img/documentlibrary/clim81supp3/tempnormal_hires.jpg

[52] Review of AHRI Directory suggests range of recovery efficiency ratings for new Gas DHW units of 70-87%. The average of existing units is estimated at 75% by the Northeast Energy Efficiency Partnerships' Mid-Atlantic Technical Reference Manual Version 1.1 (October 2010).

Electric Savings Algorithms
It is assumed that all low flow showerheads installed under PGW's ELIRP program are installed in homes that heat water using natural gas. There are no additional electric savings claimed.

Freeridership/Spillover
Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes
The measure life of a low flow showerhead is assumed to be 9 years[53].

2) Low Flow Faucet Aerators

Unique Measure Code(s): TBD
Draft date: 4/30/12
Effective date: TBD
End date: TBD

Measure Description
This measure relates to the installation of a low flow faucet aerator in either a kitchen or bathroom.

Definition of Baseline Condition
The baseline is the flow rate of the existing faucet. If this is not available, it is generally assumed that a faucet will already have a standard faucet aerator using 2.2 GPM.

Definition of Efficient Condition
The efficient condition is a faucet aerator that has a flow rate lower than the baseline condition. If this value is not available than the flow rate is assumed to be 1.5 GPM[54].

Water Savings Algorithms
The water savings for low flow faucet aerators are due to the reduced amount of water being used per minute that flows down the drain (instead of being collected in the sink).

$$\Delta Gallons = \frac{\left(\frac{GPM_{base} - GPM_{eff}}{GPM_{base}}\right) \times 2.48 \times 10.9 \times 365 \times 50\%}{3.5}$$

Where:

$\Delta Gallons$	=	Gallons of water saved
GPM_{base}	=	Gallons per minute of baseline showerhead = 2.2 GMP[55]
GPM_{eff}	=	Gallons per minute of the efficient showerhead
2.48	=	Average number of people per household[56]

[53] Pennsylvania Public Utility Commission Act 129 Technical Reference Manual (June 2011)
[54] Pennsylvania Public Utility Commission Act 129 Technical Reference Manual (June 2011)
[55] Public Service Commission of Wisconsin Focus on Energy Evaluation Default Deemed Savings Review, June 2008. http://www.focusonenergy.com/files/Document_Management_System/Evaluation/acesdeemedsavingsreview_evaluationreport.pdf
[56] Pennsylvania, Census of Population, 2000.

10.9	=	Average gallons per day used by faucet[57]
365	=	Days per year
50%	=	Drain rate, the percentage of water flowing down the drain[58]
3.5	=	Average Number of Faucets per home[59]

Natural Gas Savings Algorithms

Gas energy savings result from avoiding having to heat the saved water due to the efficient showerhead.

$$\Delta MMBtu = \frac{[\Delta Gallons \times 8.3 \times c_p \times 25] / 1{,}000{,}000}{RE_{DHW}}$$

Where:

$\Delta MMBtu$	=	MMBtu of saved natural gas
8.3	=	Constant to convert gallons to pounds (lbs.)
c_p	=	Average specific heat of water at temperature range (1.00 Btu/lb·°F)
25	=	The difference between the temperature of the water entering the house and the temperature leaving the faucet (degrees Fahrenheit).[60]
RE_{DHW}	=	Recovery efficiency of the domestic hot water heater = 75%[61]

Electric Savings Algorithms

It is assumed that all faucet aerators installed under PGW's ELIRP program are installed in homes that heat water using natural gas. There are no additional electric savings claimed.

Freeridership/Spillover

Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

Persistence

The persistence factor is assumed to be one.

Measure Lifetimes

The measure life of a faucet aerator is assumed to be 12 years[62].

3) Efficient Natural Gas Water Heater

Unique Measure Code(s): TBD
Draft date: 4/30/12
Effective date: TBD
End date: TBD

Measure Description

This measure relates to an efficient natural gas water heater.

[57] Most commonly quoted value of gallons of water used per person per day (including in U.S. Environmental Protection Agency's "water sense" documents; http://www.epa.gov/watersense/docs/home_suppstat508.pdf)
[58] Estimate consistent with Ontario Energy Board, "Measures and Assumptions for Demand Side Management Planning."
[59] East Bay Municipal Utility District; "Water Conservation Market Penetration Study" http://www.ebmud.com/sites/default/files/pdfs/market_penetration_study_0.pdf
[60] Pennsylvania Public Utility Commission Act 129 Technical Reference Manual (June 2011)
[61] See assumption for low flow shower head.
[62] Pennsylvania Public Utility Commission Act 129 Technical Reference Manual (June 2011)

Definition of Baseline Condition
The baseline is the energy factor (EF) of the existing water heater. If possible, the EF of the existing water heater should be used. If the EF of the existing water heater is unknown, 0.575 should be used[63].

Definition of Efficient Condition
The efficient condition is a natural gas water heater that is more energy efficient than the existing water heater.

Water Savings Algorithms
No water savings have been defined for this measure.

Natural Gas Savings Algorithms
MMBtu savings are realized due to the increase in efficiency factor (EF) of the new equipment. MMBtu savings vary by equipment type due to differences in model specific baseline EF and high efficiency EF percentages. Savings are calculated from the baseline new unit to the installed efficient unit. The following formula for gas savings is based on the DOE test procedure for water heaters.

$$\Delta MMBtu = \frac{\left(\frac{1}{EF_{base}} - \frac{1}{EF_{eff}}\right) \times 41{,}045 \times 365}{1{,}000{,}000}$$

Where:

EF_{base}	=	Energy Factor of baseline water heater
EF_{eff}	=	Energy Factor of efficient water heater. If combi boiler use AFUE.
41,045	=	Factor used in DOE test procedure algorithm
365	=	Days in the year

Electric Savings Algorithms
It is assumed that all faucet aerators installed under PGW's ELIRP program are installed in homes that heat water using natural gas water. There are no additional electric savings claimed.

Freeridership/Spillover
Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes
The measure life of a natural gas water heater is assumed to be 15 years[64].

4) Hot Water Heater Tank Temperature Turn-down

Unique Measure Code(s): TBD
Draft date: 4/30/12
Effective date: TBD
End date: TBD

Measure Description

[63] From Mass Save "Massachusetts Technical Reference Manual for Estimating Savings from Energy Efficiency Measures: 2011 Program Year – Plan Version." October 2010. Page 242.
[64] DEER values, updated October 10, 2008
http://www.deeresources.com/deer0911planning/downloads/EUL_Summary_10-1-08.xls

This measure relates to lowering the thermostat setting on a natural gas hot water heater to 120° F, if the temperature is set higher.

Definition of Baseline Condition
The baseline is the temperature setting of the existing water heater, usually above 135° F

Definition of Efficient Condition
The efficient condition is the new setting point for the hot water heater, 120° F.

Water Savings Algorithms
No water savings have been defined for this measure.

Natural Gas Savings Algorithms
MMBtu savings arise from lower temperature setting that reduces the standby heat losses required to maintain the tanks temperature setting.

$$\Delta MMBtu = \frac{\frac{Area \times (T_{base} - T_{eff})}{R_{DHW}} \times \frac{8,760}{1,000,000}}{RE_{DHW}}$$

Where:

$\Delta MMBtu$	=	MMBtu of saved gas per year
$Area$	=	Surface area of hot water heater (ft²)
T_{base}	=	Original temperature inside the tank (°F) = Assume 135 °F if no other information provided
T_{eff}	=	New temperature inside the tank (°F) = Assume 120° F if no other information provided
R_{DHW}	=	R-value of the hot water heater (h °F ft²/Btu) = 5.0[65]
8,760	=	Number of hours in a year
RE_{DHW}	=	Recovery efficiency of the domestic hot water heater = 75%[66]
1,000,000	=	Btu to MMBtu

The following table provides surface areas based on the number of gallons the water tank can hold, along with deemed savings values using the assumptions above.

Water Heater Size (Gal)	Height (Inches)*	Diameter (Inches)*	Total Surface Area (ft²)	Annual Savings (MMBtu)
30	60	16	29.7	1.04
40	61	16.5	31.3	1.10
50	53	18	31.9	1.12
66	58	20	39.0	1.37
80	58	22	44.4	1.56

* *From New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs (October 15, 2010). Page 98*

Electric Savings Algorithms

[65] Calculated using the base conductive heat loss co-efficient and surface areas from: *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs* (October 15, 2010). Page 98
[66] See assumption for low flow showerhead.

There are no electric savings associated with this measure.

Freeridership/Spillover
Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes
The measure life of a natural gas water heater is assumed to be 2 years[67].

5) Repair Hot Water Leaks/Plumbing Repairs

Unique Measure Code(s): TBD
Draft date: 4/30/12
Effective date: TBD
End date: TBD

Measure Description
This measure relates to repairing any leaks from hot water pipes.

Definition of Baseline Condition
The baseline condition is the amount of water leaking from the hot water pipe per minute.

Definition of Efficient Condition
The efficient condition is no hot water leaking from the hot water pipe.

Water Savings Algorithms
The water saved is the amount of water that is lost due to the leak. The following table provides the deemed water savings values for the most common types of leaks.

Leak Type	Amount per Minute	Gallons per Day
Slow Steady Drip	100 drips	14.4*
Fast Drip	200 drips	28.8*
Small Stream	1 cup (8 fl oz)	89.28

** A drip is assumed to be 0.0001 gallons*[68]

Natural Gas Savings Algorithms
Gas savings result from the avoided energy used to heat the water wasted from the leak.

$$\Delta MMBtu = \frac{\left|\Delta Gallons \times 8.3 \times c_p \times (120 - 55)\right| / 1{,}000{,}000}{RE_{DHW}}$$

Where:

$\Delta MMBtu$	=	MMBtu of saved natural gas
8.3	=	Constant to convert gallons to pounds (lbs)

[67] Page 410. Vermont Technical Reference Manual and New Jersey Clean Energy Program Protocols
[68] Figures provided to North Carolina's Dare County Water Department by the North Carolina Rural Water Association: http://www.darenc.com/water/Othsts/WtrLoss.htm (accessed June 23, 2011)

c_p	=	Average specific heat of water at temperature range (1.00 Btu/lb·°F)
120	=	Assumed temperature of hot water as it leaves the water heater and travels through the pipes.
55	=	Assumed temperature of water entering house (degrees Fahrenheit)[69]
RE_{DHW}	=	Recovery efficiency of the domestic hot water heater = 75%[70]

The following table provides deemed gas savings values based on the deemed water savings, the algorithm outlined above, and the measure lives from below.

Leak Type	Savings (MMBtu)
Slow Steady Drip	0.87
Fast Drip	0.87
Small Stream	1.35

Electric Savings Algorithms
It is assumed that all leaks repaired are for homes that heat water using natural gas water. There are no additional electric savings claimed.

Freeridership/Spillover
Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes
The savings for repairing hot water leaks persist as long as the leak would not have otherwise been fixed. PGW assumes that a smaller leak will persist longer than a larger and more noticeable leak and has adjusted the following measure lifetimes to account for this.

Leak Type	Lifetime
Slow Steady Drip	12 weeks
Fast Drip	6 weeks
Small Stream	3 week

6) DHW Pipe Insulation

Unique Measure Code(s): TBD
Draft date: 4/30/12
Effective date: TBD
End date: TBD

Measure Description
This measure relates to installing insulation on hot water pipes.

Definition of Baseline Condition
The baseline condition is the current insulation thickness on the hot water pipe.

[69] A good approximation of annual average water main temperature is the average annual ambient air temperature. Average water main temperature = 55° F based on: http://lwf.ncdc.noaa.gov/img/documentlibrary/clim81supp3/tempnormal_hires.jpg
[70] See assumption for low flow showerhead.

Definition of Efficient Condition
The efficient condition is any insulation on the hot water pipe.
If the diameter of the cold/hot feeds directly to/from the storage tank is 1" or less, a maximum length of three feet for both the cold water inlet and hot water outlet piping above the tank (six total feet) per unit will be included in the savings calculations under the program and should be installed in accordance with best practices.

For each ½" increase in diameter of the hot feed directly from the storage tank beyond 1", an additional 6' length of pipe insulation should be installed along the hot water supply piping only and the additional savings will be credited.

If a DHW recirculating system is present, all hot water supply and return piping accessible without demolition should be insulated and the additional savings will be credited.

The thickness of the DHW pipe insulation should be equivalent to the diameter of the piping. For example, a 1" diameter pipe should be insulated with 1" thick insulation; a 2-1/2" diameter pipe with 2-1/2" thick insulation.[71]

If the hot water piping diameter is in other than a ½" increment, the dimension should be rounded to the next protocol increment.

In the event that the above appears not to cover the specific DHW piping circumstance, suitable pictures and descriptions should be sent to PGW or their implementation contractor for judgment.

Water Savings Algorithms
This measure has no water savings associated with it.

Natural Gas Savings Algorithms

$$Annual\ Gas\ Savings\ (MMBtu) = Length\ \times \frac{\left(HeatLoss(Th_{base}) - HeatLoss(Th_{eff})\right)}{RE_{DHW}\ \times\ 1{,}000{,}000}$$

Where:

Length	=	Number of linear feet of steam pipe insulated
Th_{base}	=	Thickness of base condition insulation (inches)
Th_{eff}	=	Thickness of efficient condition insulation (inches)
HeatLoss(x)	=	Heat loss through hot water pipe as a function of insulation thickness x (Btu/ft /yr)
RE_{DHW}	=	Recovery efficiency of the hot water heater = 75%[72]

"HeatLoss(x)" can be found using the following lookup table.

Insulation Thickness (inches)	Heat Loss (Btu/ft/yr)
Bare	268,231
0.5	86,461
1.0	65,350
1.5	51,421
2.0	44,851
2.5	38,544

[71] Recommendation based on method pioneered by Gary Klein expert on DHW based in California
[72] See *assumption for low flow showerhead.*

Insulation Thickness (inches)	Heat Loss (Btu/ft/yr)
3.0	36,004
3.5	33,989
4.0	32,412
4.5	30,923
5.0	29,872

This table was calculated using the North American Insulation Manufacturers Association's (NAIMA) 3E Plus 4.0 Insulation Thickness Computer Program. The following assumptions were used.

Item Description	=	dhw pipe insulation
System Application	=	Pipe - Horizontal
Dimensional Standard	=	ASTM C 585 Rigid
Calculation Type	=	Heat Loss Per Hour Report
Process Temperature	=	120
Ambient Temperature	=	60
Wind Speed	=	0
Nominal Pipe Size	=	0.75
Bare Metal	=	Copper
Bare Surface Emittance	=	0.6
Insulation Layer 1	=	Polystyrene PIPE, Type XIII, C578-11b
Outer Jacket Material	=	All Service Jacket
Outer Surface Emittance	=	0.9

Electric Savings Algorithms
There are no electric savings associated with this measure.

Freeridership/Spillover
Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes
The measure life is assumed to be 20 years[73].

7) Hot Water Storage Tank Wrap

Unique Measure Code(s): TBD
Draft date: 4/30/12
Effective date: TBD
End date: TBD

[73] NYSERDA Home Performance with Energy Star

Measure Description
This measure refers to an insulating "blanket" that is wrapped around the outside of a hot water tank to reduce stand-by losses. The tank wrap must follow BPI technical standards:

> "Water heater insulation wraps shall not cover the top of oil or gas systems, and shall not obstruct the pressure relief valve, thermostats, hi-limit switch, plumbing pipes, or access plates. A minimum 2-inch clearance is required from the access door for gas burners.
>
> Water heater insulation wraps shall not be installed where forbidden by the manufacturer's instructions found on the nameplate."[74]

Definition of Baseline Condition
The baseline is the hot water heater tank without the insulating blanket.

Definition of Efficient Condition
The efficient condition is the hot water heater tank with the insulating blanket.

Water Savings Algorithms
There are no water savings due to this measure.

Natural Gas Savings Algorithms
Gas energy savings result from the reduction in standby losses.

$$\Delta MMBtu = \frac{\left(\frac{1}{R_{base}} - \frac{1}{R_{eff}}\right) \times Area \times (T_{tank} - T_{amb}) \times \frac{8{,}760}{1{,}000{,}000}}{RE_{DHW}}$$

Where:

$\Delta MMBtu$	=	MMBtu of saved gas per year
R_{eff}	=	R-value of the hot water heater with the insulating blanket (h °F ft^2/Btu)
R_{base}	=	Original R-value of the hot water heater (h °F ft^2/Btu) = 5.0[75] unless other information provided
Area	=	Surface area of the hot water heater covered by the insulating blanket (ft^2)
T_{tank}	=	Temperature inside the tank (°F) = Assume 120 °F if no other information provided
T_{amb}	=	Temperature outside the tank (°F) = 55 °F[76]
8,760	=	Number of hours in a year
RE_{DHW}	=	Recovery efficiency of the domestic hot water heater = 75%[77]
1,000,000	=	Btu to MMBtu

The following table provides assumed insulated surface areas and corresponding deemed savings values for standard tank insulation blankest

[74] Building Performance Institute, Inc. *Technical Standards for the Heating Professional*. Revised 11/20/07. Page 12.
[75] Calculated using the base conductive heat loss co-efficient and surface areas from: *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs* (October 15, 2010). Page 98
[76] Assumed to be in unconditioned space, ambient temperature assumption based on: http://lwf.ncdc.noaa.gov/img/documentlibrary/clim81supp3/tempnormal_hires.jpg
[77] See assumption for low flow showerhead.

Water Heater Size (Gal)	Height (Inches)*	Diameter (Inches)*	Surface Area of Cylinder (ft²)	Surface Area of Accessed Areas (ft²)**	Surface are of Cylinder minus Accessed Areas (ft²)	R-10 Wrap Annual Savings (MMBtu)	R-19 Wrap Annual Savings (MMBtu)
30	60	16	20.9	0.4	20.5	1.6	2.3
40	61	16.5	22.0	0.4	21.5	1.6	2.4
50	53	18	20.8	0.4	20.4	1.5	2.3
66	58	20	25.3	0.4	24.9	1.9	2.8
80	58	22	27.8	0.4	27.4	2.1	3.1

* *From New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs (October 15, 2010). Page 98*

** *Assuming square access area with 4" square and 2" clearance on each side*

Electric Savings Algorithms
This measure is assumed to be installed only on a natural gas fired hot water heating systems, so there are no electric savings associated with this measure.

Freeridership/Spillover
Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes
The measure life is assumed to be 5 years[78].

[78] Northeast Energy Efficiency Partnerships. *Mid-Atlantic Technical Reference Manual (Version 1.1)*. October 2010

IV. Low Income Retrofit Market

A. Space Heating End Use

1) Efficient Space Heating System

Unique Measure Code(s): TBD
Draft date: 4/13/11
Effective date: TBD
End date: TBD

Measure Description
This measure applies to residential-sized high-efficiency gas furnaces and boilers replacing an existing and functioning furnace or boiler of lower efficiency.

Definition of Baseline Condition
The efficiency levels (AFUE) of existing and functioning gas-fired furnaces or boilers. If the manufacturer's rated AFUE is available use it in the savings calculations. If the manufacturer's rated AFUE is not available, then calculate the existing heating system AFUE by multiplying the measured Steady State Efficiency by the appropriate multipliers in the following table:

Distribution Type	*System Type*	*Default Multiplier*
Air	Forced Air	1.0
	Gravity Feed	0.8
	Freestanding Heater	0.95
	Floor Furnace	0.9
	Wall Furnace	0.85
Water	Force Circulation (high mass)	0.85
	Force Circulation (low mass)	0.9
	Gravity Feed	0.85
	Steam	0.75

Source: Building Performance Institute, Technical Standards for the Heating Professional, Revision 11/20/07, p.6.

Definition of Efficient Condition
The installed gas furnace or boiler must have an AFUE greater than the baseline condition.

Gas Savings Algorithms
MMBtu savings are realized due to the increase in AFUE of the new equipment. MMBtu savings vary by equipment type due to differences in model-specific baseline AFUE and high efficiency AFUE percentages. Savings are calculated from the baseline existing unit to the installed efficient unit.

$$Annual\ Gas\ Savings\ (MMBtu) = HeatingUse \times \left(1 - \frac{AFUE_{Base}}{AFUE_{Eff}}\right)$$

Where:

HeatingUse	=	Annual heating use (MMBtu/yr) from weather normalized usage analysis of customer billing data from pre-treatment period. See description below.
$AFUE_{Base}$	=	Efficiency of existing baseline equipment (Annual Fuel Utilization Efficiency)
$AFUE_{Eff}$	=	Efficiency of new efficient equipment

Heating Use weather normalization methods (HeatingUse):

Method 1: Use a linear regression model of use/day as a function of HDD63[79]/day to estimate heating slope (MMbtu/HDD63) and baseload daily use (MMBtu/day) with an annual HDD63 of 4033[80] to calculate annual heating load.

Method 2: Calculate baseload (MMBtu/day) as the third lowest MMBtu/day bill for the analysis year. Then calculate raw heating use as the sum of monthly billed use minus the – baseload * sum(monthly bill elapsed days), then calculate weather adjusted heating use as raw heating use * (4033/HDD63actual).

Electric Savings Algorithms

Electric energy savings result from efficient furnace fans (ECM) that may be included with efficient furnaces. Electrical savings from fan motor efficiency does not apply to boilers.

Energy Savings
$\Delta kWh = 700\ kWh$

Demand Savings
$\Delta kW = 0\ kW$

Where:

ΔkWh	=	Gross customer annual kWh savings for the measure. Based on 500 kWh heating season plus 200 kWh cooling season.
ΔkW	=	Gross customer summer load kW savings for the measure.

Freeridership/Spillover
Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

Equipment Type	Free Ridership	Spillover
Gas Furnace	0%	0%
Gas Furnace with ECM Fan	0%	0%
Gas Boiler	0%	0%

[79] Heating degree days are calculated using base 63°F which was selected based on variable-base degree day regressions of billing data from CWP participants over the past several years. This value is higher than found for many non-low income populations in similar climates and likely reflects the low efficiency of the low income housing stock and also the targeting of high users by CWP. The use of this HDD base eliminates the need for the degree day correction factor found in some similar calculations that use HDD65.
[80] *This value of 4033 HDD63 is the average from NWS data for PHL for the years 2002 through 2009.*

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes

Equipment Type	Measure Lifetime
Gas Furnaces	20
Gas Boilers	25

Source: Lifetime estimates used by Efficiency Vermont.

Water Savings
There are no water savings for this measure.

2) Space Heating System Tune-Up

Unique Measure Code(s): TBD
Draft date: 1/1/16
Effective date: 1/1/16
End date: TBD

Measure Description
This measure applies to existing residential-sized gas furnaces and boilers. The tune-up is to improve the overall efficiency of the furnace or boiler by checking, cleaning and adjusting parts relevant to the heating equipment's combustion and heat transfer efficiency.

Definition of Baseline Condition
The efficiency levels (AFUE) of existing gas-fired furnaces or boilers. Calculate the existing heating system AFUE by multiplying the measured Steady State Efficiency by the appropriate multipliers in the following table:

Distribution Type	System Type	Default Multiplier
Air	Forced Air	1.0
	Gravity Feed	0.8
	Freestanding Heater	0.95
	Floor Furnace	0.9
	Wall Furnace	0.85
Water	Force Circulation (high mass)	0.85
	Force Circulation (low mass)	0.9
	Gravity Feed	0.85
	Steam	0.75

Source: Building Performance Institute, Technical Standards for the Heating Professional, Revision 11/20/07, p.6.

Definition of Efficient Condition
The efficiency levels (AFUE) of the gas-fired furnaces or boilers after the tune-up. Calculate the heating system AFUE by multiplying the measured Steady State Efficiency by the appropriate multipliers in the preceding table.

Gas Savings Algorithms
MMBtu savings are realized due to the increase in AFUE of the heating equipment. MMBtu savings vary by equipment type due to differences in model-specific baseline AFUE and high efficiency AFUE percentages. Savings are calculated from the baseline existing unit to the unit after the tune-up.

$$Annual\ Gas\ Savings\ (MMBtu) = HeatingUse \times \left(1 - \frac{AFUE_{Base}}{AFUE_{Eff}}\right)$$

Where:

HeatingUse	=	*Annual heating use (MMBtu/yr) from weather normalized usage analysis of customer* billing data from pre-treatment period. See description below.
$AFUE_{Base}$	=	Efficiency of existing space heating equipment (Annual Fuel Utilization Efficiency)
$AFUE_{Eff}$	=	Efficiency of heating equipment after tune-up

Heating Use weather normalization methods (HeatingUse):

Method 1: Use a linear regression model of use/day as a function of HDD63[81]/day to estimate heating slope (MMbtu/HDD63) and baseload daily use (MMBtu/day) with an annual HDD63 of 4033[82] to calculate annual heating load.

Method 2: Calculate baseload (MMBtu/day) as the third lowest MMBtu/day bill for the analysis year. Then calculate raw heating use as the sum of monthly billed use minus the – baseload * sum(monthly bill elapsed days), then calculate weather adjusted heating use as raw heating use * (4033/HDD63actual).

Electric Savings Algorithms

There are no electricity savings for this measure.

Energy Savings
$\Delta kWh = 0$ kWh

Demand Savings
$\Delta kW = 0$ kW

Where:

ΔkWh	=	Gross customer annual kWh savings for the measure.
ΔkW	=	Gross customer summer load kW savings for the measure.

Freeridership/Spillover
Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

[81] Heating degree days are calculated using base 63°F, which was selected, based on variable-base degree day regressions of billing data from CWP participants over the past several years. This value is higher than found for many non-low income populations in similar climates and likely reflects the low efficiency of the low income housing stock and also the targeting of high users by CWP. The use of this HDD base eliminates the need for the degree day correction factor found in some similar calculations that use HDD65.
[82] This value of 4033 HDD63 is the average from NWS data for PHL for the years 2002 through 2009.

Equipment Type	Free Ridership	Spillover
Gas Furnace or Boiler Tune-up	0%	0%

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes

Equipment Type	Measure Lifetime
Gas Furnace or Boiler Tune-up	2

Source: Lifetime estimate used by Illinois, Minnesota and New York TRMs.

Water Savings
There are no water savings for this measure.

3) Infiltration Reduction

Unique Measure Code(s): TBD
Draft date: 4/13/11
Effective date: TBD
End date: TBD

Measure Description
This involves decreasing the amount of air exchange between the inside of the house or unit and the outdoors without buffering from any adjacent unit(s) by sealing the sources of leaks, while maintaining minimum air exchange for air quality..

Definition of Baseline Condition
The baseline is the house in its pre-treatment condition, with opportunities for infiltration reductions.

Definition of Efficient Condition
Any decrease in infiltration will reduce energy consumption compared to the pre-treated house.

Gas Savings Algorithms

$$Annual\ Gas\ Savings\ (MMBtu) = \frac{HDD_t \times 24 \times (CFM50_{pre} - CFM50_{post})}{(21.5 \times AFUE \times 1{,}000{,}000)}$$

Where:

HDD_t = Heating degree days at temperature t, where t=63°F if no programmable thermostat has been installed and t=62°F if a programmable thermostat has been installed. From NWS data for PHL from 2002-2009, HDD63=4033 and HDD62 = 3820.

24 = hours/day

$CFM50_{pre}$ = CFM50 of building shell leakage as measured by a blower door test before treatment.
$CFM50_{post}$ = CFM50 of building shell leakage as measured by a blower door test after treatment.

21.5 = factor to convert CFM50 value to Btu/hrF heat loss rate, calculated from hourly infiltration modeling[83]

AFUE = rated AFUE of heating system. If no rating is available then use the method described in the Efficient Space Heating System section for calculating the AFUE. The AFUE of replacement equipment should be used if the heating system replacement precedes the air sealing work.

Electric Savings Algorithms

If the type of air conditioning is known, then use the appropriate algorithm below. If the type or existence of air-conditioning is not known, then assume that 83% have air-conditioning and estimate the cooling savings as 83% of a house with central air conditioning.[84]

Reduced furnace fan or boiler circulator pump usage is also likely to occur and provide electricity savings during both the heating and cooling seasons.

Energy Savings

$\Delta kWh = \Delta kWh_{Aux} + \Delta kWh_{Cool}$

$\Delta kWh_{Aux} = \textit{Annual Gas Savings (MMBtu)} \times \textit{Auxiliary}$

ΔkWh_{Cool} = 0 kWh if house has no air conditioning
= ΔkWh_{CAC} if house has central air conditioning
= ΔkWh_{RAC} if house has room air conditioning
= 83% × ΔkWh_{CAC} if no information about air conditioner

$$\Delta kWh_{CAC} = \frac{CDD \times 24 \times DUA \times (CFM50_{pre} - CFM50_{post})}{\left(21.5 \times SEER_{CAC} \times 1000\frac{W}{kW}\right)}$$

$$\Delta kWh_{RAC} = \frac{CDD \times 24 \times DUA \times F_{Room\ AC} \times (CFM50_{pre} - CFM50_{post})}{\left(21.5 \times \overline{EER}_{RAC} \times 1000\frac{W}{kW}\right)}$$

Demand Savings

ΔkW = 0 kW if house has no air conditioning
= ΔkW_{CAC} if house has central air conditioning
= ΔkW_{RAC} if house has room air conditioning

$$\Delta kW_{CAC} = \frac{\Delta kWh_{CAC}}{EFLH_{cool}} \times CF_{CAC}$$

$$\Delta kW_{RAC} = \frac{\Delta kWh_{RAC}}{EFLH_{cool\ RAC}} \times CF_{RAC}$$

Where:

ΔkWh = gross customer annual kWh savings for the measure.

ΔkW = gross customer summer load kW savings for the measure.

[83] An hourly infiltration was calculated using a modified version of the LBL (a.k.a. Sherman-Grimsrud) infiltration model with a wind effect modification (EPRI RP 2034-40, Palmiter and Bond 1991) using Philadelphia TMY2 hourly weather data. This analysis result was then adjusted to account for an assumed party wall leakage fraction of 12% and an estimated 10% thermal regain from infiltration/exfiltratiom. The resulting value of 21.5 is consistent with statistical analyses of empirical data using CFM50 values and actual gas use and savings from CWP evaluations.

[84] Percentage of houses with air-conditioning from EIA Table AC1.xls for Middle Atlantic region (PA, NY, NJ). From: http://www.eia.doe.gov/emeu/recs/recs2005/hc2005_tables/detailed_tables2005.html

Auxiliary = *Heating system auxiliary usage per MMBTU consumption (5.02 From Vermont Technical Reference Manual)*

CDD = *Cooling Degree Days (Degrees F * Days)HDD*

DUA = *Discretionary Use Adjustment to account for the fact that people do not always operate their air conditioning system when the outside temperature is greater than 65F.*

$SEER_{CAC}$ = *Seasonal Energy Efficiency Ratio of existing home central air conditioner (Btu/W•hr) (See table below for default values if actual values are not available)*

$\overline{EER}_{RAC}$ = *Average Energy Efficiency Ratio of existing room air conditioner (Btu/W•hr) (See table below for default values if actual values are not available)*

CF_{CAC} = *Demand Coincidence Factor for central AC systems (See table below)*

CF_{RAC} = *Demand Coincidence Factor for Room AC systems (See table below)*

$EFLH_{cool}$ = *Equivalent Full Load Cooling hours for Central AC and ASHP (See table below)*

$EFLH_{cool\ RAC}$ = *Equivalent Full Load Cooling hours for Room AC (See table below)*

$F_{Room\ AC}$ = *Adjustment factor to relate insulated area to area served by Room AC units*

The default values for each term are shown in the table below.

Default values for algorithm terms, Ceiling/Attic and Wall Insulation

Term	Type	Value	Source
DUA	Fixed	0.75	OH TRM[85]
$SEER_{CAC}$	Variable	Default values: Early Replacement = 10 Replace on Burnout = 13	PUC Technical Reference Manual
		Nameplate	Contractor Data Gathering
$\overline{EER}_{RAC}$	Variable	Default = 9.8	DOE Federal Test Procedure 10 CFR 430, Appendix F (Used in ES Calculator for baseline)
		Nameplate	Contractor Data Gathering
CF_{CAC}	Fixed	0.70	PUC Technical Reference Manual
CF_{RAC}	Fixed	0.58	PUC Technical Reference Manual
$F_{Room,AC}$	Fixed	0.38	Calculated[86]

[85] "State of Ohio Energy Efficiency Technical Reference Manual," prepared for the Public Utilities Commission of Ohio by Vermont Energy Investment Corporation. August 6, 2010.

EFLH, CDD and HDD by City

City	$EFLH_{cool}$ (Hours)[87]	$EFLH_{cool\ RAC}$ (Hours)[88]	CDD (Base 65)[89]	HDD (Base 65)[90]
Philadelphia	1032	320	1235	4759

Freeridership/Spillover
Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

Measure	Free Ridership	Spillover
Infiltration Reduction	0%	0%

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes

Measure	Measure Lifetime
Infiltration Reduction	20

Source: NYSERDA Home Performance with Energy Star.

Water Savings
There are no water savings for this measure.

4) Roof and Cavity Insulation

Unique Measure Code(s): TBD
Draft date: 4/13/11
Effective date: TBD
End date: TBD

Measure Description
This involves increasing the insulation levels in either the attic or walls which directly define the boundary between the house or unit and the outdoors.

Definition of Baseline Condition
The baseline is amount of insulation in the house in its pre-treatment condition.

[86] From PECO baseline study, average home size = 2323 ft², average number of room AC units per home = 2.1. Average Room AC capacity = 10,000 BtuH per ENERGY STAR Room AC Calculator, which serves 425 ft² (average between 400 and 450 ft² *for 10,000 BtuH unit per ENERGY STAR Room AC sizing chart*). $F_{Room,AC} = (425\ ft^2 * 2.1)/(2323\ ft^2) = 0.38$
[87] PA 2010 TRM Table 2-1.
[88] PA SWE Interim Approved TRM Protocol – Residential Room AC Retirement
[89] Climatography of the United States No. 81. Monthly Station Normals of Temperature, Precipitation, and Heating and Cooling Degree Days 1971-2000, 36 Pennsylvania. NOAA. http://cdo.ncdc.noaa.gov/climatenormals/clim81/PAnorm.pdf
[90] Ibid.

Definition of Efficient Condition
Any increase in insulation will reduce energy consumption compared to the pre-treated house.

Gas Savings Algorithms

$$Annual\ Gas\ Savings\ (MMBtu) = \frac{HDD_t \times 24 \times AREA \times \left({}^{1}/_{R_{pre}} - {}^{1}/_{R_{post}} \right)}{(AFUE \times 1{,}000{,}000)}$$

Where:

HDD_t	=	Heating degree days at temperature t, where t=63°F if no programmable thermostat has been installed and t=62°F if a programmable thermostat has been installed[91].
24	=	Hours per day
AREA	=	*Net insulated area in square feet. Estimated at 85% of gross area for cavities.*
R_{pre}	=	R value of roof/cavity pre-treatment. R_{pre} = 5 unless there is existing insulation.
R_{post}	=	R value of roof/ cavity after insulation is installed.
AFUE	=	Rated AFUE of heating system. If no rating is available then use the method described in the Efficient Space Heating System section for calculating the AFUE. The AFUE of replacement equipment should be used if the heating system replacement precedes the air sealing work.

Electric Savings Algorithms
If the type of air conditioning is known, then use the appropriate algorithm below. If the type or existence of air-conditioning is not known, then assume that 83% have air-conditioning and estimate the cooling savings as 83% of a house with central air conditioning.[92]

Reduced furnace fan or boiler circulator pump usage is also likely to occur and provide electricity savings during both the heating and cooling seasons.

Energy Savings

$\Delta kWh = \Delta kWh_{Aux} + \Delta kWh_{Cool}$

ΔkWh_{Aux} $= Annual\ Gas\ Savings\ (MMBtu) \times Auxiliary$

ΔkWh_{Cool} = 0 kWh if house has no air conditioning
= ΔkWh_{CAC} if house has central air conditioning
= ΔkWh_{RAC} if house has room air conditioning
= 83% × ΔkWh_{CAC} if no information about air conditioner

$$\Delta kWh_{CAC} = \frac{CDD \times 24 \frac{hr}{day} \times DUA}{SEER_{CAC} \times 1000 \frac{W}{kW}} \times \left[AREA \times \left(\frac{1}{R_{pre}} - \frac{1}{R_{post}} \right) \right]$$

[91] From NWS data for PHL from 2002-2009, HDD63=4033 and HDD62 = 3820
[92] Percentage of houses with air-conditioning from EIA Table AC1.xls for Middle Atlantic region (PA, NY, NJ). From: http://www.eia.doe.gov/emeu/recs/recs2005/hc2005_tables/detailed_tables2005.html

$$\Delta kWh_{RAC} = \frac{CDD \times 24\frac{hr}{day} \times DUA \times F_{Room\ AC}}{\overline{EER}_{RAC} \times 1000\frac{W}{kW}} \times \left[AREA \times \left(\frac{1}{R_{pre}} - \frac{1}{R_{post}}\right)\right]$$

Demand Savings

ΔkW = 0 kW if house has no air conditioning
= ΔkW_{CAC} if house has central air conditioning
= ΔkW_{RAC} if house has room air conditioning

$$\Delta kW_{CAC} = \frac{\Delta kWh_{CAC}}{EFLH_{cool}} \times CF_{CAC}$$

$$\Delta kW_{RAC} = \frac{\Delta kWh_{RAC}}{EFLH_{cool\ RAC}} \times CF_{RAC}$$

Where:

ΔkWh = gross customer annual kWh savings for the measure.
ΔkW = gross customer summer load kW savings for the measure.

Auxiliary = *Heating system auxiliary usage per MMBTU consumption (5.02 From Vermont Technical Reference Manual)*

CDD = *Cooling Degree Days (Degrees F * Days)HDD*

DUA = *Discretionary Use Adjustment to account for the fact that people do not always operate their air conditioning system when the outside temperature is greater than 65F.*

$SEER_{CAC}$ = *Seasonal Energy Efficiency Ratio of existing home central air conditioner (Btu/W•hr) (See table below for default values if actual values are not available)*

$\overline{EER}_{RAC}$ = *Average Energy Efficiency Ratio of existing room air conditioner (Btu/W•hr) (See table below for default values if actual values are not available)*

CF_{CAC} = *Demand Coincidence Factor for central AC systems (See table below)*

CF_{RAC} = *Demand Coincidence Factor for Room AC systems (See table below)*

$EFLH_{cool}$ = *Equivalent Full Load Cooling hours for Central AC and ASHP (See table below)*

$EFLH_{cool\ RAC}$ = *Equivalent Full Load Cooling hours for Room AC (See table below)*

$F_{Room\ AC}$ = *Adjustment factor to relate insulated area to area served by Room AC units*

The default values for each term are shown in the table below.

Default values for algorithm terms, Ceiling/Attic and Wall Insulation

Term	Type	Value	Source
DUA	Fixed	0.75	OH TRM[93]
$SEER_{CAC}$	Variable	Default values: Early Replacement = 10 Replace on Burnout = 13	PUC Technical Reference Manual
		Nameplate	Contractor Data Gathering
$\overline{EER}_{RAC}$	Variable	Default = 9.8	DOE Federal Test Procedure 10 CFR 430, Appendix F (Used in ES Calculator for baseline)
		Nameplate	Contractor Data Gathering
CF_{CAC}	Fixed	0.70	PUC Technical Reference Manual
CF_{RAC}	Fixed	0.58	PUC Technical Reference Manual
$F_{Room,AC}$	Fixed	0.38	Calculated[94]

EFLH, CDD and HDD by City

City	$EFLH_{cool}$ (Hours)[95]	$EFLH_{cool\ RAC}$ (Hours)[96]	CDD (Base 65)[97]	HDD (Base 65)[98]
Philadelphia	1032	320	1235	4759

Freeridership/Spillover
Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

Measure	Free Ridership	Spillover
Insulation	0%	0%

Persistence
The persistence factor is assumed to be one.

[93] "State of Ohio Energy Efficiency Technical Reference Manual," prepared for the Public Utilities Commission of Ohio by Vermont Energy Investment Corporation. August 6, 2010.
[94] From PECO baseline study, average home size = 2323 ft^2, average number of room AC units per home = 2.1. Average Room AC capacity = 10,000 BtuH per ENERGY STAR Room AC Calculator, which serves 425 ft^2 (average between 400 and 450 ft^2 for 10,000 BtuH unit per ENERGY STAR Room AC sizing chart). $F_{Room,AC} = (425\ ft^2 * 2.1)/(2323\ ft^2) = 0.38$
[95] PA 2010 TRM Table 2-1.
[96] PA SWE *Interim Approved* TRM Protocol – Residential Room AC Retirement
[97] Climatography of the United States No. 81. Monthly Station Normals of Temperature, Precipitation, and Heating and Cooling Degree Days 1971-2000, 36 Pennsylvania. NOAA. http://cdo.ncdc.noaa.gov/climatenormals/clim81/PAnorm.pdf
[98] Ibid.

Measure Lifetimes

Measure	Measure Lifetime
Roof Insulation	40
Cavity Insulation	40

Source: NYSERDA Home Performance with Energy Star.

Water Savings
There are no water savings for this measure.

5) Programmable Thermostat

Unique Measure Code(s): TBD
Draft date: 4/13/11
Effective date: TBD
End date: TBD

Measure Description
This is a programmable thermostat controlling a residential-sized gas furnace or boiler.

Definition of Baseline Condition
The baseline is a manual thermostat where each temperature setting change requires human intervention.

Definition of Efficient Condition
The efficient thermostat is one that can be programmed to automatically increase or lower the temperature setting at different times of the day and week.

Gas Savings Algorithms

$$Annual\ Gas\ Savings\ (MMBtu) = HeatingUse \times \left(1 - {}^{HDD_{62}}/_{HDD_{63}}\right) = HeatingUse \times 0.053 = 1.53\ MMBtu$$

Where:

HeatingUse = Annual heating use (MMBtu/yr) from weather normalized usage analysis of customer billing data from pre-treatment period (see description under heating system replacement). If thermostat measure is performed after shell measures of insulation or air sealing, then subtract the projected savings from those measures from the pre retrofit heating use.

HDD_{62} = 3820

The annual heating degree days based on 62°F, representing the estimated balance point temperature of the home with the programmable thermostat.

HDD_{63} = 4033

The annual heating degree days based on 63°F, representing the estimated balance point temperature of the home with the programmable thermostat.

An analysis of variable base degree day billing data from the CWP has found an average net reduction in balance point temperature of about 1.0°F for thermostat installations. Multiple impact evaluations have also found heating savings averaging about 5%-6% from thermostat installations. These two findings are consistent with each other and indicate an estimated average impact based on employing the approach from past CWP contractors to targeting customers and selecting homes to receive thermostats and the savings opportunities and compliance rates achieved. The savings may not be accurate when applied to different populations in different ways.

Electric Savings Algorithms

If the type of air conditioning is known, then use the appropriate algorithm below. If the type or existence of air-conditioning is not known, then assume that 83% have air-conditioning and estimate the cooling savings as 83% of a house with central air conditioning.[99]

Reduced furnace fan or boiler circulator pump usage is also likely to occur and provide electricity savings during both the heating and cooling seasons, but these auxiliary savings are not accounted for in the following algorithms.

Energy Savings

$\Delta kWh = \Delta kWh_{Aux} + \Delta kWh_{Cool}$

$\Delta kWh_{Aux} = Annual\ Gas\ Savings\ (MMBtu) \times Auxiliary$

ΔkWh_{Cool} = 0 kWh if house has no air conditioning
= ΔkWh_{CAC} if house has central air conditioning
= 0 if house has room air conditioning
= 83% × ΔkWh_{CAC} if no information about air conditioner

$$\Delta kWh_{CAC} = CAP_{COOL} \times \left(\frac{12{,}000 \frac{Btu}{ton} \times \frac{1}{1{,}000} \frac{kWh}{Wh}}{EER_{COOL} \times Eff_{duct}} \right) \times EFLH \times ESF_{COOL}$$

Demand Savings

$\Delta kW = 0\ kW$

Where:

ΔkWh = gross customer annual kWh savings for the measure.

ΔkW = gross customer summer load kW savings for the measure.

CAP_{COOL} = *capacity of the air conditioning unit in tons, based on nameplate capacity (see table below)*

EER_{COOL} = *Seasonally averaged efficiency rating of the baseline unit . (see table below)*

Eff_{duct} = *duct system efficiency (see table below)*

ESF_{COOL} = *energy savings factor for cooling and heating, respectively (see table below)*

[99] Percentage of houses with air-conditioning from EIA Table AC1.xls for Middle Atlantic region (PA, NY, NJ). From: http://www.eia.doe.gov/emeu/recs/recs2005/hc2005_tables/detailed_tables2005.html

EFLH = *equivalent full load hours*

Residential Electric HVAC Calculation Assumptions

Component	Type	Value	Sources
CAP_{COOL}	Variable	Nameplate data	Contractor Data Gathering
		Default: 3 tons	1
EER_{COOL}	Variable	Nameplate data	Contractor Data Gathering
		Default: Cooling = 10 SEER Default: Heating = 1.0 (electric furnace COP)	2
Eff_{duct}	Fixed	0.8	3
ESF_{COOL}	Fixed	2%	4
EFLH	Fixed	Philadelphia Cooling = 1,032 Hours	5

Sources:

6. Average size of residential air conditioner.
7. Minimum Federal Standard for new Central Air Conditioners/Heat Pumps between 1990 and 2006.
8. New York Standard Approach for Estimating Energy Savings from Energy Efficiency Measures in Commercial and Industrial Programs, September 1, 2009.
9. DEER 2005 cooling savings for climate zone 16, assumes a variety of thermostat usage patterns.
10. US Department of Energy, ENERGY STAR Calculator. Accessed 3/16/2009.

Freeridership/Spillover

Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

Equipment Type	Free Ridership	Spillover
Programmable Thermostat	0%	0%

Persistence

The persistence factor is assumed to be one.

Measure Lifetimes

Equipment Type	Measure Lifetime
Programmable Thermostat	15

Source: New Jersey Clean Energy Program Protocols (December 2009).

Water Savings

There are no water savings for this measure.

6) Duct Work Insulation

Unique Measure Code(s): TBD
Draft date: 7/28/11
Effective date: TBD
End date: TBD

Measure Description
This measure relates to installing insulation on ducts in unconditioned spaces.

Definition of Baseline Condition
The baseline condition is assumed to be an un-insulated duct.

Definition of Efficient Condition
The efficient condition is the duct with insulation installed.

Water Savings Algorithms
This measure has no water savings associated with it.

Natural Gas Savings Algorithms

$$Annual\ Gas\ Savings\ (MMBtu) = Length \times \frac{EFLH_{heat}}{24 \times 365} \times \frac{\left(HeatLoss(Th_{base}) - HeatLoss(Th_{eff})\right)}{AFUE \times 1{,}000{,}000}$$

Where:

Length	=	Number of linear feet of duct work insulated
$EFLH_{heat}$	=	Equivalent full load heating hours = 730 hours
Th_{base}	=	Thickness of base condition insulation (inches)
Th_{eff}	=	Thickness of efficient condition insulation (inches)
HeatLoss(x)	=	Heat loss through duct work as a function of insulation thickness x (Btu/ft /yr)
AFUE	=	Rated AFUE of heating system. If no rating is available then use the method described in the Efficient Space Heating System section for calculating the AFUE. The AFUE of replacement equipment should be used if the heating system replacement precedes the duct work insulation.

"HeatLoss(x)" can be found using the following lookup table.

Insulation Thickness (inches)	Heat Loss (Btu/ft/yr)
Bare	1,120,000
0.25	339,500
0.5	205,300
0.75	190,700
1	128,300
1.5	93,970

Insulation Thickness (inches)	Heat Loss (Btu/ft/yr)
2	74,370
2.5	61,620
3	52,650
3.5	45,990
4	40,830

This table was calculated using the North American Insulation Manufacturers Association's (NAIMA) 3E Plus 4.0 Insulation Thickness Computer Program. The following assumptions were used.

Item Description	=	bare duct
Calculation Type	=	Heat Loss Per Year Report
Geometry Description	=	Steel Duct - Rectangular Horz.
System Units	=	ASTM C585
Bare Surface Emittance	=	0.8
Process Temperature	=	140 °F
Ave. Ambient Temperature	=	41.8 °F[100]
Ave. Wind Speed	=	0 mph
Relative Humidity	=	N/A
Dew Point	=	N/A
Condensation Control Thickness	=	N/A
Hours Per Year	=	2000[101]
Outer Jacket Material	=	Aluminum, oxidized, in service
Outer Surface Emittance	=	0.1
Insulation Layer 1	=	Duct Wrap, 1.0 pound per cubic foot, C1290,
Duct Horiz Dimension	=	12 in.
Duct Vert Dimension	=	8 in.

Electric Savings Algorithms
No electric savings are currently claimed for this measure.

Freeridership/Spillover
Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes
The measure life is assumed to 18 years[102].

[100] Average winter temperature for Philadelphia from "Cost Savings and Comfort for Existing Buildings", 3rd Edition, by John Krigger, Saturn Resource Management. Page 255.
[101] Low end of 2,000 – 2,500 winter heating load hours from Air-conditioning and Refrigeration Institute. http://www.waterfurnace.ca/Engineer/Misc%20References/ARI%20Cooling%20&%20Heating%20Load%20Hours%20Map.pdf
[102] NYSERDA Home Performance with Energy Star

7) Heating Pipe Insulation

Unique Measure Code(s): TBD
Draft date: 7/28/11
Effective date: TBD
End date: TBD

Measure Description
This measure relates to installing insulation on space heating pipes in unconditioned spaces.

Definition of Baseline Condition
The baseline condition is the current insulation thickness on a space heating hot water or steam pipe.

Definition of Efficient Condition
The efficient condition is any insulation thicker than that already on the pipe.

Water Savings Algorithms
This measure has no water savings associated with it.

Natural Gas Savings Algorithms

$$Annual\ Gas\ Savings\ (MMBtu) = Length \times H_{heat} \times \frac{\left(HeatLoss(Th_{base}) - HeatLoss(Th_{eff})\right)}{AFUE \times 1{,}000{,}000}$$

$$H_{Heat} = \frac{HDD \times 24}{Dt} = \frac{4{,}033 \times 24}{59} = 1{,}640$$

Where:

Length	=	Number of linear feet of heating pipe insulated
H_{heat}	=	Heating hours for a properly sized boiler. Used as an estimate of the hours in which the space-heating pipe would be hotter than the ambient temperature and would therefore experience heat loss.
Th_{base}	=	Thickness of base condition insulation (inches)
Th_{eff}	=	Thickness of efficient condition insulation (inches)
HeatLoss(x)	=	Heat loss through pipe as a function of insulation thickness x (Btu/ft /hr)
AFUE	=	Rated AFUE of heating system. If no rating is available then use the method described in the Efficient Space Heating System section for calculating the AFUE. The AFUE of replacement equipment should be used if the heating system replacement precedes the pipe insulation.
HDD	=	Base 63° F Heating Degree Days for Philadelphia = 4,033 [103]
Dt	=	Design temperature difference (assume from 11° F to 70° F for properly sized boiler)[104] = 59° F

"HeatLoss(x)" can be found using the following lookup table.

[103] Based on NCDC ASOS temperature data for PHL from 2002 through 2009.
[104] *11 degree design temperature source: 5th Edition Residential Energy, Cost Savings and Comfort for Existing Buildings.* John Krigger and Chris Dorsi, 2009, Saturn Resource Management, Appendix A-8, p. 280.

Insulation Thickness (inches)	Steam Heat Loss (Btu/ft/hr)	Hot Water Heat Loss (Btu/ft/hr)
Bare	201.4	72.12
0.5	47.75	15.24
1.0	31.15	11.2
1.5	24.09	8.67
2.0	20.28	7.51
2.5	17.98	6.42
3.0	16.35	5.98
3.5	15.13	5.64
4.0	14.06	5.37
4.5	13.31	5.12

This table was calculated using the North American Insulation Manufacturers Association's (NAIMA) 3E Plus 4.0 Insulation Thickness Computer Program. The following assumptions were used.

Item Description	=	steam piping
System Application	=	Pipe - Horizontal
Dimensional Standard	=	ASTM C 585 Rigid
Calculation Type	=	Heat Loss Per Hour Report
Process Temperature	=	212
Ambient Temperature	=	60
Wind Speed	=	0
Nominal Pipe Size	=	2
Bare Metal	=	Copper
Bare Surface Emittance	=	0.6
Insulation Layer 1	=	850F Mineral Fiber PIPE, Type I, C547-11
Outer Jacket Material	=	All Service Jacket
Outer Surface Emittance	=	0.9

Item Description	=	hot water piping
System Application	=	Pipe - Horizontal
Dimensional Standard	=	ASTM C 585 Rigid
Calculation Type	=	Heat Loss Per Hour Report
Process Temperature	=	180
Ambient Temperature	=	60
Wind Speed	=	0
Nominal Pipe Size	=	0.75
Bare Metal	=	Copper
Bare Surface Emittance	=	0.6
Insulation Layer 1	=	Phenolic SHEET+TUBE,Type III, C1126-11
Outer Jacket Material	=	All Service Jacket
Outer Surface Emittance	=	0.9

Electric Savings Algorithms
There are no electric savings associated with this measure.

Freeridership/Spillover
Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes
The measure life is assumed to be 20 years[105].

8) Duct Work Sealing

Unique Measure Code(s): TBD
Draft date: 4/30/2013
Effective date: TBD
End date: TBD

Measure Description
This measure provides estimates for stand-along savings from sealing ducts in a retrofit project and preventing heated air from leaking into unconditioned spaces. In order to verify savings, a duct-leakage test must be used to calculate a reduction in CFM-25 readings.

Definition of Baseline Condition
The baseline condition is assumed to be a duct that has not been sealed.

Definition of Efficient Condition
The efficient condition is a duct that has been sealed to reduce outside leakage.

Water Savings Algorithms
This measure has no water savings associated with it.

Natural Gas Savings Algorithms

$$Annual\ Gas\ Savings\ (MMBtu) = (CFMpre - CFMpost) \times DSFgas$$

Where:

CFMpre	=	Reading from duct-blaster test at 25 pascals, before sealing performed
CFMpost	=	Reading from duct-blaster test at 25 pascals, after sealing performed
DSFgas	=	Duct sealing factor for gas systems, 0.035 MMBtus/CFM-25[106]

Electric Savings Algorithms
Electric savings per 100 CFM-25 reduction:[107]

- 110.0 kWh in heating fan savings

[105] NYSERDA Home Performance with Energy Star
[106] Based on 3.5 MMBtus savings per 100 CFM reduction for duct sealing from UI/CL&P Program Savings Documentation – 2011, page 131
[107] UI/CL&P Program Savigns Documentation, 2011, page 131

- If a central air conditioner is present
    - 105.9 kWh from cooling
    - 0.23 kW summer peak demand savings

Freeridership/Spillover
Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes
The measure life is assumed to 18 years[108].

9) High Efficiency Window

Unique Measure Code(s): TBD
Draft date: 7/29/13
Effective date: TBD
End date: TBD

Measure Description
This involves installing a window with a U-factor less than a baseline window.

Definition of Baseline Condition
The baseline is the minimum window required by code. IECC 2009 for Philadelphia requires a U-factor of 0.35 or less.

Definition of Efficient Condition
An efficient window is any window exceeding Energy Star® requirements for U-factor of 0.32 or less.

Gas Savings Algorithms

$$Annual\ Gas\ Savings\ (MMBtu) = \frac{HDD_t\ \times 24\ \times AREA\ \times (U_{base} - U_{eff})}{(AFUE \times 1{,}000{,}000)}$$

Where:

HDD_t	=	Heating degree days at temperature t, where t=63°F if no programmable thermostat has been installed and t=62°F if a programmable thermostat has been installed[109].
24	=	Hours per day
AREA	=	Square feet of window area.
U_{base}	=	U-factor of new baseline window. U_{base} = 0.35 based on IECC 2009.
U_{eff}	=	U-factor of efficient window.
AFUE	=	Rated AFUE of heating system. If no rating is available then use the method described in the Efficient Space Heating System section for calculating the AFUE. The AFUE of replacement equipment should be used if the heating system

[108] California DEER estimage.
[109] From NWS data for PHL from 2002-2009, HDD63=4033 and HDD62 = 3820

replacement precedes the air sealing work. Use default AFUE of 80% if actual AFUE is not available.

Electric Savings Algorithms

If the type of air conditioning is known, then use the appropriate algorithm below. If the type or existence of air-conditioning is not known, then assume that 83% have air-conditioning and estimate the cooling savings as 83% of a house with central air conditioning.[110]

Reduced furnace fan or boiler circulator pump usage is also likely to occur and provide electricity savings during both the heating and cooling seasons.

Energy Savings

$\Delta kWh = \Delta kWh_{Aux} + \Delta kWh_{Cool}$

$\Delta kWh_{Aux} = \textit{Annual Gas Savings (MMBtu)} \times \textit{Auxiliary}$

ΔkWh_{Cool} = 0 kWh if house has no air conditioning
= ΔkWh_{CAC} if house has central air conditioning
= ΔkWh_{RAC} if house has room air conditioning
= 83% × ΔkWh_{CAC} if no information about air conditioner

$$\Delta kWh_{CAC} = \frac{CDD \times 24\frac{hr}{day} \times DUA}{SEER_{CAC} \times 1000\frac{W}{kW}} \times \left[AREA \times \left(\frac{1}{R_{pre}} - \frac{1}{R_{post}}\right)\right]$$

$$\Delta kWh_{RAC} = \frac{CDD \times 24\frac{hr}{day} \times DUA \times F_{Room\ AC}}{\overline{EER}_{RAC} \times 1000\frac{W}{kW}} \times \left[AREA \times \left(\frac{1}{R_{pre}} - \frac{1}{R_{post}}\right)\right]$$

Demand Savings

ΔkW = 0 kW if house has no air conditioning
= ΔkW_{CAC} if house has central air conditioning
= ΔkW_{RAC} if house has room air conditioning

$$\Delta kW_{CAC} = \frac{\Delta kWh_{CAC}}{EFLH_{cool}} \times CF_{CAC}$$

$$\Delta kW_{RAC} = \frac{\Delta kWh_{RAC}}{EFLH_{cool\ RAC}} \times CF_{RAC}$$

Where:

ΔkWh = gross customer annual kWh savings for the measure.

ΔkW = *gross customer summer load kW savings for the measure.*

Auxiliary = *Heating system auxiliary usage per MMBTU consumption (5.02 From Vermont Technical Reference Manual)*

CDD = *Cooling Degree Days (Degrees F * Days)HDD*

DUA = *Discretionary Use Adjustment to account for the fact that people do not always operate their air conditioning system when the outside temperature is greater than 65F.*

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110 Percentage of houses with air-conditioning from EIA Table AC1.xls for Middle Atlantic region (PA, NY, NJ). From: http://www.eia.doe.gov/emeu/recs/recs2005/hc2005_tables/detailed_tables2005.html

$SEER_{CAC}$ = *Seasonal Energy Efficiency Ratio of existing home central air conditioner (Btu/W•hr) (See table below for default values if actual values are not available)*

$\overline{EER}_{RAC}$ = *Average Energy Efficiency Ratio of existing room air conditioner (Btu/W•hr) (See table below for default values if actual values are not available)*

CF_{CAC} = *Demand Coincidence Factor for central AC systems (See table below)*

CF_{RAC} = *Demand Coincidence Factor for Room AC systems (See table below)*

$EFLH_{cool}$ = *Equivalent Full Load Cooling hours for Central AC and ASHP (See table below)*

$EFLH_{cool\ RAC}$ = *Equivalent Full Load Cooling hours for Room AC (See table below)*

$F_{Room\ AC}$ = *Adjustment factor to relate insulated area to area served by Room AC units*

The default values for each term are shown in the table below.

Default values for algorithm terms, Ceiling/Attic and Wall Insulation

Term	Type	Value	Source
DUA	Fixed	0.75	OH TRM[111]
$SEER_{CAC}$	Variable	Default values: Early Replacement = 10 Replace on Burnout = 13	PUC Technical Reference Manual
		Nameplate	Contractor Data Gathering
$\overline{EER}_{RAC}$	Variable	Default = 9.8	DOE Federal Test Procedure 10 CFR 430, Appendix F (Used in ES Calculator for baseline)
		Nameplate	Contractor Data Gathering
CF_{CAC}	Fixed	0.70	PUC Technical Reference Manual
CF_{RAC}	Fixed	0.58	PUC Technical Reference Manual
$F_{Room,AC}$	Fixed	0.38	Calculated[112]

[111] "State of Ohio Energy Efficiency Technical Reference Manual," prepared for the Public Utilities Commission of Ohio by Vermont Energy Investment Corporation. August 6, 2010.
[112] From PECO baseline study, average home size = 2323 ft², average number of room AC units per home = 2.1. Average Room AC capacity = 10,000 BtuH per ENERGY STAR Room AC Calculator, which serves 425 ft² (average between 400 and 450 ft² for 10,000 BtuH unit per ENERGY STAR Room AC sizing chart). $F_{Room,AC} = (425\ ft^2 * 2.1)/(2323\ ft^2) = 0.38$

EFLH, CDD and HDD by City

City	$EFLH_{cool}$ (Hours)[113]	$EFLH_{cool RAC}$ (Hours)[114]	CDD (Base 65)[115]	HDD (Base 65)[116]
Philadelphia	1032	320	1235	4759

Freeridership/Spillover
Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

Measure	Free Ridership	Spillover
Window	0%	0%

Persistence
The persistence factor is assumed to be one.

Measure Lifetime

Measure	Measure Lifetime
Window	30

Source: NREL Measure Database.

Water Savings
There are no water savings for this measure.

[113] PA 2010 TRM Table 2-1.
[114] PA SWE *Interim Approved TRM Protocol – Residential Room AC Retirement*
[115] Climatography of the United States No. 81. Monthly Station Normals of Temperature, Precipitation, and Heating and Cooling Degree Days 1971-2000, 36 Pennsylvania. NOAA. http://cdo.ncdc.noaa.gov/climatenormals/clim81/PAnorm.pdf
[116] Ibid.

B. Domestic Hot Water End Use

1) Low Flow Showerhead

Unique Measure Code(s): TBD
Draft date: 6/8/11
Effective date: TBD
End date: TBD

Measure Description
This measure relates to the installation of a low flow showerhead in a home. This is a retrofit direct install measure.

Definition of Baseline Condition
The baseline is the flow rate of the showerhead being replaced. If this is not available a baseline value of 2.5 GPM will be used.

Definition of Efficient Condition
The flow rate of the efficient showerhead should be greater than the flow rate of the baseline condition. If this value is not available it is assumed to be 1.5 GPM[117].

Water Savings Algorithms
The water savings for low flow showerheads are due to the reduced amount of water being used per shower.

$$\Delta Gallons = \frac{\left(\frac{GPM_{base} - GPM_{eff}}{GPM_{base}}\right) \times 2.48 \times 11.6 \times 365}{1.6}$$

Where:

$\Delta Gallons$	=	Gallons of water saved
GPM_{base}	=	Maximum gallons per minute of baseline showerhead. Default = 2.5 GPM if measured rate is not available[118]
GPM_{eff}	=	Maximum gallons per minute of the efficient showerhead
2.48	=	Average number of people per household[119]
11.6	=	Average gallons of water per person per day used for showering[120]
365	=	Days per year
1.6	=	Average number of showers per home[121]

Natural Gas Savings Algorithms

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[117] Pennsylvania Public Utility Commission Act 129 Technical Reference Manual (June 2011)
[118] The Energy Policy Act of 1992 established the maximum flow rate for showerheads at 2.5 gallons per minute (GPM)
[119] Pennsylvania, Census of Population, 2000.
[120] Most commonly quoted value of gallons of water used per person per day (including in U.S. Environmental Protection Agency's "water sense" documents; http://www.epa.gov/watersense/docs/home_suppstat508.pdf)
[121] Estimate based on review of a number of studies:

c) Pacific Northwest Laboratory; "Energy Savings from Energy-Efficient Showerheads: REMP Case Study Results, Proposed Evaluation Algorithm, and Program Design Implications" http://www.osti.gov/bridge/purl.cover.jsp;jsessionid=80456EF00AAB94DB204E848BAE65F199?purl=/10185385-CEkZMk/native/
d) East Bay Municipal Utility District; "Water Conservation Market Penetration Study" http://www.ebmud.com/sites/default/files/pdfs/market_penetration_study_0.pdf

Gas energy savings result from avoiding having to heat the saved water due to the efficient showerhead.

$$\Delta MMBtu = \frac{[\Delta Gallons \times 8.3 \times c_p \times (105 - 55)] / 1{,}000{,}000}{RE_{DHW}}$$

Where:

$\Delta MMBtu$	=	MMBtu of saved natural gas
8.3	=	Constant to convert gallons to pounds (lbs)
c_p	=	Average specific heat of water at temperature range (1.00 Btu/lb·°F)
105	=	Assumed temperature of water coming out of showerhead (degrees Fahrenheit)
55	=	Assumed temperature of water entering house (degrees Fahrenheit)[122]
RE_{DHW}	=	Recovery efficiency of the domestic hot water heater = 75%[123]

Electric Savings Algorithms
It is assumed that all low flow showerheads installed under PGW's ELIRP program are installed in homes that heat water using natural gas. There are no additional electric savings claimed.

Freeridership/Spillover
Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes
The measure life of a low flow showerhead is assumed to be 9 years[124].

2) Low Flow Faucet Aerators

Unique Measure Code(s): TBD
Draft date: 6/8/11
Effective date: TBD
End date: TBD

Measure Description
This measure relates to the installation of a low flow faucet aerator in either a kitchen or bathroom.

Definition of Baseline Condition
The baseline is the flow rate of the existing faucet. If this is not available, it is generally assumed that a faucet will already have a standard faucet aerator using 2.2 GPM.

Definition of Efficient Condition
The efficient condition is a faucet aerator that has a flow rate lower than the baseline condition. If this value is not available than the flow rate is assumed to be 1.5 GPM[125].

[122] A good approximation of annual average water main temperature is the average annual ambient air temperature. Average water main temperature = 55° F based on: http://lwf.ncdc.noaa.gov/img/documentlibrary/clim81supp3/tempnormal_hires.jpg
[123] Review of AHRI Directory suggests range of recovery efficiency ratings for new Gas DHW units of 70-87%. The average of existing units is estimated at 75% by the Northeast Energy Efficiency Partnerships' Mid-Atlantic Technical Reference Manual Version 1.1 (October 2010).
[124] Pennsylvania Public Utility Commission Act 129 Technical Reference Manual (June 2011)
[125] Pennsylvania Public Utility Commission Act 129 Technical Reference Manual (June 2011)

Water Savings Algorithms

The water savings for low flow faucet aerators are due to the reduced amount of water being used per minute that flows down the drain (instead of being collected in the sink).

$$\Delta Gallons = \frac{\left(\frac{GPM_{base} - GPM_{eff}}{GPM_{base}}\right) \times 2.48 \times 10.9 \times 365 \times 50\%}{3.5}$$

Where:

$\Delta Gallons$	=	Gallons of water saved
GPM_{base}	=	Gallons per minute of baseline showerhead = 2.2 GMP[126]
GPM_{eff}	=	Gallons per minute of the efficient showerhead
2.48	=	Average number of people per household[127]
10.9	=	Average gallons per day used by faucet[128]
365	=	Days per year
50%	=	Drain rate, the percentage of water flowing down the drain[129]
3.5	=	Average Number of Faucets per home[130]

Natural Gas Savings Algorithms

Gas energy savings result from avoiding having to heat the saved water due to the efficient showerhead.

$$\Delta MMBtu = \frac{[\Delta Gallons \times 8.3 \times c_p \times 25] / 1{,}000{,}000}{RE_{DHW}}$$

Where:

$\Delta MMBtu$	=	MMBtu of saved natural gas
8.3	=	Constant to convert gallons to pounds (lbs)
c_p	=	Average specific heat of water at temperature range (1.00 Btu/lb·°F)
25	=	The difference between the temperature of the water entering the house and the temperature leaving the faucet (degrees Fahrenheit).[131]
RE_{DHW}	=	Recovery efficiency of the domestic hot water heater = 75%[132]

Electric Savings Algorithms

It is assumed that all faucet aerators installed under PGW's ELIRP program are installed in homes that heat water using natural gas. There are no additional electric savings claimed.

Freeridership/Spillover

Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

[126] Public Service Commission of Wisconsin Focus on Energy Evaluation Default Deemed Savings Review, June 2008. http://www.focusonenergy.com/files/Document_Management_System/Evaluation/acesdeemedsavingsreview_evaluationreport.pdf

[127] Pennsylvania, Census of Population, 2000.

[128] Most commonly quoted value of gallons of water used per person per day (including in U.S. Environmental Protection Agency's "water sense" documents; http://www.epa.gov/watersense/docs/home_suppstat508.pdf)

[129] Estimate consistent with Ontario Energy Board, "Measures and Assumptions for Demand Side Management Planning."

[130] East Bay Municipal Utility District; "Water Conservation Market Penetration Study" http://www.ebmud.com/sites/default/files/pdfs/market_penetration_study_0.pdf

[131] Pennsylvania Public Utility Commission Act 129 Technical Reference Manual (June 2011)

[132] See assumption for low flow shower head.

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes
The measure life of a faucet aerator is assumed to be 12 years[133].

3) Efficient Natural Gas Water Heater

Unique Measure Code(s): TBD
Draft date: 6/21/11
Effective date: TBD
End date: TBD

Measure Description
This measure relates to an efficient natural gas water heater.

Definition of Baseline Condition
The baseline is the energy factor (EF) of the existing water heater. If possible, the EF of the existing water heater should be used. If the EF of the existing water heater is unknown, 0.575 should be used[134].

Definition of Efficient Condition
The efficient condition is a natural gas water heater that is more energy efficient than the existing water heater.

Water Savings Algorithms
No water savings have been defined for this measure.

Natural Gas Savings Algorithms
MMBtu savings are realized due to the increase in efficiency factor (EF) of the new equipment. MMBtu savings vary by equipment type due to differences in model specific baseline EF and high efficiency EF percentages. Savings are calculated from the baseline new unit to the installed efficient unit. The following formula for gas savings is based on the DOE test procedure for water heaters.

$$\Delta MMBtu = \frac{\left(\frac{1}{EF_{base}} - \frac{1}{EF_{eff}}\right) \times 41{,}045 \times 365}{1{,}000{,}000}$$

Where:

EF_{base}	=	Energy Factor of baseline water heater
EF_{eff}	=	Energy Factor of efficient water heater. If combi boiler use AFUE.
41,045	=	Factor used in DOE test procedure algorithm
365	=	Days in the year

Electric Savings Algorithms
It is assumed that all faucet aerators installed under PGW's ELIRP program are installed in homes that heat water using natural gas water. There are no additional electric savings claimed.

[133] Pennsylvania Public Utility Commission Act 129 Technical Reference Manual (June 2011)
[134] From Mass Save "Massachusetts Technical Reference Manual for Estimating Savings from Energy Efficiency Measures: 2011 Program Year – Plan Version." October 2010. Page 242.

Freeridership/Spillover
Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes
The measure life of a natural gas water heater is assumed to be 15 years[135].

4) Hot Water Heater Tank Temperature Turn-down

Unique Measure Code(s): TBD
Draft date: 6/21/11
Effective date: TBD
End date: TBD

Measure Description
This measure relates to lowering the thermostat setting on a natural gas hot water heater to 120° F, if the temperature is set higher.

Definition of Baseline Condition
The baseline is the temperature setting of the existing water heater. usually above 135° F

Definition of Efficient Condition
The efficient condition is the new setting point for the hot water heater, 120° F.

Water Savings Algorithms
No water savings have been defined for this measure.

Natural Gas Savings Algorithms
MMBtu savings arise from lower temperature setting that reduces the standby heat losses required to maintain the tanks temperature setting.

$$\Delta MMBtu = \frac{\frac{Area \times (T_{base} - T_{eff})}{R_{DHW}} \times \frac{8{,}760}{1{,}000{,}000}}{RE_{DHW}}$$

Where:

$\Delta MMBtu$	=	MMBtu of saved gas per year
$Area$	=	Surface area of hot water heater (ft^2)
T_{base}	=	Original temperature inside the tank (°F) = Assume 135 °F if no other information provided
T_{eff}	=	New temperature inside the tank (°F) = Assume 120° F if no other information provided
R_{DHW}	=	R-value of the hot water heater (h °F ft^2/Btu) = 5.0[136]
8,760	=	Number of hours in a year

[135] DEER values, updated October 10, 2008
http://www.deeresources.com/deer0911planning/downloads/EUL_Summary_10-1-08.xls
[136] Calculated using the base conductive heat loss co-efficient and surface areas from: *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs* (October 15, 2010). Page 98

RE_{DHW}	=	Recovery efficiency of the domestic hot water heater = 75%[137]
1,000,000	=	Btu to MMBtu

The following table provides surface areas based on the number of gallons the water tank can hold, along with deemed savings values using the assumptions above.

Water Heater Size (Gal)	Height (Inches)*	Diameter (Inches)*	Total Surface Area (ft^2)	Annual Savings (MMBtu)
30	60	16	29.7	1.04
40	61	16.5	31.3	1.10
50	53	18	31.9	1.12
66	58	20	39.0	1.37
80	58	22	44.4	1.56

* *From New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs (October 15, 2010). Page 98*

Electric Savings Algorithms
There are no electric savings associated with this measure.

Freeridership/Spillover
Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes
The measure life of a natural gas water heater is assumed to be 2 years[138].

5) Repair Hot Water Leaks/Plumbing Repairs

Unique Measure Code(s): TBD
Draft date: 6/8/11
Effective date: TBD
End date: TBD

Measure Description
This measure relates to repairing any leaks from hot water pipes.

Definition of Baseline Condition
The baseline condition is the amount of water leaking from the hot water pipe per minute.

Definition of Efficient Condition
The efficient condition is no hot water leaking from the hot water pipe.

[137] See assumption for low flow showerhead.
[138] Page 410. Vermont Technical Reference Manual and New Jersey Clean Energy Program Protocols

Water Savings Algorithms
The water saved is the amount of water that is lost due to the leak. The following table provides the deemed water savings values for the most common types of leaks.

Leak Type	Amount per Minute	Gallons per Day
Slow Steady Drip	100 drips	14.4*
Fast Drip	200 drips	28.8*
Small Stream	1 cup (8 fl oz)	89.28

* *A drip is assumed to be 0.0001 gallons*[139]

Natural Gas Savings Algorithms
Gas savings result from the avoided energy used to heat the water wasted from the leak.

$$\Delta MMBtu = \frac{[\Delta Gallons \times 8.3 \times c_p \times (120 - 55)] / 1{,}000{,}000}{RE_{DHW}}$$

Where:

$\Delta MMBtu$	=	MMBtu of saved natural gas
8.3	=	Constant to convert gallons to pounds (lbs)
c_p	=	Average specific heat of water at temperature range (1.00 Btu/lb·°F)
120	=	Assumed temperature of hot water as it leaves the water heater and travels through the pipes.
55	=	Assumed temperature of water entering house (degrees Fahrenheit)[140]
RE_{DHW}	=	Recovery efficiency of the domestic hot water heater = 75%[141]

The following table provides deemed gas savings values based on the deemed water savings, the algorithm outlined above, and the measure lives from below.

Leak Type	Savings (MMBtu)
Slow Steady Drip	0.87
Fast Drip	0.87
Small Stream	1.35

Electric Savings Algorithms
It is assumed that all leaks repaired are for homes that heat water using natural gas water. There are no additional electric savings claimed.

Freeridership/Spillover
Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

Persistence
The persistence factor is assumed to be one.

[139] Figures provided to North Carolina's Dare County Water Department by the North Carolina Rural Water Association: http://www.darenc.com/water/Othsts/WtrLoss.htm (accessed June 23, 2011)
[140] A good approximation of annual average water main temperature is the average annual ambient air temperature. Average water main temperature = 55° F based on: http://lwf.ncdc.noaa.gov/img/documentlibrary/clim81supp3/tempnormal_hires.jpg
[141] See assumption for low flow showerhead.

Measure Lifetimes
The savings for repairing hot water leaks persist as long as the leak would not have otherwise been fixed. PGW assumes that a smaller leak will persist longer than a larger and more noticeable leak and has adjusted the following measure lifetimes to account for this.

Leak Type	Lifetime
Slow Steady Drip	12 weeks
Fast Drip	6 weeks
Small Stream	3 week

6) DHW Pipe Insulation

Unique Measure Code(s): TBD
Draft date: 7/28/11
Effective date: TBD
End date: TBD

Measure Description
This measure relates to installing insulation on hot water pipes.

Definition of Baseline Condition
The baseline condition is the current insulation thickness on the hot water pipe.

Definition of Efficient Condition
The efficient condition is any insulation thicker than that already on the hot water pipe.

If the diameter of the cold/hot feeds directly to/from the storage tank is 1" or less, a maximum length of three feet for both the cold water inlet and hot water outlet piping above the tank (six total feet) per unit will be included in the savings calculations under the program and should be installed in accordance with best practices.

For each ½" increase in diameter of the hot feed directly from the storage tank beyond 1", an additional 6' length of pipe insulation should be installed along the hot water supply piping only and the additional savings will be credited.

If a DHW recirculating system is present, all hot water supply and return piping accessible without demolition should be insulated and the additional savings will be credited.

The thickness of the DHW pipe insulation should be equivalent to the diameter of the piping. For example, a 1" diameter pipe should be insulated with 1" thick insulation; a 2-1/2" diameter pipe with 2-1/2" thick insulation.[142]

If the hot water piping diameter is in other than a ½" increment, the dimension should be rounded to the next protocol increment.

In the event that the above appears not to cover the specific DHW piping circumstance, suitable pictures and descriptions should be sent to PGW or their implementation contractor for judgment.

Water Savings Algorithms
This measure has no water savings associated with it.

Natural Gas Savings Algorithms

[142] Recommendation based on method pioneered by Gary Klein expert on DHW based in California

$$Annual\ Gas\ Savings\ (MMBtu) = Length \times \frac{\left(HeatLoss(Th_{base}) - HeatLoss(Th_{eff})\right)}{RE_{DHW} \times 1{,}000{,}000}$$

Where:

Length	=	Number of linear feet of steam pipe insulated
Th_{base}	=	Thickness of base condition insulation (inches)
Th_{Eff}	=	Thickness of efficient condition insulation (inches)
HeatLoss(x)	=	Heat loss through hot water pipe as a function of insulation thickness x (Btu/ft /yr)
RE_{DHW}	=	Recovery efficiency of the hot water heater = 75%[143]

"HeatLoss(x)" can be found using the following lookup table.

Insulation Thickness (inches)	**Heat Loss (Btu/ft/yr)**
Bare	268,231
0.5	86,461
1.0	65,350
1.5	51,421
2.0	44,851
2.5	38,544
3.0	36,004
3.5	33,989
4.0	32,412
4.5	30,923
5.0	29,872

This table was calculated using the North American Insulation Manufacturers Association's (NAIMA) 3E Plus 4.0 Insulation Thickness Computer Program. The following assumptions were used.

Item Description	=	dhw pipe insulation
System Application	=	Pipe - Horizontal
Dimensional Standard	=	*ASTM C 585 Rigid*
Calculation Type	=	Heat Loss Per Hour Report
Process Temperature	=	120
Ambient Temperature	=	60
Wind Speed	=	0
Nominal Pipe Size	=	0.75
Bare Metal	=	Copper
Bare Surface Emittance	=	0.6
Insulation Layer 1	=	Polystyrene PIPE, Type XIII, C578-11b
Outer Jacket Material	=	All Service Jacket

[143] See assumption for low flow showerhead.

Outer Surface Emittance = 0.9

Electric Savings Algorithms
There are no electric savings associated with this measure.

Freeridership/Spillover
Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes
The measure life is assumed to be 20 years[144].

Measure Cost
The measure cost is the actual cost of installing the insulation, both materials and labor.

O&M Cost Adjustments
It is assumed that there are no O&M cost differences between the efficient and baseline equipment.

7) Hot Water Storage Tank Wrap

Unique Measure Code(s): TBD
Draft date: 6/8/11
Effective date: TBD
End date: TBD

Measure Description
This measure refers to an insulating "blanket" that is wrapped around the outside of a hot water tank to reduce stand-by losses. The tank wrap must follow BPI technical standards:

> "Water heater insulation wraps shall not cover the top of oil or gas systems, and shall not obstruct the pressure relief valve, thermostats, hi-limit switch, plumbing pipes, or access plates. A minimum 2-inch clearance is required from the access door for gas burners.
>
> Water heater insulation wraps shall not be installed where forbidden by the manufacturer's instructions found on the nameplate."[145]

Definition of Baseline Condition
The baseline is the hot water heater tank without the insulating blanket.

Definition of Efficient Condition
The efficient condition is the hot water heater tank with the insulating blanket.

Water Savings Algorithms
There are no water savings due to this measure.

Natural Gas Savings Algorithms
Gas energy savings result from the reduction in standby losses.

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[144] NYSERDA Home Performance with Energy Star
[145] Building Performance Institute, Inc. *Technical Standards for the Heating Professional.* Revised 11/20/07. Page 12.

$$\Delta MMBtu = \frac{\left(\frac{1}{R_{base}} - \frac{1}{R_{eff}}\right) \times Area \times (T_{tank} - T_{amb}) \times \frac{8,760}{1,000,000}}{RE_{DHW}}$$

Where:

$\Delta MMBtu$	=	MMBtu of saved gas per year
R_{eff}	=	R-value of the hot water heater with the insulating blanket (h °F ft²/Btu)
R_{base}	=	Original R-value of the hot water heater (h °F ft²/Btu) = 5.0[146] unless other information provided
Area	=	Surface area of the hot water heater covered by the insulating blanket (ft²)
T_{tank}	=	Temperature inside the tank (°F) = Assume 120 °F if no other information provided
T_{amb}	=	Temperature outside the tank (°F) = 55 °F[147]
8,760	=	Number of hours in a year
RE_{DHW}	=	Recovery efficiency of the domestic hot water heater = 75%[148]
1,000,000	=	Btu to MMBtu

The following table provides assumed insulated surface areas and corresponding deemed savings values for standard tank insulation blankest

Water Heater Size (Gal)	Height (Inches)*	Diameter (Inches)*	Surface Area of Cylinder (ft²)	Surface Area of Accessed Areas (ft²)**	Surface are of Cylinder minus Accessed Areas (ft²)	R-10 Wrap Annual Savings (MMBtu)	R-19 Wrap Annual Savings (MMBtu)
30	60	16	20.9	0.4	20.5	1.6	2.3
40	61	16.5	22.0	0.4	21.5	1.6	2.4
50	53	18	20.8	0.4	20.4	1.5	2.3
66	58	20	25.3	0.4	24.9	1.9	2.8
80	58	22	27.8	0.4	27.4	2.1	3.1

** From New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs (October 15, 2010). Page 98*

*** Assuming square access area with 4" square and 2" clearance on each side*

Electric Savings Algorithms

This measure is assumed to be installed only on a natural gas fired hot water heating systems, so there are no electric savings associated with this measure.

Freeridership/Spillover

Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

Persistence

The persistence factor is assumed to be one.

Measure Lifetimes

The measure life is assumed to be 5 years[149].

[146] Calculated using the base conductive heat loss co-efficient and surface areas from: *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs* (October 15, 2010). Page 98

[147] Assumed to be in unconditioned space, ambient temperature assumption based on: http://lwf.ncdc.noaa.gov/img/documentlibrary/clim81supp3/tempnormal_hires.jpg

[148] See assumption for low flow showerhead.

V. Non-Residential Time of Replacement Market

A. Space Heating End Use

1) Efficient Space Heating System

Unique Measure Code(s): TBD
Draft date: 4/27/12
Effective date: TBD
End date: TBD

Measure Description
This measure applies to non-residential-sized (≥300MBH) gas boilers purchased at the time of natural replacement. A qualifying boiler must meet minimum efficiency requirements (Thermal Efficiency).

Definition of Baseline Condition
The efficiency levels of the gas-fired boilers that would have been purchased absent this or another DSM program are shown in the following table.

Equipment Type	Baseline Thermal Efficiency
Gas Boiler	80%

Definition of Efficient Condition
The installed gas boiler must have a Thermal Efficiency greater than that shown in the table below. Efficient model minimum Thermal Efficiency requirements are detailed below.

Equipment Type	Minimum Thermal Efficiency
Gas Boiler Tier 1	90%
Gas Boiler Tier 2	85%

Gas Savings Algorithms
MMBtu savings are realized due to the increase in Thermal Efficiency of the new equipment. MMBtu savings vary by equipment type due to differences in model capacity and Thermal Efficiency percentages. Savings are calculated from the baseline new unit to the installed efficient unit.

$$Annual\ Gas\ Savings\ (MMBtu) = \frac{Capacity_{Out}}{1{,}000} \times \left(\frac{1}{TE_{Base}} - \frac{1}{TE_{Eff}}\right) \times EFLH_{Heat}$$

Where:

[149] Northeast Energy Efficiency Partnerships. *Mid-Atlantic Technical Reference Manual (Version 1.1)*. October 2010

$Capacity_{Out}$	= Output capacity of equipment to be installed (kBtu/hr)
1,000	= *Conversion from kBtu to MMBtu*
TE_{Base}	= Thermal Efficiency of new baseline equipment
TE_{Eff}	= Thermal Efficiency of new equipment
$EFLH_{Heat}$	= Equivalent Full Load Heating Hours
HDD	= Base 63° F Heating Degree Days for Philadelphia = 4,033[150]
Dt	= Design temperature difference (assume from 0° F to 70° F)

Equivalent Full Load Heating Hours by Building Type

Building Type	EFLH[151]
Multifamily	1435
Education	1529
Food Sales	1846
Food Service	2021
Health Care	2779
Lodging	778
Retail	1519
Office	1457
Public Assembly	1752
Public Order/Safety	1250
Religious Worship	1509
Service	2478
Warehouse/Storage	1047

Electric Savings Algorithms

Not applicable.

Freeridership/Spillover

Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

Equipment Type	Free Ridership	Spillover
Gas Boiler	0%	0%

Persistence

The persistence factor is assumed to be one.

Measure Lifetimes

Equipment Type	*Measure Lifetime*

[150] Based on NCDC ASOS temperature data for PHL from 2002 through 2009.

[151] From NJ Protocols for Philadelphia, adjusted for the PGW evaluation. The evaluation estimated realization rates using 3 methods and found savings to be 317%, 166% and 169%. PGW adjusted the EFLH based on the two lowest realization rates and adjusted the NJ Protocols EFLH by 168%.

Gas Boilers	25

Source: Consortium for Energy Efficiency, High Efficiency Commercial Boiler Systems Initiative Description, May 16, 2011, p. 17. *Lifetimes range from 24-35 years.*

Water Savings
There are no water savings for this measure.

2) Steam Trap

Unique Measure Code(s): TBD
Draft date: *5/28/15*
Effective date: TBD
End date: TBD

Measure Description
This measure applies to replacing non-residential steam traps on heating systems or repair of the steam trap by replacing the internal working parts with a new insert.

Definition of Baseline Condition
The baseline criterion is a faulty steam trap in need of replacing. No minimum leak rate is required. Any leaking or blow through trap can be repaired or replaced. If a customer chooses to repair or replace all the steam traps at the facility without verification, the savings are adjusted. Savings for full replacement projects are reduced by the percentage of traps found to be leaking on average from the studies listed. If an audit is performed on a site, then the leaking and blowdown can be adjusted.

Definition of Efficient Condition
Customers must have leaking traps to qualify. However, if a customer opts to replace all traps without inspection, the savings are discounted to take into consideration the fact that some traps are being replaced that have not yet failed. This measure may consist of either installation of a whole new steam trap or replacement of the internal working parts with an insert.

Gas Savings Algorithms

$$\Delta MMBtu = S \times \left(\frac{Hv}{B}\right) \times Hr \times A \times L\,/1{,}000{,}000$$

Where:

$\Delta MMBtu$	=	MMBtu of saved gas per year
S	=	Maximum theoretical steam loss per trap (lb/hr/trap). See table of values.
Hv	=	Heat of vaporization of steam, (Btu/lb). See table of values.
B	=	Boiler efficiency, (%)
Hr	=	Annual operating hours of steam plant. See table of values.
A	=	Adjustment factor to account for reducing the maximum theoretical steam flow (S) to the average steam flow (the Enbridge factor).
L	=	Leaking and blow-thru factor. If the steam trap has been audited and is known to be leaking, then this factor is 100%, if unaudited and *unknown if leaking, then see table of values below.*

1,000,000 = Btu to MMBtu

Steam Trap Algorithm Input Values

Steam Trap Application and Pressure	Avg Steam Loss, S (lb/hr/trap) [152]	Heat of Vaporization Hv (Btu/lb) [153]	Default Boiler Efficiency B [154]	Operating Hours, H [155]	Adjustment Factor, A [156]	Leaking & Blow-thru factor for unaudited traps, L [157]
Commercial/Multifamily, low pressure	13.8	951	80%	2,720	50%	27%
Dry Cleaners	38.1	890	80%	2,425	50%	27%
Industrial Low Pressure PSIG<15	13.8	951	80%	7,752	50%	16%
Industrial Medium Pressure 15<PSIG<30	12.7	945	80%	7,752	50%	16%
Industrial Medium Pressure 30<PSIG<75	19	928	80%	7,752	50%	16%
Industrial High Pressure 75<PSIG<125	67.9	894	80%	7,752	50%	16%
Industrial High Pressure 125<PSIG<175	105.8	868	80%	7,752	50%	16%
Industrial High Pressure 175<PSIG<250	143.7	846	80%	7,752	50%	16%
Industrial High Pressure PSIG>250	200.5	820	80%	7,752	50%	16%

Electric Savings Algorithms

Not applicable.

Freeridership/Spillover

Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

Equipment Type	Free Ridership	Spillover

[152] Resource Solutions Group "Steam Traps Revision #1" dated August 2011.

[153] Heat of vaporization of steam at the inlet pressure to the steam trap. Implicit assumption that the average boiler nominal pressure where the vaporization occurs, is essentially that same pressure. Reference Resource Solutions Group "Steam Traps Revision #1" dated August 2011.

[154] California Energy Commission Efficiency Data for Steam Boilers as sited in Resource Solutions Group "Steam Traps Revision #1" dated August 2011.

[155] Resource Solutions Group "Steam Traps Revision #1" dated August 2011, which references Enbridge service territory data and kW Engineering study. Commercial/Multifamily hours adjusted to Philadelphia based on the HDD in Philadelphia relative to Chicago.

[156] Enbridge adjustment factor used as referenced in Resource Solutions Group "Steam Traps Revision #1" dated August 2011 and DOE Federal Energy Management Program Steam Trap Performance Assessment.

[157] Dry cleaners survey data as referenced in Resource Solutions Group "Steam Traps Revision #1" dated August 2011. If trap is known to be leaking, then this factor is 100%.

Steam Traps	0%	0%

Persistence
The persistence factor is assumed to be one.

Measure Lifetime
6 years[158]

Water Savings
There may be water savings for this measure, but the amount has not been calculated.

B.Commercial Kitchen End Uses

1) Commercial Convection Ovens

Unique Measure Code(s): TBD
Draft date: 4/30/12
Effective date: TBD
End date: TBD

Measure Description
A general-purpose chamber designed for heating, roasting, or baking food by forcing hot dry air over the surface of the food product. The rapidly moving hot air strips away the layer of cooler air next to the food and enables the food to absorb the heat energy. For the purposes of this specification, convection ovens do not include ovens that have the ability to heat the cooking cavity with saturated or superheated steam. Maximum water consumption within the oven cavity must not exceed 0.25 gallons/hour. Ovens that include a hold feature are eligible under this specification as long as convection is the only method used to fully cook the food.

- Full-Size Convection Oven: A convection oven that is able to accept a minimum of five standard full-size sheet pans measuring 18 x 26 x 1-inch.

This does not cover ovens designed for residential or laboratory applications; hybrid ovens, such as those incorporating steam and/or microwave settings in addition to convection; other oven types, as defined in Section 1, *including combination, conventional or standard, conveyor, slow cook-and-hold, deck, mini-rack, rack, range, rapid* cook, and rotisserie ovens.

Definition of Baseline Condition
Cooking energy efficiency of 44% and Idle Energy Rate of 15,100 Btu/h[159].

Definition of Efficient Condition
Cooking energy efficiency greater than or equal to 46%[160] and an Idle Energy Rate less than or equal to 12,000 Btu/h

[158] Source paper is the Resource Solutions Group "Steam Traps Revision #1" dated August 2011. Primary studies used to prepare the source paper include Enbridge Steam Trap Survey, KW Engineering Steam Trap Survey, Enbridge Steam Saver Program 2005, Armstrong Steam Trap Survey, DOE Federal Energy Management Program Steam Trap Performance Assessment, Oak Ridge National Laboratory Steam System Survey Guide, KEMA Evaluation of PG&E's Steam Trap Program, Sept. 2007. Communication with vendors suggested a inverted bucket steam trap life typically in the range of 5 - 7 years, float and thermostatic traps 4- 6 years, float and thermodynamic disc traps of 1 - 3 years.
[159] ENERGY STAR calculator default input.

Additional criteria:

1) Must be full-size (for gas)
2) Have been installed in compliance with manufacturer instructions and meeting all applicable local, State, and Federal codes and standards;
3) *Are third-party certified to:*
    a. NSF/ANSI Standard 4, Commercial Cooking, Rethermalization and Powered Hot Food Holding and Transport Equipment
    b. ANSI/UL 197, Commercial Electrical Cooking Appliances (electric ovens only)
    c. ANSI Z83.11, Gas Food Service Equipment (gas ovens only)

All criteria are the same as the ENERGY STAR label.

Gas Savings Algorithms

The following shows the expected gas savings from a full-size commercial convection oven meeting the above specifications. These savings come from the Energy Star calculator.[161]

$$Annual\ Gas\ Savings\ (MMBtu) = 12.90\ MMBtu$$

Electric Savings Algorithms

There are no electric savings from this measure.

Energy Savings

$\Delta kWh = 0\ kWh$

Demand Savings

$\Delta kW = 0\ kW$

Where:

ΔkWh = gross customer annual kWh savings for the measure.

ΔkW = gross customer summer load kW savings for the measure.

Freeridership/Spillover

Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

Equipment Type	Free Ridership	Spillover
Commercial Convection Oven	0%	0%

Persistence

The persistence factor is assumed to be one.

Measure Lifetimes

[160] Using ASTM Standard F1496-99 (Reapproved 2005) based on heavy load (potato) cooking test.

[161] http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COO

Equipment Type	Measure Lifetime
Commercial Convection Oven	12

Sources: CA DEER, MA 2011 TRM, ENERGY STAR.

Water Savings
There are no water savings for this measure.

2) Commercial Gas Fryer

Unique Measure Code(s): TBD
Draft date: 4/30/12
Effective date: TBD
End date: TBD

Measure Description
An appliance, including a cooking vessel, in which oil is placed to such a depth that the cooking food is essentially supported by displacement of the cooking fluid rather than by the bottom of the vessel. Heat is delivered to the cooking fluid by heat transfer from gas burners through either the walls of the fryer or through tubes passing through the cooking fluid.

- Standard Fryer: A fryer with a vat that measures >12 inches and < 18 inches wide, and a shortening capacity > 25 pounds and < 65 pounds.
- Large Vat Fryer: A fryer with a vat that measures > 18 inches and < 24 inches wide, and a shortening capacity > 50 pounds.

Definition of Baseline Condition
Heavy Load (French Fry) Cooking Energy Efficiency of 35%.
Idlle energy rate:

- 14,000 Btu/h for Standard Fryer
- 16,000 Btu/h for Large Vat Fryer

Definition of Efficient Condition
Heavy Load (French Fry) Cooking Energy Efficiency greater than or equal to 50%.
Idle energy rate less than or equal to:

- 9,000 Btu/h for Standard Fryer
- 12,000 Btu/h for Large Vat Fryer

All criteria are the same as the ENERGY STAR label.

Gas Savings Algorithms
The following shows the expected gas savings from Energy Star commercial fryers meeting the above specifications. These savings come from the Energy Star calculator.[162]

Standard Fryer (per frypot):

$$Annual\ Gas\ Savings\ (MMBtu) = 50.80\ MMBtu$$

[162] http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COO

Large Vat Fryer (per frypot):

$$Annual\ Gas\ Savings\ (MMBtu) = 79.50\ MMBtu$$

Electric Savings Algorithms

There are no electric savings from this measure.

Energy Savings
ΔkWh = 0 kWh

Demand Savings
ΔkW = 0 kW

Where:

ΔkWh = gross customer annual kWh savings for the measure.
ΔkW = gross customer summer load kW savings for the measure.

Freeridership/Spillover
Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

Equipment Type	Free Ridership	Spillover
Commercial Fryer	0%	0%

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes

Equipment Type	Measure Lifetime
Commercial Fryer	12

Sources: CA DEER, MA 2011 TRM, ENERGY STAR.

Water Savings
There are no water savings for this measure.

3) Commercial Gas Steamers (Cooking)

Unique Measure Code(s): TBD
Draft date: 4/30/12
Effective date: TBD
End date: TBD

Measure Description
Also referred to as a "compartment steamer," a device with one or more food steaming compartments in which the energy in the steam is transferred to the food by direct contact. Models may include countertop models, wall-mounted models and floor-models mounted on a stand, pedestal or cabinet-style base.

Definition of Baseline Condition
Cooking energy efficiency of 18% and Idle Energy Rate of 3,000 Btu/h per pan[163].

Definition of Efficient Condition
Cooking energy efficiency greater than or equal to 38% and an Idle Energy Rates less than the maximum values in the table below.

# of Pans	Cooking Efficiency	Idle Rate (Btu/hr)
3 pans	38%	6,250
4 pans	38%	8,350
5 pans	38%	10,400
6 + pans	38%	12,500

All criteria are the same as the ENERGY STAR label.

Gas Savings Algorithms
The following shows the expected gas savings from a commercial steam cooker meeting the above specifications. These savings come from the Energy Star calculator.[164]

# of Pans	Annual Gas Savings (MMBtu)
3 pans	76.6
4 pans	86.4
5 pans	96.2
6 pans	105.4
7 + pans	105.4+ 14.2 per pan > 6 pans

Electric Savings Algorithms

There are no electric savings from this measure.

Energy Savings
$\Delta kWh = 0\ kWh$

Demand Savings

[163] The baseline comes from PG&E's online calculator at
http://www.fishnick.com/saveenergy/tools/calculators/gsteamercalc.php

[164] http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COO
4 pan is interpolated between 3 and 5 pan.

$\Delta kW = 0\ kW$

Where:

ΔkWh = gross customer annual kWh savings for the measure.

ΔkW = gross customer summer load kW savings for the measure.

Freeridership/Spillover

Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

Equipment Type	Free Ridership	Spillover
Commercial Steam Cooker	0%	0%

Persistence

The persistence factor is assumed to be one.

Measure Lifetimes

Equipment Type	Measure Lifetime
Commercial Steam Cooker	12

Sources: CA DEER, MA 2011 TRM, ENERGY STAR.

Water Savings

According to the Energy Star calculator the water savings would be 162,060 gallons per year for an Energy Star steamer compared to a baseline steamer.

4) Commercial Gas Griddle

Unique Measure Code(s): TBD
Draft date: 4/30/12
Effective date: TBD
End date: TBD

Measure Description

Single or double sided gas griddle.

Definition of Baseline Condition

Cooking energy efficiency of 32% and Normalized Idle Energy Rate of 3,500 Btu/h per square foot[165].

Definition of Efficient Condition

Cooking energy efficiency greater than or equal to 38% and a Normalized Idle Energy Rate less than or equal to 2,650 Btu/h per square foot.

All criteria are the same as the ENERGY STAR label.

[165] From the Energy Star calculator

Gas Savings Algorithms
The following shows the expected gas savings from a commercial gas griddle meeting the above specifications. These savings come from the Energy Star calculator.[166]

$$Annual\ Gas\ Savings\ (MMBtu) = 13.10\ MMBtu$$

Electric Savings Algorithms

There are no electric savings from this measure.

Energy Savings
$\Delta kWh = 0\ kWh$

Demand Savings
$\Delta kW = 0\ kW$

Where:

ΔkWh = gross customer annual kWh savings for the measure.
ΔkW = gross customer summer load kW savings for the measure.

Freeridership/Spillover
Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

Equipment Type	Free Ridership	Spillover
Commercial Gas Griddle	0%	0%

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes

Equipment Type	*Measure Lifetime*
Commercial Gas Griddle	12

Sources: CA DEER, MA 2011 TRM, ENERGY STAR.

Water Savings
There are no water savings for this measure.

[166] http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COO

5) Pre-rinse Spray Valve

Unique Measure Code(s): TBD
Draft date: 4/30/12
Effective date: TBD
End date: TBD

Measure Description
Commercial dishwasher pre-rinse spray valves use hot water under pressure to clean food items off plates, flatware, and other kitchen items before they are placed into a commercial dishwasher. Pre-rinse valves are handheld devices, consisting of a spray nozzle, a squeeze lever that controls the water flow, and a dish guard bumper. Often they include a spray handle clip, allowing the user to lock the lever in the full spray position for continual use. The pre-rinse valve is part of the pre-rinse unit assembly that typically includes an insulated handle, a spring supported metal hose, a wall bracket, and dual faucet valves. Pre-rinse valves are inexpensive and frequently interchangeable within different manufacturers' hose assemblies. They are usually placed at the entrance to a dishwasher and can also be located over a sink, used in conjunction with a faucet fixture.

Definition of Baseline Condition
The baseline is a standard pre-rinse spray valve using approximately 1.6 gpm.

Definition of Efficient Condition
An efficient pre-rinse spray valve uses an average of 1.28 gpm.

Gas Savings Algorithms
The following shows the expected gas savings from an energy efficient pre-rinse spray valve meeting the above specifications.[167]

$$Annual\ Gas\ Savings\ (MMBtu) = 6.38\ MMBtu$$

Electric Savings Algorithms

There are no electric savings from this measure.

Energy Savings
ΔkWh = 0 kWh

Demand Savings
ΔkW = 0 kW

Where:

ΔkWh = gross customer annual kWh savings for the measure.
ΔkW = gross customer summer load kW savings for the measure.

Freeridership/Spillover
Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

Equipment Type	Free Ridership	Spillover
Pre-rinse Spray Valve	0%	0%

[167] ENERGY STAR calculator 4/14.

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes

Equipment Type	Measure Lifetime
Pre-rinse Spray Valve	5[168]

Water Savings
Expected water savings would be 62,305 gallons per year.[169]

C.Commercial Domestic Hot Water End Use

1) Commercial Domestic Hot Water Heater

Unique Measure Code(s): TBD
Draft date: 5/28/15
Effective date: TBD
End date: TBD

Measure Description
Installation of high-efficiency, gas-fired, storage-type or tankless, domestic hot water heaters greater than 75,000 Btu/hr.

Definition of Baseline Condition
Base case heater is a code-compliant storage gas heater as specified in ASHRAE 90.1-2007.

Definition of Efficient Condition
The efficient heater is a storage or tankless gas heater with equal to or exceeding 94% thermal efficiency.

Gas Savings Algorithms
If multiple heaters are used, they are treated as a single unit, with system input capacity and standby loss rate equal to the sum of all units.

$$\Delta MMBtu = BaselineUse - EfficientUse$$

For commercial buildings other than multifamily:
The maximum of:

$$BaselineUse = A \times E_b$$

or

$$BaselineUse = \frac{SLR_b \times 8760}{10^6}$$

[168] Massachusetts 2011 Technical Reference Manual.
[169] Massachusetts 2011 Technical Reference Manual.

For multifamily buildings:
The maximum of:

$$BaselineUse = U \times E_b$$
or
$$BaselineUse = \frac{SLR_b \times 8760}{10^6}$$

All building types:

$$EfficientUse = \left(BaselineUse - 8760 \times \frac{(SLR_b - SLR_e)}{10^6} \times \eta_b \right) \times \frac{\eta_b}{\eta_e}$$

$$SLR_b = CAP_{H,b} \times \frac{1000}{800} + 110 \times \sqrt{CAP_{W,b}}$$ [170]

$$CAP_{H,b} = CAP_{H,e} \times \frac{\eta_e}{\eta_b}$$

Where:

$\Delta MMBtu$	=	MMBtu of saved gas per year
$BaselineUse$	=	Baseline DHW gas usage (MMBtu)
$EfficientUse$	=	Efficient DHW gas usage (MMBtu)
A	=	Building floor area (ft^2), input
E_b	=	For commercial buildings other than multifamily this is the annual baseline gas energy usage rate per building ft^2 ($MMBtu/ft^2/yr$). For multifamily this is the annual baseline gas energy usage rate per apartment unit (MMBtu/unit/yr). See table of values by building type.
U	=	Number of apartment units in multifamily building, input.
ΔT	=	Differential temperature rise (75°F)
SLR_e	=	Proposed efficient water heater standby loss rate (Btu/hr), input. Equal to zero if tankless. If unavailable, assume the same as SLR_b
η_e	=	Thermal efficiency of proposed efficient water heater (%)
η_b	=	Thermal efficiency of baseline water heater (80%)[171]
$CAP_{H,e}$	=	Heat Input capacity of proposed efficient water heater (MBh, 1000 Btu/hr), input
$CAP_{W,e}$	=	Water Storage capacity of proposed efficient water heater (gal), input
$CAP_{H,b}$	=	Heat Input capacity of baseline water heater (MBh)
SLR_b	=	Baseline water heater standby loss rate (Btu/hr)

Annual Baseline Gas Usage Rate by Building Type

[170] ASHRAE 90.1-2007, Table 7.8.
[171] ASHRAE 90.1-2007, Table 7.8.

Building Type	Annual Baseline Gas Usage Rate, E_b (MMBtu/ft2/yr)[172]
Education	0.00525
Grocery/Convenience Store	0.00319
Restaurant/Cafeteria	0.03996
Inpatient Health Care	0.03935
Outpatient Health Care	0.00350
Lodging	0.02915
Retail (other than in mall)	0.00103
Retail (in mall)	0.00309
Office	0.00165
Police/Fire Station/Jail	0.01514
Other	0.00165
	Annual Baseline Gas Usage Rate, E_b (MMBtu/unit/yr)[173]
Multifamily	22.5

Electric Savings Algorithms

There are no electric savings from this measure.

Energy Savings
$\Delta kWh = 0\ kWh$

Demand Savings
$\Delta kW = 0\ kW$

Where:

ΔkWh = gross customer annual kWh savings for the measure.
ΔkW = gross customer summer load kW savings for the measure.

Freeridership/Spillover
Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

Equipment Type	Free Ridership	Spillover
Commercial DHW Heater	0%	0%

[172] U.S. Energy Information Administration Table E8A. Natural Gas Consumption and Energy Intensities by End Use for All Buildings, 2003.
[173] GDS Associates, Inc. (2009). Natural Gas Energy Efficiency Potential in Massachusetts. Prepared for GasNetworks.

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes

Equipment Type	Measure Lifetime
Commercial DHW Heater	12

Sources: CA DEER, MA 2011 TRM, ENERGY STAR.

Water Savings
There are no water savings for this measure.

D.All End Uses

1) Custom Measure

Unique Measure Code(s): TBD
Draft date: 7/22/13
Effective date: TBD
End date: TBD

Measure Description
This measure applies to all custom measures, not otherwise specified in this TRM.

Definition of Baseline Condition
The baseline represents the typical equipment that is installed without a DSM program. The efficiency level is based on the current Federal standards, or state and local building codes that are applicable.

Definition of Efficient Condition
The efficient measure is any equipment that uses less energy than the baseline equipment.

Gas Savings Algorithms
The generalized equation for a custom measure compares the baseline usage to the efficient usage.

$$Annual\ Gas\ Savings\ (MMBtu) = BaselineUse - EfficientUse$$

Where:

$BaselineUse$ = The gas usage of baseline equipment or building.

$EfficientUse$ = The gas usage of efficient equipment or building.

Electric Savings Algorithms

Energy Savings

$\Delta kWh = BaselinekWh - EfficientkWh$

Demand Savings

$\Delta kW = BaselinekW - EfficientkW$

Where:

ΔkWh	=	Gross customer annual kWh savings for the measure.
ΔkW	=	Gross customer summer load kW savings for the measure.
BaselinekWh	=	The electric kWh usage of baseline equipment or building.
EfficientkWh	=	The electric kWh usage of efficient equipment or building.
BaselinekW	=	The electric kW usage of baseline equipment or building.
EfficientkW	=	The electric kW usage of efficient equipment or building.

Freeridership/Spillover

Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

Equipment Type	Free Ridership	Spillover
Custom Measure	0%	0%

Persistence

The persistence factor is assumed to be one.

Measure Lifetimes

Where available, custom measure lifetimes should be based on similar measures defined elsewhere in this TRM.

Water Savings

The water savings are the difference between the baseline and efficient equipment annual water usage in gallons.

VI. Non-Residential New Construction

A.All End Uses

1) Custom Measures

Unique Measure Code(s): TBD
Draft date: 4/30/12
Effective date: TBD
End date: TBD

Measure Description
This measure applies to all custom measures, not otherwise specified in this TRM.

Definition of Baseline Condition
The baseline represents the typical equipment that is installed without a DSM program. The efficiency level is based on the current Federal standards, or state and local building codes that are applicable.

Definition of Efficient Condition
The efficient measure is any equipment that uses less energy than the baseline equipment.

Gas Savings Algorithms
The generalized equation for a custom measure compares the baseline usage to the efficient usage.

$$Annual\ Gas\ Savings\ (MMBtu) = BaselineUse - EfficientUse$$

Where:

BaselineUse = The gas usage of baseline equipment or building.

EfficientUse = The gas usage of efficient equipment or building.

Electric Savings Algorithms

Energy Savings
ΔkWh = *BaselinekWh* - *EfficientkWh*

Demand Savings
ΔkW = *BaselinekW* - *EfficientkW*

Where:

ΔkWh = Gross customer annual kWh savings for the measure.

ΔkW = Gross customer summer load kW savings for the measure.

BaselinekWh = The electric kWh usage of baseline equipment or building.

EfficientkWh = The electric kWh usage of efficient equipment or building.

BaselinekW = The electric kW usage of baseline equipment or building.

EfficientkW = The electric kW usage of efficient equipment or building.

Freeridership/Spillover
Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

Equipment Type	Free Ridership	Spillover
Custom Measure	0%	0%

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes
Where available, custom measure lifetimes should be based on similar measures defined elsewhere in this TRM.

Water Savings
The water savings are the difference between the baseline and efficient equipment annual water usage in gallons.

VII. Non-Residential Retrofit

A. Space Heating End Use

1) Efficient Space Heating System

Unique Measure Code(s): TBD
Draft date: 5/6/14
Effective date: TBD
End date: TBD

Measure Description
This measure applies to high-efficiency gas furnaces and boilers replacing an existing and functioning furnace or boiler of lower efficiency and possibly different capacity.

Definition of Baseline Condition
The baseline represents the existing equipment that is currently installed. The efficiency level and capacity are based on measurements or nameplate information.

Definition of Efficient Condition
The efficient measure is any equipment that uses less energy than the baseline equipment.

Gas Savings Algorithms
The following equation accounts for differences between the baseline and efficient space heating equipment efficiencies and capacities.

$$Annual\ Gas\ Savings\ (MMBtu) = \frac{Capacity_{base}}{1{,}000} \times \left[\frac{1}{AFUE_{base}} - \frac{SR \times (1 + A_{avg})}{AFUE_{eff}}\right] \times EFLH_{Heat,base}$$

$$SR = \frac{Capacity_{eff}}{Capacity_{base}}$$

$$EFLH_{Heat,base} = \frac{Annual\ Gas\ Use_{base} \times AFUE_{base}}{Capacity_{base}}$$

Where:

$Annual\ Gas\ Savings\ (MMBtu)$	=	The annual gas savings of the efficient space heating equipment compared to the existing equipment.
$Capacity_{base}$	=	The existing space heating equipment output capacity (MBH)
$AFUE_{base}$	=	Efficiency of existing space heating equipment (Annual Fuel Utilization Efficiency)
SR	=	Sizing ratio of new efficient relative to the existing baseline equipment (See algorithm above).
A_{avg}	=	Runtime percent change adjustment. See table of values below based on SR value.[174]

[174] Developed by Practical Energy Solutions using simulation modeling.

$AFUE_{eff}$ = Efficiency of proposed efficient space heating equipment (Annual Fuel Utilization Efficiency)

$EFLH_{Heat;base}$ = Equivalent full load heating hours for existing baseline equipment (See algorithm above).

$Capacity_{eff}$ = The proposed efficient space heating equipment output capacity (MBH)

$Annual\ Gas\ Use_{base}$ = The annual gas usage of the existing space heating equipment, based on weather-normalized gas bills (kBtu).

Sizing Ratio (SR)	**Run Time Adjustment (A_{avg})**
50%	78%
55%	65%
60%	54%
65%	45%
70%	36%
75%	28%
80%	21%
85%	15%
90%	10%
95%	5%
100%	0%
105%	-4%
110%	-8%
115%	-12%
120%	-15%
125%	-18%
130%	-21%
135%	-23%
140%	-26%
145%	-28%
150%	-30%
155%	-32%
160%	-34%
165%	-36%
170%	-37%
175%	-39%
180%	-40%
185%	-42%
190%	-43%
195%	-44%
200%	-46%

Electric Savings Algorithms

Energy Savings

ΔkWh = *BaselinekWh - EfficientkWh*

Demand Savings

$\Delta kW = BaselinekW - EfficientkW$

Where:

ΔkWh	=	Gross customer annual kWh savings for the measure.
ΔkW	=	Gross customer summer load kW savings for the measure.
BaselinekWh	=	The electric kWh usage of baseline equipment or building.
EfficientkWh	=	The electric kWh usage of efficient equipment or building.
BaselinekW	=	The electric kW usage of baseline equipment or building.
EfficientkW	=	The electric kW usage of efficient equipment or building.

Freeridership/Spillover

Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

Equipment Type	Free Ridership	Spillover
Space Heating Equipment	0%	0%

Persistence

The persistence factor is assumed to be one.

Measure Lifetimes

Equipment Type	Measure Lifetime
Gas Furnaces	20
Gas Boilers	25

Source: Lifetime estimates used by Efficiency Vermont.

Water Savings

The water savings are the difference between the baseline and efficient equipment annual water usage in gallons.

B. All End Uses

1) Custom Measures

Unique Measure Code(s): TBD
Draft date: 4/30/12
Effective date: TBD
End date: TBD

Measure Description

This measure applies to all custom retrofit measures, not otherwise specified in this TRM.

Definition of Baseline Condition

The baseline represents the existing equipment that is currently installed. The efficiency level is based on measurements or nameplate information.

Definition of Efficient Condition
The efficient measure is any equipment that uses less energy than the baseline equipment.

Gas Savings Algorithms
The generalized equation for a custom measure compares the baseline usage to the efficient usage.

$$Annual\ Gas\ Savings\ (MMBtu) = BaselineUse - EfficientUse$$

Where:

BaselineUse = The gas usage of baseline equipment or building.

EfficientUse = The gas usage of efficient equipment or building.

Electric Savings Algorithms

Energy Savings
ΔkWh = $BaselinekWh - EfficientkWh$

Demand Savings
$\Delta kW = BaselinekW - EfficientkW$

Where:

ΔkWh = Gross customer annual kWh savings for the measure.

ΔkW = Gross customer summer load kW savings for the measure.

BaselinekWh = The electric kWh usage of baseline equipment or building.

EfficientkWh = The electric kWh usage of efficient equipment or building.

BaselinekW = The electric kW usage of baseline equipment or building.

EfficientkW = The electric kW usage of efficient equipment or building.

Freeridership/Spillover
Until studies have been performed to determine the free ridership and spillover, the values are assumed to be zero.

Equipment Type	Free Ridership	Spillover
Custom Measure	0%	0%

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes
Where available, custom measure lifetimes should be based on similar measures defined elsewhere in this TRM.

Water Savings
The water savings are the difference between the baseline and efficient equipment annual water usage in gallons.

CERTIFICATE OF SERVICE

I hereby certify that I have this day served a true copy of PGW's Demand Side Management Program Annual Report FY 2015 upon the participants listed below in accordance with the requirements of § 1.54 (relating to service by a participant).

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