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June 5, 2015

Via Hand Delivery
Rosemary Chiavetta, Secretary
PA Public Utility Commission
P.O. 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:

Pursuant to Ordering ¶ 3 of the Opinion and Order dated May 7, 2015 enclosed for filing please find the original of Philadelphia Gas Works' ("PGW") Sixth Year Implementation Plan, Fiscal Year 2016, for its Demand Side Management ("DSM") Program.

Please contact me if you have any questions

Sincerely,

Daniel Clearfield

DC/lww
Enclosure

cc: Cert. of Service w/enc.

{L0596975.1}

PHILADELPHIA GAS WORKS

FIVE-YEAR ENERGYSENSE DEMAND SIDE MANAGEMENT PORTFOLIO

SIXTH YEAR IMPLEMENTATION PLAN

FISCAL YEAR 2016

JUNE, 2015

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I. PORTFOLIO IMPLEMENTATION PLAN

A. Introduction

This FY 2016 Implementation Plan ("Plan") describes the processes and steps that Philadelphia Gas Works ("PGW" or "the Company") will follow to implement its EnergySense Fiscal Year 2016 Demand-Side Management Portfolio ("DSM Portfolio") as approved by the Pennsylvania Public Utility Commission ("PUC") by order entered May 7, 2015 at dockets P-2009-2097639 and R-2009-2139884. This plan also updates progress to date in FY 2015 for the Company's DSM Portfolio.

The FY 2016 program year is a temporary extension of the initial PGW Five-Year DSM Portfolio ("Phase I") programming approved by the Commission by order entered on July 29, 2010. The order approved PGW's Phase I programs for five years, through August 31, 2015. PGW's DSM Phase I has benefitted PGW's customers, the environment, and the regional economy. PGW filed a petition to extend the programs on December 23, 2014, at Docket No. P-2014-2459362, for an additional five-year period ("Phase II") and allowing for ongoing programming thereafter.

In April 2015, PGW requested a one-year extension of the current programming, including ELIRP, as an interim measure while the full DSM Phase II proceeding is underway. On May 7th, the PUC approved this request, and ordered ("Order") a limited extension of PGW's DSM Phase I DSM Plan for an interim period ("DSM Bridge Plan") from September 1, 2015, through either: (1) August 31, 2016; or, (2) upon the effective date of a Phase II compliance plan filed in response to a final Commission Order at Docket Number P-2014-2459362, whichever is earlier. Although this plan provides implementation details for one full year of activity, the company will amend the Plan depending upon when the PUC issues a final DSM Phase II order.[1]

[1] PGW's LIURP regulatory baseline requirements for FY 2016 and FY 2017 are $1,459,600 and $1,460,800 (respectively) in nominal dollars.

B. Summary of Activity to Date

1. Budgets

PGW has spent $36.0 million on total delivery of all six launched DSM programs from inception through February 28, 2015. These expenditures are detailed in the following tables.

Table 1 – Costs by Program from Inception through February, 2015 (Nominal)

Program	Inception to Feb 28, 2015
Enhanced Low Income Retrofit	$27,408,042
Residential Heating Equipment Rebates	$2,403,494
Comprehensive Residential Retrofit Incentives	$1,108,852
High Efficiency Construction Incentives (Residential)	$240,710
Residential Total	**$31,161,098**
Commercial and Industrial Retrofit Incentives	$516,523
Commercial and Industrial Equipment Rebates	$381,908
High Efficiency Construction Incentives (Nonresidential)	$-
Non-residential Total	**$898,431**
Portfolio-wide Costs	$3,892,279
UTILITY TOTAL	**$35,951,808**
Participant Costs	$3,392,603
Total	**$39,344,411**

Table 2 – Portfolio Costs by Category from Inception through February, 2015 (Nominal)

Category	Inception to Feb 28, 2015
Customer Incentives	$23,938,205
Administration and Management	$3,101,974
Marketing and Business Development	$957,391
Contractor Costs	$7,574,773
Inspection and Verification	$188,973
On-site Technical Assessment	$-
Evaluation	$190,490
UTILITY TOTAL	**$35,951,808**
Participant Costs	$3,392,603
Total	**$39,344,411**

2. Savings

a) Gas savings

Table 3 – Natural Gas Savings from Inception through February, 2015

Program	Incremental Net Annual Gas Savings (MMBtus/yr)	Incremental Net Lifetime Gas Savings (MMBtus)
Enhanced Low Income Retrofit	234,529.6	4,851,319.6
Residential Heating Equipment Rebates	50,039.3	1,088,249.6
Comprehensive Residential Retrofit Incentives	6,752.2	188,330.7
High Efficiency Construction Incentives (Residential)	2,034.4	36,676.7
Residential Total	**293,355.7**	**6,164,576.7**
Commercial and Industrial Retrofit Incentives	8,483.8	167,794.1
Commercial and Industrial Equipment Rebates	9,773.4	216,599.0
High Efficiency Construction Incentives (Nonresidential)	-	-
Non-residential Total	**18,257.2**	**384,393.1**
PORTFOLIO TOTAL	**311,612.9**	**6,548,969.7**

b) Non-Gas Savings

Table 4 – Non-Gas Savings from Inception through February, 2015

	Inception through Feb 28, 2015			
Program	Incremental Net Annual Electiricy Savings (MWh)	Incremental Net Lifetime Electricity Savings (MWh)	Incremental Net Summer Peak Demand Savings (kW)	Incremental Net Annual Water Savings (Million Gallons)
Enhanced Low Income Retrofit	2,437.7	56,151.3	900.4	12.1
Residential Heating Equipment Rebates	256.2	5,124.0	-	-
Home Rebates	82.5	2,516.3	-	0.0
High Efficiency Construction Incentives (Residential)	5.5	138.9	1.7	0.5
Residential Total	**2,782.0**	**63,930.5**	**902.0**	**12.7**
Commercial and Industrial Retrofit Incentives	115.5	2,020.6	12.3	2.6
Commercial and Industrial Equipment Rebates	-	-	-	1.9
High Efficiency Construction Incentives (Nonresidential)	-	-	-	-
Non-residential Total	**115.5**	**2,020.6**	**12.3**	**4.4**
PORTFOLIO TOTAL	**2,897.4**	**65,951.1**	**914.3**	**17.1**

3. Cost-Effectiveness

From inception through February 28, 2015, the EnergySense portfolio shows a Total Resource Cost ("TRC") Benefit Cost Ratio ("BCR") of 1.19, and a Present Value ("PV") of Net Benefits of $7.8 million (2014 dollars). The portfolio continued to trend upwards in both BCR and PV Net Benefits through the latest year of program activities. This year's results demonstrate a two percent improvement in BCR and 60 percent improvement in Net Benefits.

Table 5 – Cost-Effectiveness Results from Inception through February, 2015 (2014$)[2]

Program	Total Resource Cost Test				% Of Total	
	PV of Benefits	PV of Costs	PV of Net Benefits	BCR	PV of Benefits	PV of Costs
Enhanced Low Income Retrofit	$37,312,851	$29,200,730	$8,112,121	1.28	76%	70%
Residential Heating Equipment Rebates	$7,481,719	$4,651,042	$2,830,677	1.61	15%	11%
Comprehensive Residential Retrofit Incentives	$1,336,786	$1,887,401	$(550,615)	0.71	3%	5%
High Efficiency Construction Incentives (Residential)	$285,191	$251,349	$33,842	1.13	1%	1%
Residential Total	**$46,416,546**	**$35,990,522**	**$10,426,024**	**1.29**	**94%**	**87%**
Commercial and Industrial Retrofit Incentives	$1,403,066	$967,985	$435,081	1.45	3%	2%
Commercial and Industrial Equipment Rebates	$1,536,638	$504,782	$1,031,856	3.04	3%	1%
High Efficiency Construction Incentives (Nonresidential)	$-	$-	$-		0%	0%
Non-residential Total	**$2,939,704**	**$1,472,767**	**$1,466,937**	**2.00**	**6%**	**4%**
Portfolio-wide Costs	$-	$4,102,036	$(4,102,036)	-	0%	10%
PORTFOLIO TOTAL	**$49,356,250**	**$41,565,325**	**$7,790,925**	**1.19**	**100%**	**100%**

Program	Gas Administrator Test				% Of Total	
	PV of Benefits	PV of Costs	PV of Net Benefits	BCR	PV of Benefits	PV of Costs
Enhanced Low Income Retrofit	$31,241,566	$29,200,730	$2,040,836	1.07	74%	77%
Residential Heating Equipment Rebates	$7,090,887	$2,504,602	$4,586,285	2.83	17%	7%
Comprehensive Residential Retrofit Incentives	$1,120,556	$1,125,275	$(4,719)	1.00	3%	3%
High Efficiency Construction Incentives (Residential)	$216,738	$248,291	$(31,553)	0.87	1%	1%
Residential Total	**$39,669,747**	**$33,078,898**	**$6,590,849**	**1.20**	**94%**	**87%**
Commercial and Industrial Retrofit Incentives	$994,406	$530,989	$463,417	1.87	2%	1%
Commercial and Industrial Equipment Rebates	$1,365,001	$390,484	$974,517	3.50	3%	1%
High Efficiency Construction Incentives (Nonresidential)	$-	$-	$-		0%	0%
Non-residential Total	**$2,359,407**	**$921,472**	**$1,437,935**	**2.56**	**6%**	**2%**
Portfolio-wide Costs	$-	$4,102,036	$(4,102,036)	-	0%	11%
PORTFOLIO TOTAL	**$42,029,154**	**$38,102,406**	**$3,926,747**	**1.10**	**100%**	**100%**

2 As described in PGW's FY20111 DSM Implementation Plan, the TRC cost-effectiveness test is the primary test used in determining DSM programs' cost-effectiveness. However, PGW also includes the Gas Administrator cost-effectiveness test to provide another perspective on program cost-effectiveness based on utility system costs and benefits.

4. Program Impacts

The Enhanced Low Income Retrofit ("ELIRP") program has been the lead program in PGW's DSM portfolio, representing 76 percent of all portfolio spending to date. From inception to-date, the program has resulted in 5,803 closed cases, 3,289 closed-limited cases, for a total 9,092 customers with installations. The ELIRP program now demonstrates a cumulative BCR of 1.28. The ELIRP program is in the midst of a third-party impact evaluation, the results of which are expected in late FY 2015 and will provide further insight into ELIRP effectiveness. PGW expects to report on these results in its upcoming FY 2015 DSM Annual Report. Beginning in FY 2016, PGW will begin branding the ELIRP program to customers as the CRP Home Comfort program.

The Residential Heating Equipment Rebate ("RHER") program has also been cost-effective so far, with a BCR of 1.61, and has continued to increase participation. The program has experienced increased participation among multifamily building owners; however many of these projects install small-capacity heaters with relatively low TRC cost effectiveness. PGW updated the rebate design in FY2015 to reduce the incentives for projects likely installing smaller-sized heaters in an effort to improve Gas Administrator cost-effectiveness, and the company has continued to monitor the issue. RHER participation continues to trend upwards, although not as quickly as past predictions. From inception to-date RHER has rebated 2,368 pieces of heating equipment totaling $1,951,590.

The Home Rebates program[3] has experienced strong conversion rates from initial audits to completed projects, and projects have demonstrated cost-effectiveness. To drive Home Rebates Program participation and provide customers with additional choices, PGW added two new contractors to the program in 2015. Unfortunately, the program faced a setback in early FY 2015 when one of the most active contractors withdrew after closing local operations. There are currently six participating Home Rebates program contractors. From inception through February 28, 2015, there have been 618 audits and 277 completed jobs.

PGW's FY 2015 Implementation Plan projected that from inception in FY 2013 through FY 2015, the Home Rebates program was expected to provide lifetime net present benefits in 2009$ of -$1.2 million with a BCR of 0.73. However, the program is starting to get to levels where it could be sustainable going forward and start providing net TRC benefits. The TRC BCR from inception through February 28, 2015, is 0.71 with negative $550,615 (2014 dollars) in present value net benefits. Setting aside administrative costs, the program has achieved a TRC BCR of 1.12 since inception and $115,000 in present value of net benefits in (2009 dollars). The Gas Administrator Cost test measures more narrowly the return to gas ratepayers, ignoring other resource savings and any additional participant costs. As Table 5 shows, under this test, the program has essentially broken

[3] Originally referred to as the Comprehensive Residential Retrofit ("CRRI") program.

even since inception. Furthermore, it has achieved a 1.20 BCR for the first half of FY15, despite low activity levels.

On the non-residential side, the Commercial and Industrial Efficient Equipment Rebates ("CIER") program has likewise shown strong cost-effectiveness with a cumulative TRC BCR of 3.04, though participation remains lower than predicted. Since the beginning of FY 2015, the program has increased participation in the food service equipment and boiler equipment categories; though the newly launched water heater and steam trap rebates initial uptake has been slow. Participation in the custom CIER category is increasing, with several projects involving low-flow water fixtures in multifamily buildings. Overall, the CIER program has received 121 prescriptive and custom equipment applications and incentivized 93 projects totaling $244,870 to-date.

The Commercial and Industrial Retrofit Incentive ("CIRI") program[4] has provided incentives for 21 projects with incentives totaling over $343,641. The program is TRC cost-effective with a cumulative BCR of 1.45, and continues to see strong participation for low-income multifamily buildings, which make up the majority of grants issued to-date. A church and a small manufacturing facility are among the non-residential commercial properties with completed CIRI projects. PGW continues to market to and work with non-residential program applicants in developing viable projects.

The High Efficiency Construction Incentives ("HECI") program[5] has provided technical assistance and grants for the design and construction of multifamily, mix-use, and single family home developments. The program is TRC cost-effective with a cumulative BCR of 1.13, though participation has been slower than predicted. To date, the HECI program has received 60 applications and incentivized 15 projects totaling $118,065. PGW is currently working with a number of other projects that are anticipated to close by the end of FY 2016.

Overall, the EnergySense portfolio remains TRC cost-effective and customer uptake of the programs is continuing to increase. Counteracting these gains, however, is the continued decline in the projected commodity cost of natural gas, which has continued to erode the portfolio's forecasted net benefits. The program implementation details that follow are designed to maintain program cost-effectiveness through continued participation growth and slight adjustments to target measures.

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[4] The CIRI program is advertised to customers as the "Efficient Building Grants" program for ease of marketing and communications.

[5] The HECI program is advertised to customers as the "Efficient Construction Grants" program for ease of marketing and communications.

C. Portfolio Budgets, Savings, and Cost-Effectiveness

1. Budgets

In accordance with the terms of the Order in FY 2016 (assuming the Bridge Plan will last for the entire fiscal year), PGW plans to spend approximately $10.7 million on total delivery of all six launched DSM programs. PGW's administration costs come to $900,000, or 8.4 percent of the sixth year's budget.

Table 6 – Projected Budgets by Program for FY 2016 (Nominal)

PROGRAM	FY 2016
Enhanced Low Income Retrofit	$7,570,000
Residential Heating Equipment Rebates	$777,000
Comprehensive Residential Retrofit Incentives	$666,614
High Efficiency Construction Incentives – Residential	$90,500
Residential Total	**$9,104,114**
Commercial and Industrial Retrofit Incentives	$284,200
Commercial and Industrial Equipment Rebates	$313,650
High Efficiency Construction Incentives – Nonresidential	$90,500
Commercial & Industrial Total	**$688,350**
Portfolio Administration and Management	$600,000
Portfolio Marketing and Business Development	$300,000
Portfolio-Wide Costs Total	**$900,000**
Utility Costs	**$10,692,464**
Participant Costs	$2,394,143
Total	**$13,086,607**

Table 7 – Projected Portfolio Budget by Cost Category for FY 2016 (Nominal)

Category	FY 2015
Customer Incentives & Measure Installation Costs	$7,674,164
Administration and Management	$630,000
Marketing and Business Development	$300,000
Contractor Costs	$1,867,000
Inspection and Verification	$171,300
Evaluation	$50,000
Utility Costs	**$10,692,464**
Participant Costs	$2,394,143
Total	**$13,086,607**

2. Savings

a) Gas savings

Table 8 – Projected Natural Gas Savings for FY 2016

Program	Incremental Net Annual Gas Savings (MMBtus/yr)	Incremental Net Lifetime Gas Savings (MMBtus)
Enhanced Low Income Retrofit	54,633.6	1,098,818
Residential Heating Equipment Rebates	14,151.6	310,263
Comprehensive Residential Retrofit Incentives	7,463.5	218,759
High Efficiency Construction Incentives (Residential)	1,388.8	25,293
Residential Total	**77,637.5**	**1,653,133**
Commercial and Industrial Retrofit Incentives	4,817.1	89,405
Commercial and Industrial Equipment Rebates	10,951.5	175,481
High Efficiency Construction Incentives (Nonresidential)	1,388.8	25,293
Non-residential Total	**17,157.5**	**290,180**
PORTFOLIO TOTAL	**94,795.0**	**1,943,313**

b) Non-Gas Savings

Table 9 – Projected Non-Gas Savings for FY 2016

Program	Incremental Net Annual Electricity Savings (MWh)	Incremental Net Lifetime Electricity Savings (MWh)	Incremental Net Annual Summer Peak Demand Savings (kW)	Incremental Net Annual Water Savings (Million Gallons)
Enhanced Low Income Retrofit	665.0	15,207.3	253.3	2.9
Residential Heating Equipment Rebates	89.2	1,783.4	0.0	0.0
Home Rebates	90.1	2,702.3	0.0	0.1
High Efficiency Construction Incentives - Residential	3.7	106.3	0.0	0.5
Residential Total	847.9	19,799.4	253.3	3.5
Commercial and Industrial Retrofit Incentives	61.9	1,322.4	0.0	1.2
Commercial and Industrial Equipment Rebates	0.0	0.0	0.0	5.8
High Efficiency Construction Incentives - Nonresidential	3.7	106.3	0.0	0.5
Commercial & Industrial Total	65.6	1,428.7	0.0	7.6
Total Portfolio	913.5	21,228.0	253.3	11.1

3. Cost-Effectiveness

a. Projected Performance

Table 10–Projected Cost-Effectiveness Results FY 2016 (2014$)

Program	Total Resource				% of Total	
	PV Benefits	PV Costs	PV Net Benefits	BCR	PV Benefits	PV Costs
Enhanced Low Income Retrofit	$7,936,750	$6,981,373	$955,377	1.14	58%	58%
Residential Heating Equipment Rebates	$1,960,729	$1,759,731	$200,997	1.11	14%	15%
Comprehensive Residential Retrofit Incentives	$1,430,761	$1,411,554	$19,206	1.01	10%	12%
High Efficiency Construction Incentives (Residential)	$180,632	$124,970	$55,662	1.45	1%	1%
Residential Total	**$11,508,871**	**$10,277,628**	**$1,231,243**	**1.12**	**84%**	**85%**
Commercial and Industrial Retrofit Incentives	$695,045	$426,080	$268,965	1.63	5%	4%
Commercial and Industrial Equipment Rebates	$1,322,846	$410,398	$912,448	3.22	10%	3%
High Efficiency Construction Incentives (Nonresidential)	$180,632	$124,970	$55,662	1.45	1%	1%
Commercial & Industrial Total	**$2,198,524**	**$961,449**	**$1,237,075**	**2.29**	**16%**	**8%**
Portfolio-wide Costs		$830,194	$(830,194)	n/a	0%	7%
Total Portfolio	**$13,707,395**	**$12,069,271**	**$1,638,124**	**1.14**	**100%**	**100%**

Program	Gas Administrator				% of Total	
	PV Benefits	PV Costs	PV Net Benefits	BCR	PV Benefits	PV Costs
Enhanced Low Income Retrofit	$6,380,289	$6,981,373	$(601,084)	0.91	57%	71%
Residential Heating Equipment Rebates	$1,827,411	$716,715	$1,110,695	2.55	16%	7%
Comprehensive Residential Retrofit Incentives	$1,244,314	$614,823	$629,491	2.02	11%	6%
High Efficiency Construction Incentives (Residential)	$129,574	$83,481	$46,093	1.55	1%	1%
Residential Total	**$9,581,587**	**$8,396,391**	**$1,185,196**	**1.14**	**86%**	**85%**
Commercial and Industrial Retrofit Incentives	$497,148	$262,157	$234,991	1.90	4%	3%
Commercial and Industrial Equipment Rebates	$947,195	$289,323	$657,873	3.27	8%	3%
High Efficiency Construction Incentives (Nonresidential)	$129,574	$83,481	$46,093	1.55	1%	1%
Commercial & Industrial Total	**$1,573,917**	**$634,960**	**$938,957**	**2.48**	**14%**	**6%**
Portfolio-wide Costs		$830,194	$(830,194)	n/a	0%	8%
Total Portfolio	**$11,155,505**	**$9,861,545**	**$1,293,959**	**1.13**	**100%**	**100%**

As provided in previous IPs Table 11 presents an alternative evaluation by expanding the cost-effectiveness analysis of projected portfolio performance to include the additional value estimated by Resource Insight, Inc. for the demand-reduction-induced price effect ("DRIPE"), and projected market prices for carbon emissions. These results should be compared to Table 10, since, in addition to the standard benefit estimates generally used in Pennsylvania, PGW is also quantifying the value of two sources of real economic value to PGW and Pennsylvania utility ratepayers from gas DSM savings:

1. Reductions in future gas prices caused by DSM reductions in market demand, and reductions in gas supply and price risk as a result of lower PGW system gas demand.
2. Avoided internalized market costs of greenhouse gas emissions due to reduced gas consumption.

These additional sources of value amount to an additional $2.9 million in 2014 present worth.[6] Additional details on how these values were developed can be found in PGW's DSM Phase II Plan.

Table 11 – Projected Cost-effectiveness Results for 2016 (including value of DRIPE and Internalized CO2)

Program	Total Resource				% of Total	
	PV Benefits	PV Costs	PV Net Benefits	BCR	PV Benefits	PV Costs
Enhanced Low Income Retrofit	$9,654,914	$6,981,373	$2,673,542	1.38	58%	58%
Residential Heating Equipment Rebates	$2,387,163	$1,759,731	$627,432	1.36	14%	15%
Comprehensive Residential Retrofit Incentives	$1,799,270	$1,411,554	$387,716	1.27	11%	12%
High Efficiency Construction Incentives – Residential	$210,261	$124,970	$85,291	1.68	1%	1%
Residential Total	**$14,051,609**	**$10,277,628**	**$3,773,980**	**1.37**	**85%**	**85%**
Commercial and Industrial Retrofit Incentives	$834,047	$426,080	$407,967	1.96	5%	4%
Commercial and Industrial Equipment Rebates	$1,506,431	$410,398	$1,096,033	3.67	9%	3%
High Efficiency Construction Incentives - Nonresidential	$210,261	$124,970	$85,291	1.68	1%	1%
Commercial & Industrial Total	**$2,550,739**	**$961,449**	**$1,589,291**	**2.65**	**15%**	**8%**
Portfolio-wide Costs		$830,194	$(830,194)	n/a	0%	7%

6 Approximately $250,000 of the $2.9 million in additional benefits comes from DRIPE. The remaining $2.6 million in benefits accrue from avoided CO2 emissions.

Total Portfolio	$16,602,348	$12,069,271	$4,533,077	1.38	100%	100%

D. Plan Development

This Plan updates information provided in previous Implementation Plans, provides details on projected program activities in FY 2016.

The following material changes were made to PGW's DSM Plan to develop this Sixth Year Implementation Plan and to ensure compliance with the approved settlement. Additional details are provided in the relevant sections of the Plan.

1. Portfolio-wide changes

- Avoided costs for natural gas were updated based on latest available data, and dropped significantly in the near future and slightly less after 2024.

- The nominal discount rate used for cost-effectiveness analysis was updated to 4.980 percent from 4.976 percent in FY 2015 to reflect PGW's latest actual cost of capital.

2. Program-specific changes

CRP Home Comfort

- PGW will adopt more rigorous quality assurance inspection standards and increase contractor mentoring activities to improve savings realization rates and avoid missed savings opportunities.
- Beginning in FY 2016 the program, previously "ELIRP," will be communicated to customers as the CRP Home Comfort Program, to encourage participation through improved understanding and awareness of the program.

RHER

- Monitor cost-effectiveness of small capacity heating equipment, and issue new program guidelines as necessary.
- Discontinue rebates for programmable thermostats.
- Pilot an initiative encouraging multifamily building owners to install higher efficiency and more cost-effective furnaces in order to receive higher, customized rebates.

CIRI

- Expand program outreach to non-residential commercial property owners.

CIER

- Expand steam trap rebate offering to include steam trap inserts.
- Expand eligibility to a broader range of high efficiency commercial-size hot water heaters by including models that are 94% Thermal Efficiency but not ENERGY STAR® certified.

HECI

- Revise the residential-sized water heater baseline to 0.615 Energy Factor, in accordance with updates to Federal standards.
- Continue monitoring incentive levels with respect to project gas benefits, and issue revised guidelines if necessary.
- Increase targeting of single-family home developers, and specifically real estate development companies that develop in "bulk" parcels.

Home Rebates

- PGW will consider updating incentive structure to drive program participation while still protecting cost-effectiveness.
- Revise the residential-sized water heater baseline to 0.615 Energy Factor, in accordance with updates to Federal standards.

E. Coordination Activities

PGW continually seeks to coordinate DSM Portfolio efforts as much as possible with other organizations and programs in order to leverage existing resources and avoid lost opportunities and duplication of services. During FY 2016 PGW will continue the following coordination activities:

Program/Organization & Description of Coordination
ENERGY STAR® In an effort to promote the Commercial Equipment Rebates Program commercial food service rebates for ENERGY STAR rated equipment, PGW became an ENERGY STAR Energy Efficiency Program Sponsor in FY 2012. This collaboration has allowed PGW to stay up-to-date with ENERGY STAR activities, and will allow it to be included in its national registries of rebates and incentives.
EnergyWorks The EnergyWorks Commercial program, providing low-interest financing for larger commercial energy efficiency projects is still available. PGW will continue to identify opportunities to collaborate with EnergyWorks on individual projects in combining PGW's rebates and grants with the attractive EnergyWorks financing.
Habitat for Humanity PGW and Habitat for Humanity coordinate services through Habitat's Home Repair and Weatherization Program. Habitat's program focuses on individual neighborhoods and provides weatherization and structural repairs to support housing revitalization. Under this arrangement, PGW and Habitat share data as appropriate and identify customers who are enrolled or eligible for both Habitat's Home Repair and Weatherization Program and CRP Home Comfort. Habitat and PGW contractors identify pre-treatment and structural issues for Habitat to address, and PGW contractors focus on weatherization To-date, PGW has coordinated with Habitat for Humanity on five projects.

Program/Organization & Description of Coordination
National Nursing Center Consortium PGW developed collaboration with National Nursing Center Consortium's Lead and Healthy Homes Program. NNCC provides home visits, consultations and home hazard remediation services for homes that have children under seven with asthma conditions, or have the presence of lead paint, pests, or other environmental hazards. PGW will share data to identify homes in both programs, give referrals and coordinate treatment when possible. PGW will begin coordinating cases with NNCC in FY 2016.
Pennsylvania CareerLink Philadelphia PGW has collaborated with the Philadelphia Workforce Investment Board and the Philadelphia Workforce Development Corporation through PA CareerLink Philadelphia to connect local unemployed workers with weatherization training programs and then onto employment with our CRP Home Comfort CSPs. To date, PGW CSPs have hired 32 local, unemployed entry-level workers through this collaboration.
Pennsylvania Housing Finance Authority ("PHFA") PHFA currently provides funding assistance for multifamily residential energy-efficiency projects through their Smart Rehab program and administration of the Low Income Housing Tax Credit program. The overlap between these programs PGW's CIRI and HECI programs presents a significant coordination opportunity. PHFA also manages the Homeowner Energy Efficiency Loan Program (HEELP), which provides low interest loans for weatherization and critical repairs. PGW customers participating in the Home Rebates program may use HEELP to finance their projects.
Philadelphia Department of Public Health Green & Healthy Homes and Lead Poison Prevention Programs Through this collaboration, PGW and Healthy Homes share data on customers who are assigned in both programs. Healthy Homes is able to treat many health, safety and structural issues, which then allows CRP Home Comfort CSPs to comprehensively treat homes otherwise not feasible. Additionally, through this Green and Healthy Home Initiative collaboration, PDPH has offered to provide free trainings and certifications in identifying relevant health and safety issues to PGW's CRP Home Comfort CSPs. The hope is that this exposure to the relevant issues can be a potential first step in developing a more coordinated in-home collaboration that can achieve significant programmatic savings for all.

F. Marketing

The EnergySense marketing strategy will continue to be conducted as two general and complementary campaigns targeting end-users: one in support of the residential programs and the second in support of the commercial programs. In tandem with these campaigns, PGW will continue its marketing to trade allies including HVAC installers, project architects and engineers, the efficient equipment supply chain, to support continued engagement among this market.

i) Residential Program Marketing

During FY 2016, PGW will continue use the Home Rebates program as the primary message for residential end-user marketing activities, with the intention of driving customers to comprehensive retrofits first and then if they are unable to participate, offer the prescriptive rebate programs as an alternative. PGW will continue its successful neighborhood outreach marketing efforts that utilize targeted advertisements, outreach through local businesses, presentations at community meetings and participation in local events. These activities will have a goal of establishing multiple touch-points to develop "warm" leads who, by the time they contact the program, are ready to proceed with an assessment. To-date, PGW has conducted similar targeted outreach activities in eight neighborhoods throughout the city.

One new campaign PGW will launch in late FY15, which may tie-over into FY16, is a campaign that utilizes extensive data analytics and thermal imagery to identify customers that may benefit the most from a home retrofit project. The campaign will offer customers the opportunity to opt-in for obtaining thermal photographs of their homes demonstrating air leakage and inefficiencies, with the goal of making the case to proceed with a full energy assessment.

Other activities will include re-engaging Home Rebates customers that had energy assessments but have not yet completed a project, as well as customers that participated in other PGW EnergySense programs. PGW will continue limited market awareness activities, including targeted print and online advertisements, radio, and PGW bill stuffers.

PGW will also continue its outreach to trade allies at HVAC supply houses, trade associations, PGW's monthly email newsletters and other venues in order to keep contractors, property managers, architects and other industry professionals updated on programs and encourage them to seek high efficiency options.

ii) Commercial Programs Marketing

PGW's commercial programs will utilize a more specialized marketing strategy to target the various customer markets and influencers most likely to generate EnergySense projects. In the HECI program, PGW will continue to focus its marketing on property developers through the real-estate industry network and building association, including realtors, appraisers, inspectors and property management companies. This outreach is expected to forge deeper ties with real estate and developer industry organizations. PGW plans to further focus outreach activities on single family developers through wholesale real estate developers that buy properties in bulk. Targeting these developers will increase the efficiency and scale of marketing activities.

Similar to previous years, PGW plans to work together with building industry associations and equipment dealers to present EnergySense commercial program information through small presentations and regularly scheduled webinars. PGW will coordinate with food service manufactures and provide application and rebate information for contractors at point of sale at supply houses. Communication activities targeting building owners will also include a Request for Application, similar to that released in previous years, to encourage customers to apply immediately for the Efficient Building Grants Program.

PGW also plans to continue outreach to the trade allies that act as chief influencers to individuals making purchasing decisions for companies, and educate them on the benefits of high efficiency natural gas equipment. PGW will reach these influencers, consisting of project architects, engineers and mechanical contractors through direct communications, presentations at firms, and outreach through trade organizations. PGW will seek to expand its outreach through key industry organizations, such as the Philadelphia Chapter of the Architects Institute of America, the Delaware Valley Green Building Council, International Facility Management Association of Greater Philadelphia, Urban Land Institute of Philadelphia, and Building Institute Association of Philadelphia.

G. Evaluation, Monitoring, and Verification

iii) Planning and Reporting

PGW will continue to provide an Annual Report for FY 2016 four months after the close of the fiscal year. Should the PUC file an order on PGW's DSM Phase II petition mid-year in FY 2016, PGW may issue an amendment to this Implementation Plan.

iv) Quality Control

In 2015, PGW selected a new vendor to perform quality control inspections in ELIRP, and equipment verifications for RHER and CIER. Contracting with a single vendor for these programs has streamlined the portfolio's quality control process. Through the use of this vendor, PGW will implement enhanced verifications in the CRP Home Comfort (formerly ELIRP) program to better identify savings opportunities, as discussed further in that program's section below. In the RHER and CIER programs, PGW will utilize the vendor to verify project installations and provide additional program insights that can inform program improvements.

v) Roles and Responsibilities

PGW selected a portfolio grant and rebate payment processing firm in FY 2015. Beginning in FY 2016, the firm will issue incentives for the HECI and CIRI programs in addition to the RHER and CIER programs it served in FY 2015. Doing so will allow PGW's payment process to become more streamlined and cut down the amount of time it takes to issue customer payments. Given results from the RHER Impact Evaluation and surveys, PGW is also exploring opportunities to improve rebate processing timelines, from application to rebate payment, in order to increase customer satisfaction. The selected vendor will also provide call-support through a program information hotline, and may also be utilized for targeted direct-mail marketing activities.

vi) Data Management

There will be no changes to PGW's portfolio data management system in FY 2016.

vii) Evaluations

The following is a schedule of PGW's third-party program evaluations that are currently underway, or are planned for FY 2016. PGW will use the studies for program design improvements, and to inform updates to PGW's TRM assumptions.

- The CIRI Impact Evaluation is currently underway, and is scheduled to be completed by the end of FY 2015.

- The CIER Impact Evaluation and Market Study are currently in draft and are expected to be finalized by the end of FY 2015.

- The HECI Market Study is currently underway, and is scheduled to be completed by the end of FY 2015. The HECI Impact Evaluation is scheduled to take place in FY 2016. This was deferred due to the limited sample size of customers in the first years of activity.

- The Home Rebates Impact Evaluation is scheduled to take place in FY 2016 based on FY 2014 activity.

H. Key Assumptions

i) Avoided Costs

PGW updated its assumptions for the natural gas commodity portion of avoided costs as part of the detailed program design process in July 2010, and has provided updated studies annually as part of all Implementation Plans to date.[7] The updated avoided costs fell by approximately 8.5% percent in real terms compared to the previous year's estimates. Costs for all periods analyzed fell by approximately 1% to 37% percent, bringing the current avoided gas cost projections to their lowest levels since portfolio inception. Table 12 shows the average change in projected avoided cost over various time frames.

Table 12 – Percentage Change in Avoided Costs Between Plans

Year	Space Heating	Baseload	Water Heating
	April 2014 to March 2015		
2013 - 2016	-9.7%	-11.0%	-10.6%
2017 - 2021	-12.7%	-14.4%	-13.8%
2022 - 2031	-5.4%	-5.6%	-5.5%
2013 - 2031	**-8.2%**	**-9.1%**	**-8.8%**
	April 2013 to March 2015		
2013 - 2016	-3.1%	-3.8%	-3.6%
2017 - 2021	-7.4%	-8.6%	-8.2%
2022 - 2031	1.2%	0.4%	0.7%
2013 - 2031	**-2.0%**	**-2.9%**	**-2.6%**
	April 2012 to March 2015		
2013 - 2016	4.4%	-0.2%	1.2%
2017 - 2021	-7.2%	-12.8%	-11.1%
2022 - 2031	0.0%	-4.3%	-3.0%
2013 - 2031	**-1.0%**	**-5.7%**	**-4.2%**
	March 2011 to March 2015		
2013 - 2016	-6.6%	-20.8%	-16.7%
2017 - 2021	-22.7%	-34.1%	-30.8%
2022 - 2031	-14.9%	-23.4%	-21.0%
2013 - 2031	**-15.2%**	**-25.7%**	**-22.7%**
	March 2010 to March 2015		
2012 - 2016	-5.6%	-20.9%	-16.3%
2017 - 2021	-19.3%	-34.5%	-30.6%
2022 - 2031	-10.3%	-22.6%	-19.4%
2013 - 2031	**-21.1%**	**-31.1%**	**-28.3%**

[7] See Appendix III.A for table of updated avoided costs.

September 2009 to March 2015			
2012 - 2016	-24.4%	-37.0%	-33.5%
2017 - 2021	-31.7%	-42.2%	-39.2%
2022 - 2031	-26.8%	-34.8%	-32.6%
2013 - 2031	**-27.6%**	**-37.2%**	**-34.5%**

PGW also examined the portfolio under an alternative, expanded scope by including an estimate of the economic value of wholesale price reduction in gas avoided costs caused by demand reductions resulting from energy-efficiency improvements. These effects, referred to collectively as DRIPE, reflect the same market dynamics as the swings in gasoline prices that result from seasonal and secular variation in gasoline demand. DRIPE varies over time and scope of the analysis. The estimate of gas DRIPE for Pennsylvania ranges from $0.13 to $0.38 per MMBtu (in 2014 dollars). Resource Insight, Inc.'s full analysis was provided most recently in the PGW's Phase II Plan.

In addition to DRIPE, the expanded analysis included the estimates for the long-run value of internalized market prices for reduced greenhouse gas emissions resulting from gas DSM. The methodology for calculating these figures was included in the FY 2014, and FY 2015 Implementation Plans, as well as PGW's Phase II plan.

The avoided costs components of DRIPE and greenhouse gas emissions are not reflected in Table 10 above. However, the values are reflected in Table 11 in order to show the impact from these additional considerations.

ii) Benefit-Cost Analysis

The cost-effectiveness results reported in this plan were calculated using standard industry practice for conducting the TRC and Gas Program Administrator tests for cost-effectiveness.

The analysis used a real discount rate ("RDR") of 2.92 percent. The RDR was calculated using assumptions of a nominal discount rate ("NDR") of 4.98 percent and a future inflation rate of 2.0 percent. The inflation assumption has remained constant, while the nominal discount rate has been updated to reflect PGW's true average weighted cost of capital, which rose very slightly from 4.976 percent to 4.980 percent.

iii) Technical Reference Manual

PGW has filed an updated TRM as Appendix G to this plan. The TRM has been updated to reflect new baseline assumptions for residential domestic hot water heaters based on new Federal standards, and revised assumptions for the commercial steam trap and commercial domestic hot water heater measures for reasons discussed in the CIER section below.

II. FY 2016 Program Plans

This section provides details on completed and planned implementation activities in FY 2016 for all six DSM programs comprising PGW's EnergySense Portfolio:

- The CRP Home Comfort Program
- The Residential Heating Equipment Rebate Program ("RHER")
- The Efficient Building Grants Program ("CIRI")
- The Commercial and Industrial Equipment Rebate Program ("CIER")
- The Efficient Construction Grants Program ("HECI")
- The Home Rebates Program

A. CRP Home Comfort Program

i) Program Description

The CRP Home Comfort program, currently PGW's Low-Income Usage Reduction Program ("LIURP"), seeks to provide cost-effective energy savings to 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 the 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 energy efficient heating systems as feasible.
- Providing comprehensive weatherization services as feasible.
- 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.

ii) Costs, Savings and Benefits

In order to more accurately project future savings, PGW has made updates to projections based on actual activities to date. As a result of these actual findings, PGW has increased the average savings and spending per project, while slightly lowering the cost per MMBtu of gas savings. This has led to a decrease in the number of participants required to meet savings and spending goals and an increase in projected benefits.

The CRP Home Comfort program aims to serve 1,759 customers in FY 2016, with associated annualized gas savings of 54.6 BBtus, or 31.1 MMbtu/customer. In FY 2016, the program is projected to cost $7.57 million. The following table shows a breakout of participation, costs, and savings.

Table 13 – Projected CRP Home Comfort Impacts for FY 2016

	Projected (FY 2016)
PARTICIPATION	
Customers with Installations	1,759
COSTS	
Measure Installation Costs	$5,972,000
Administration and Management	$30,000
Marketing and Business Development	$-
Contractor Costs	$1,493,000
Inspection and Verification	$75,000
Evaluation	$-
Utility Costs	**$7,570,000**
Participant Costs	$-
Total	**$7,570,000**
BENEFITS	
Net Annual BBtu	54.6
Net Lifetime BBtu	1,098.8
Net Annual MMBtu / Customer	31.1
Weighted Lifetime (years)	20.1

In FY 2016, PGW will continue its activities to improve cost-effectiveness by coordinating with other agencies to mitigate issues that prevent comprehensive weatherization, and addressing customer refusals. The company also plans to conduct the two additional activities below to further improve CRP Home Comfort cost-effectiveness:

A. Improving Contractor Work-scopes and Savings

Beginning in FY 2015, PGW engaged a new Quality Control Inspector with the goal of improving work quality, communication and cost-effectiveness. PGW's inspector is now primarily focused on identifying missed opportunities and educating Conservation Service Providers ("CSP") on achieving greater and more cost-effective savings in homes. PGW will also increase the frequency of "enhanced" inspections that use a blower door and infrared cameras for detailed investigations of work quality.

In addition to inspections, the firm will perform on-site mentoring with CSP staff on identifying and addressing all potential savings opportunities. Through these activities, PGW hopes to further improve CRP Home Comfort cost-effectiveness and per-project savings.

B. Improving CRP Customer Engagement

In FY 2016, PGW is exploring several new changes designed to improve customer cooperation with the CRP Home Comfort program requirements. The most prominent change is that PGW plans to re-brand the ELIRP program as CRP Home Comfort to increase customer acceptance and educate customers about the benefits of weatherization. PGW selected the name to specify that the program is designed solely for CRP customers, and that the weatherization treatment improves comfort and quality of life in the household. PGW will explore new ways to use this new branding to educate CRP customers at various touch points with the company so that they are more willing to participate when contacted by contractors, and understand that their participation is required as a condition of CRP enrollment.

PGW will also encourage its CSPs to use the new brand to improve customer engagement. One example is a post-card mailer to encourage selected customers to accept CRP Home Comfort treatment. PGW will track these activities in FY 2016 and expand within the program if successful.

iii) Workflow

There are no updates to the CRP Home Comfort workflow.

iv) Target Market and Program Eligibility

There are no updates to the CRP Home Comfort target market and program eligibility.

v) Target End-use Measures

The majority of installations include air sealing and/or insulation in the basement and attic as well as some low cost measures such as low flow faucet aerators, low flow showerheads, and training on the use of programmable thermostats. Approximately 33 percent of comprehensively treated homes (64 percent of all closed cases) received a new furnace or boiler. In homes where comprehensive treatment is prohibited due to poor conditions (principally, health and safety and water issues) the CSPs install basic measures, such as a programmable thermostat, pipe insulation, or a carbon monoxide detector, as feasible.

vi) Incentive Strategy

There are no updates to the incentive strategy.

vii) Roles and Responsibilities

There are no updates to roles and responsibilities.

viii) Evaluation, Monitoring, and Verification

In FY 2016, PGW plans to update reporting fields to collect additional demographic data about the homes treated, in order to provide information requested in the latest LIURP codebook. There are no further evaluation, monitoring, and verification updates planned for the CRP Home Comfort program.

B. *Residential Heating Equipment Rebates Program*

i) Program Description

The RHER program issues prescriptive rebates on premium efficiency gas appliances and heating equipment to increase the penetration of these measures in the homes of PGW's customers. The program has the following objectives:

- Promote the selection of premium efficiency residential models 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.

Eligible customers select their own licensed contractor to install the premium efficiency equipment and receive cash rebates to offset the majority of the higher efficiency equipment's incremental costs. The program launched April, 2011.

ii) Costs, Savings, and Benefits

Projections

The program aims to serve 1,084 customers in FY 2016, with associated annualized gas savings of 14.2 BBtu, or 3.1 MMBtu/customer. The program is projected to cost $777,000. The following table shows a detailed breakout of participation, costs, and savings.

Table 14 – Projected RHER Impacts for FY 2016

	Projected (FY 2016)
PARTICIPATION	
Rebates Issued	1,084
COSTS	
Customer Incentives	$668,000
Administration and Management	$-
Marketing and Business Development	$-

Contractor Costs	$50,000
Inspection and Verification	$9,000
Evaluation	$50,000
Utility Costs	**$777,000**
Participant Costs	$1,131,100
Total	**$1,908,100**
BENEFITS	
Net Annual BBtu	14.2
Net Lifetime BBtu	310.3
Net Annual MMBtu / Customer	3.1
Weighted Lifetime (years)	21.9

PGW has seen an increase in the number of claims received for smaller capacity furnaces from landlord/developers for multifamily buildings, although this trend has stabilized. Though this increase in participation benefits the program, the smaller units result in a lower level of cost-effectiveness.

PGW continues to monitor the cost-effectiveness of multifamily projects. It is currently working to better encourage customers to seek comprehensive projects, and steer multifamily projects to HECI or CIRI where project comprehensiveness may offset measures that are less cost-effective. The company also plans to encourage multifamily building owners to adopt cost-effective, higher efficiency equipment that will be analyzed on a project-by-project basis. PGW will guide landlords and developers to purchase units that exceed the efficiency of the program's prescriptive equipment, and will calculate custom rebates that provide a greater incentive to adopt the cost-effective equipment. This strategy will help PGW improve program cost-effectiveness while incentivizing a higher efficiency alternative that may be adopted as a prescriptive measure in future program years.

iii) Workflow

There are no updates to the workflow for RHER.

iv) Target Market and Program Eligibility

There are no updates to program eligibility.

v) Target End-use Measures

Beginning in FY2016, PGW will discontinue offering thermostat rebates. PGW found that the majority of thermostat rebate applicants have incomplete information or are missing documentation on their HVAC contractor invoices. This resulted in payments being delayed, rebate processor time and other customer service challenges that did not justify the cost.

PGW has decided to postpone its plans to offer the combi-boiler measure until Phase II. The measure was originally proposed to be explored for launch in the FY 2014 IP, but was postponed for launch in the FY 2015 IP. The primary roadblock has been to develop a list of "eligible" equipment that meets PGW's efficiency requirements and can operate on the company's low-pressure distribution system. Furthermore, new measures take several months or even years to be adopted in the market, requiring more time to build the program than PGW currently has in its Bridge Plan approval.

As discussed above in the cost, savings and benefits section, PGW will also pilot a custom equipment strategy that encourages multifamily property owners planning to install small capacity heaters to instead install higher efficiency, more cost-effective options. The target equipment and rebates for these custom projects would be determined on a case-by-case basis.

Projections

PGW updated projections for rebates based on new incentive levels and market acceptance. Updated projections can be found in the table below

Table 15 – Projected Rebates for FY 2016 by Equipment Type

Fiscal Year	2016
Natural Gas Furnace	832
Natural Gas Boiler	252

vi) Incentive Strategy

The following table shows the proposed rebate schedule for FY2016.

Table 16 – FY 2016 Planned Residential Equipment Rebates

Measure	First Rebate Per-Project	Additional Rebates Per-Project[8]
Natural Gas Furnace 94% AFUE	$500	$250
Natural Gas Water Boiler, 94% AFUE	$1,500	$800

Since receiving the FY 2013 impact evaluation on RHER, which identified lower savings than predicted, PGW has closely tracked the impact that smaller capacity boilers and furnaces have on the program's cost-effectiveness. PGW revised the rebate amounts in FY 2015 in response to this problem, in an effort to reduce incentives to projects that are likely to install smaller-sized equipment, but the issue of small capacity heaters remain a challenge to program cost effectives due in-part to the falling commodity costs discussed

[8] Projects are defined as one individual/entity receiving a rebate for one building address.

in the Avoided Costs section above. PGW will continue to monitor this issue in FY 2016 and revise program guidelines if necessary to reduce the quantity of cost in-effective products coming through the program.

vii) Roles and Responsibilities

There are no updates to roles and responsibilities

viii) Evaluation, Monitoring, and Verification

PGW's rebate processor maintains a real-time database of rebate activity. PGW collects program activity from its rebate processor and reviews it for accuracy. Program data is then stored at PGW for long-term purposes.

In 2016, PGW will have an independent evaluation performed on its CY2014 year. The evaluation is expected to identify program improvements, and may guide changes to program assumptions used in the TRM. Any changes to the TRM will be filed with the PUC.

PGW is seeking ways to improve its application review and verification processes to improve customer satisfaction. In FY 2016, PGW will develop a process to give enhanced review for claims that have challenges being approved. For example, in situations where an HVAC contractor does not provide the required itemized invoice showing the heater paid in full after requests from the customer and PGW, PGW will consider sending its inspector on-site to verify the equipment, giving PGW the needed assurance to approve the rebate.

C. Commercial and Industrial Retrofit Incentives Program

i) Program Description

The Efficient Building Grants or CIRI 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 for cost-effective gas-saving investments including high-efficiency heating system replacements, improved system controls, and building thermal performance enhancements. The program also assists participants in arranging 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 offering customized financial incentives that, when combined with third-party

financing, can provide participating customers with immediate positive cash flow.

- Promote a better understanding of energy efficiency options available to PGW's nonresidential customers.

CIRI seeks to educate and encourage facility managers, department heads, and financial officers to conduct audits of their facilities and identify cost-effective energy saving retrofit opportunities. PGW then provides an incentive for completing the installation of the identified savings measures. The initial phase of the program specifically targeted energy efficiency opportunities in multi-family buildings. As the program ramped-up additional commercial and industrial customer classes have been targeted.

ii) Costs, Savings, and Benefits

Projections

The CIRI program aims to serve 12 customers in FY 2016, with associated annualized gas savings of 4.8 BBtu, or 401 MMBtu/customer. The program is projected to cost $284,200 in FY 2016.

Table 17 – Projected CIRI Impacts for FY 2016

	Projected (FY 2016)
PARTICIPATION	
Customers with Installations	12
COSTS	
Measure Installation Costs	$202,900
Administration and Management	$-
Marketing and Business Development	$-
Contractor Costs	$70,000
On-site Technical Assessment	$-
Evaluation	$-
Utility Costs	**$284,200**
Participant Costs	$177,789
Total	**$461,989**
BENEFITS	
Net Annual BBtu	4.8
Net Lifetime BBtu	89.4
Net Annual MMBtu / Customer	401.4
Weighted Lifetime (years)	18.6

iii) Workflow

In FY 2016, the only workflow update that PGW plans to make is to streamline the application process to improve customer experience and increase the number of project leads. Furthermore, this update will make it easier for business owners to complete their CIRI screening application prior to work beginning at the property, reducing the number of projects that are ineligible due to project timing.

iv) Target Market and Program Eligibility

There are no updates to the target market and program eligibility.

v) Target End-use Measures

There are no updates to the target end-use measures.

vi) Incentive Strategy

There are no updates to the incentive strategy.

vii) Roles and Responsibilities

There are no updates to roles and responsibilities.

viii) Evaluation, Monitoring, and Verification

There are no updates to evaluation, monitoring, and verification for CIRI.

D. Commercial and Industrial Equipment Rebates Program

i) Program Description

The CIER program issues prescriptive rebates on premium efficiency gas appliances and heating equipment to increase the penetration of these measures in the facilities of PGW's commercial, industrial, and multi-family customers. The program has the following objectives:

- Promote the selection of premium efficiency residential models at the time of purchase of commercial and industrial sized gas heating equipment.
- 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.

Eligible customers will select their own licensed contractor to install the premium efficiency equipment and receive cash rebates to offset of the majority of the higher efficiency equipment's incremental costs.

ii) Costs, Savings, and Benefits

Projections

The program aims to serve 170 customers in FY 2016, with associated annualized gas savings of 11.0 BBtu, or 64.5 MMBtu per-customer. The program is projected to cost $313,650. The following table shows a detailed breakout of participation, costs, and savings.

Table 18 – Projected CIER Impacts for FY 2016

	Projected (FY 2016)
PARTICIPATION	
Customers with Installations	170
COSTS	
Measure Installation Costs	$236,650
Administration and Management	$-
Marketing and Business Development	$-
Contractor Costs	$60,000
Inspection and Verification	$17,000

On-site Technical Assessment	$-
Evaluation	$-
Utility Costs	**$313,650**
Participant Costs	$131,335
Total	**$444,985**
BENEFITS	
Net Annual BBtu	11.0
Net Lifetime BBtu	175.5
Net Annual MMBtu / Customer	64.5
Weighted Lifetime (years)	16.0

iii) Workflow

Although no immediate new workflow changes will be implemented, PGW plans to use the CIER impact evaluation and market study to guide any necessary program updates.

iv) Target Market and Program Eligibility

There are no updates to program eligibility.

v) Target End-use Measures

In response to the launch of a new PGW EnergySense steam trap incentives in FY 2015, PGW heard from several firms interested in retrofitting steam traps with new functional mechanisms, rather than replacing the entire unit. By replacing just the functional components, the repair can be more cost-effective due to significantly lower labor and slightly lower materials costs. Beginning in FY 2016, PGW will plan to offer prescriptive rebates for steam trap inserts as an alternative to full replacement units. PGW will verify the installation through signed confirmation from the installer indicating the number of installed traps or steam trap repair kits, providing invoices indicating trap model and manufacturer as well as the model and manufacturer of the steam trap repair kit, and/or visual inspection of the trap and confirmation of the submittals. Both steam trap conservation methods will yield significant gas savings, and, to the best of PGW's knowledge, have been implemented by conservation programs at Nicor Gas and Peoples Gas in Pennsylvania.

PGW also plans to update the eligibility requirements of commercial-sized hot water heaters by eliminating the requirement that equipment be ENERGY STAR® certified. Equipment eligibility will be solely based on meeting a minimum rating of 94% thermal efficiency as certified by AHRI. This change is due to the customers investing in high efficiency commercial hot-water heaters that are new to the market but which have not sought ENERGY STAR certification.

vi) Incentive Strategy

Table 19 – FY 2016 CIER Incentive Strategy

Measure Name	Minimum Efficiency	Rebate Amount
Boiler, Hot Water (300 ≤ MBH ≤ 2,500)	90% Thermal Efficiency (Et)	\$2,900 - \$8,400
Boiler, Hot Water (300 ≤ MBH ≤ 2,500)	85% Thermal Efficiency (Et)	\$800-\$6,300
Commercial Gas Large Vat Fryer (Per-Frypot)	ENERGY STAR®	\$1,900
Commercial Gas Standard Vat Fryer (Per-Frypot)	ENERGY STAR®	\$1,400
Commercial Gas Steam Cooker (Per Pan)	ENERGY STAR®	\$600
High-Efficiency Pre-Rinse Spray Valve	1.28 Gallons per Minute (GPM) maximum	\$25
CI Domestic Hot Water Heaters (input ≥ 75 KBtu/h)	≥94% Et	\$4/MBH of rated input capacity
Low Pressure Steam Trap Replacement or Insert	PSIG < 15	\$50
Medium Pressure Steam Trap Replacement or Insert	15 ≤ PSIG < 75	\$150
High Pressure Steam Trap Replacement or Insert	75 ≤ PSIG	\$250

vii) Roles and Responsibilities

There are no updates to roles and responsibilities.

viii) Evaluation, Monitoring, and Verification

There are no updates to evaluation, monitoring, and verification for the CIER program.

E. High Efficiency Construction Incentives Program

i) Program Description

The HECI program promotes natural gas energy efficiency in the new construction and gut rehab markets, both for residential and non-residential projects. The program provides technical assistance and prescriptive financial incentives for projects that go beyond building code. For commercial projects, incentives increase for projects based on natural gas savings compared to the code baseline. The program has the following objectives:

- Conserve natural gas consumption through cost-effective energy efficiency measures in new construction and gut rehabilitation projects.
- Promote a better understanding of energy efficiency options available in the new construction and gut rehabilitation markets.

HECI seeks to convince homebuilders, building owners, engineers, architects, and contractors to incorporate natural gas energy efficiency into the design of their projects and go beyond standards dictated by the building code. The program provides technical assistance and incentives for meeting efficiency thresholds. PGW has engaged a CSP to assess the project plans and verify eligibility, helping the customers meet and exceed program energy savings requirements. PGW provides the financial incentive to the customer upon the completion of the project.

ii) Costs, Savings, and Benefits

Projections

The program aims to serve 30 single-family residential units, 10 multifamily buildings, and two commercial new construction projects in FY 2016, with associated annualized gas savings of 2.8 BBtu, or 66.4 MMBtu/customer. The program is projected to cost approximately $181,000.

Table 20 – Projected HECI Impacts for FY 2016

	Projected (FY 2016)
PARTICIPATION	
Customers with Installations	42
COSTS	
Measure Installation Costs	$157,000
Administration and Management	$-
Marketing and Business Development	$-
Contractor Costs	$16,000
Inspection and Verification	$8,000
On-site Technical Assessment	$-

Evaluation	$-
Utility Costs	**$181,000**
Participant Costs	$90,009
Total	**$271,009**
BENEFITS	
Net Annual BBtu	2.8
Net Lifetime BBtu	50.6
Net Annual MMBtu / Customer	66.1
Weighted Lifetime (years)	18.2

iii) Workflow

There are no updates to Workflow in the HECI program.

iv) Target Market and Program Eligibility

There are no updates to target market and program eligibility in the HECI program.

v) Target End-use Measures

In accordance with new U.S. Department of Energy manufacturer standards, PGW has increased its baseline water heater assumptions from 0.58 energy factor to 0.615 for storage hot water heaters. In the short-term, below-baseline equipment will continue to be available through retailers; however, PGW's adoption of the new standards will encourage customers to go further in designing high-efficiency projects that exceed the new, higher standards.

vi) Incentive Strategy

PGW continues to find that in some projects the calculated customer grant may exceed gas benefits due to prescriptive rebates being included within the comprehensive custom projects. This issue was addressed in FY 2015 when the incentives for HECI and RHER were adjusted to protect gas administrator test cost-effectiveness while still aligning program incentives. Although the issue has become much rarer, on some occasions, a customer's combined RHER and HECI project incentive may exceed the gas benefits for that project. This issue is further aggravated by the fact that gas avoided costs have fallen again with the FY 2016 IP. PGW will continue to track this issue in FY 2016 and if it becomes more frequent again, make any necessary program incentive design changes.

vii) Roles and Responsibilities

There are no updates to roles and responsibilities

viii) Evaluation, Monitoring, and Verification

There are no updates to evaluation, monitoring, and verification for the HECI program.

F. Home Rebates Program

i) Program Description

The Home Rebates program provides incentives to customers and contractors that perform comprehensive natural gas energy efficiency retrofits. The Home Rebates program has the following goals:

- Save natural gas through cost-effective residential retrofits.
- Achieve an average reduction of at least 20 percent in annual gas heating consumption among all participants.
- Promote better understanding of energy efficiency options available for the residential market.

Home Rebates provides incentives to single-family residential customers for implementing natural gas saving measures in their home, such as air sealing, insulation, and heating system replacements. Customers are eligible for a subsidized energy assessment and can earn rebates based on the calculated first-year MMBtu savings of their completed measures. PGW, through a third-party administrator, oversees a network of contractors approved to perform work under Home Rebates. The program builds on the lessons learned from implementing ELIRP, which promotes similar energy efficiency packages among PGW's low-income population through use of approved conservation service providers ("CSPs").

ii) Costs, Savings, and Benefits

Projections

PGW aims to complete 257 Home Rebates projects in FY 2016, with associated annualized gas savings of 7.5 BBtu, or 29.0 MMBtu/customer. The program is projected to cost $666,614.

PGW has revised its Home Rebates program assumptions to account for the program's strong conversion rates from initial audits to completed projects. Although the program is not projected to achieve cumulative TRC cost-effectiveness in Phase I, due to slow market uptake and high implementation costs, it is projected to provide positive TRC net benefits going forward despite falling gas commodity costs. The Home Rebates Program is projected to achieve a 1.01 BCR in the FY 2016 program year and a Gas Administrator BCR of 2.02.

Table 21 – Projected Home Rebates Impacts for FY 2016

	Projected (FY 2016)
PARTICIPATION	
Analyses/Audits	643
Customers with Installations	257
COSTS	
Measure Installation Costs	$437,614
Administration and Management	$-
Marketing and Business Development	$-
Contractor Costs	$178,000
Inspection and Verification	$51,000
On-site Technical Assessment	$-
Evaluation	$-
Utility Costs	**$666,614**
Participant Costs	$863,909
Total	**$1,530,523**
BENEFITS	
Net Annual BBtu	7.5
Net Lifetime BBtu	218.8
Net Annual MMBtu / Customer	29.0
Weighted Lifetime (years)	29.3

iii) Workflow

There are no updates to the program workflow.

iv) Target Market, Program Eligibility and Process

There are no updates to Home Rebates target market, program eligibility and process.

v) Target End-use Measures

PGW will apply the updated residential domestic hot water heater baseline discussed above in the HECI section to Home Rebates where applicable.

In FY 2016, PGW will also encourage CSPs to perform more low-cost and "labor-only" measures that easily capture savings that can be done at the time of an audit to provide customers with immediate value and deliver program savings without additional cost. Low-cost "labor-only" measures include hot water tank turn-downs and thermostat adjustments. Similarly PGW will explore new ways to market basic measure packages at the time of audit, such as door weather-stripping and basic air sealing, pipe wrap, thermostat and health and safety measures that can be easily included early in a project.

vi) Incentive Strategy

The primary challenge in the Home Rebates program has been limited customer participation. A secondary challenge to program success is the number of projects that do not proceed with a comprehensive project. The Home Rebates program has achieved a high project conversion rate of 44% since inception, but significant percentages of homes still do not proceed after receiving an audit. To combat these issues, PGW is launching a limited time offer in FY 2015 to provide a $500 bonus to encourage the completion of comprehensive projects. The promotion is designed to motivate customers that had audits performed but have not yet acted upon them, and to encourage borderline customers to participate. This incentive is simple to communicate, and gives CSPs an opportunity to reach out to old customers and motivate new ones. Pending the outcome of this incentive promotion, PGW may offer other similar short-term marketing promotions, such as referral bonuses, in FY 2016.

In addition to short-term marketing promotions, PGW will review the results of the comprehensive project bonus promotion to inform potential changes to the Home Rebates Program incentive strategy. One option that PGW is exploring is to calculate rebates based on lifetime savings, instead of first-year savings. This shift would provide higher incentives for comprehensive projects that achiever higher savings over a longer period of time, and therefore more cost-effective savings. PGW is exploring design strategies to ensuring this change would be effective and could be implemented seamlessly into the program's communications and workflow.

vii) Roles and Responsibilities

There are no updates to roles and responsibilities in the Home Rebates program.

viii) Evaluation, Monitoring, and Verification

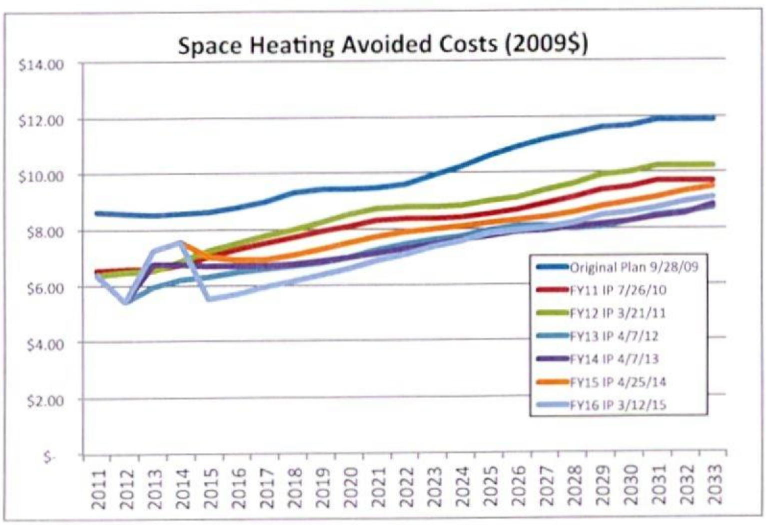
There are no updates to evaluation, monitoring, and verification in the Home Rebates program.

III. Appendices

A. PGW Avoided Gas Costs Over Time

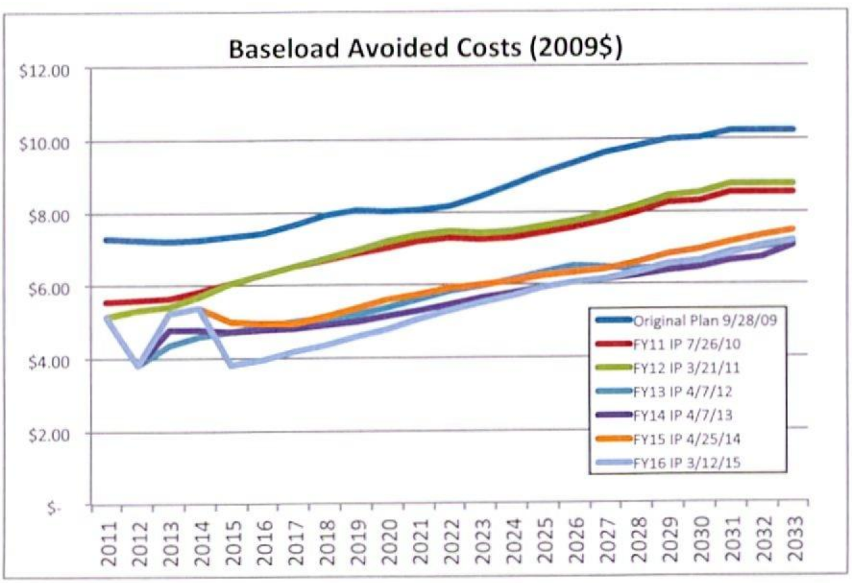
Comparison of Space Heating Avoided Costs (2009$)

Year	Original Plan 9/28/09	FY11 IP 7/26/10	FY12 IP 3/21/11	FY13 IP 4/7/12	FY14 IP 4/7/13	FY15 IP 4/25/14	FY16 IP 3/12/15
2011	$8.63	$6.54	$6.35	$6.35	$6.35	$6.35	$6.35
2012	$8.55	$6.57	$6.48	$5.40	$5.40	$5.40	$5.40
2013	$8.51	$6.59	$6.51	$5.97	$6.75	$7.24	$7.24
2014	$8.54	$6.77	$6.84	$6.22	$6.73	$7.54	$7.54
2015	$8.62	$7.04	$7.21	$6.34	$6.67	$7.00	$5.52
2016	$8.77	$7.30	$7.51	$6.46	$6.67	$6.90	$5.69
2017	$9.00	$7.52	$7.76	$6.60	$6.70	$6.91	$5.97
2018	$9.29	$7.70	$8.00	$6.72	$6.76	$7.08	$6.15
2019	$9.44	$7.90	$8.25	$6.81	$6.85	$7.29	$6.35
2020	$9.43	$8.09	$8.50	$6.97	$6.96	$7.51	$6.57
2021	$9.46	$8.27	$8.71	$7.22	$7.11	$7.70	$6.83
2022	$9.57	$8.36	$8.80	$7.42	$7.27	$7.87	$7.09
2023	$9.88	$8.34	$8.78	$7.59	$7.44	$7.97	$7.34
2024	$10.24	$8.38	$8.82	$7.73	$7.61	$8.06	$7.56
2025	$10.58	$8.51	$8.96	$7.94	$7.71	$8.18	$7.79
2026	$10.91	$8.66	$9.12	$8.10	$7.85	$8.29	$7.93
2027	$11.19	$8.87	$9.34	$8.08	$7.92	$8.38	$8.02
2028	$11.41	$9.12	$9.60	$8.00	$8.01	$8.55	$8.19
2029	$11.59	$9.38	$9.88	$8.04	$8.13	$8.80	$8.44
2030	$11.65	$9.48	$9.98	$8.23	$8.26	$8.92	$8.56
2031	$11.87	$9.69	$10.24	$8.45	$8.41	$9.10	$8.74
2032	$11.87	$9.69	$10.24	$8.57	$8.50	$9.32	$8.95
2033	$11.87	$9.69	$10.24	$8.70	$8.83	$9.46	$9.09



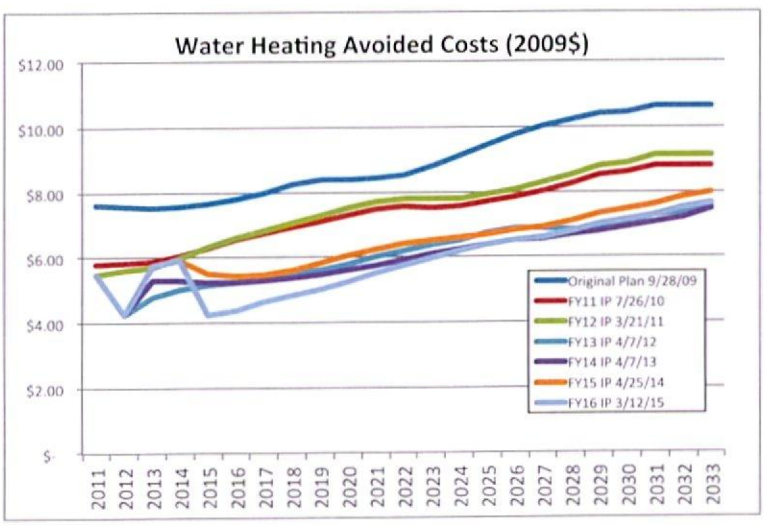
Comparison of Baseload Avoided Costs (2009$)

Year	Original Plan 9/28/09	FY11 IP 7/26/10	FY12 IP 3/21/11	FY13 IP 4/7/12	FY14 IP 4/7/13	FY15 IP 4/25/14	FY16 IP 3/12/15
2011	$7.28	$5.54	$5.15	$5.15	$5.15	$5.15	$5.15
2012	$7.24	$5.59	$5.32	$3.82	$3.82	$3.82	$3.82
2013	$7.21	$5.64	$5.40	$4.36	$4.80	$5.23	$5.23
2014	$7.24	$5.82	$5.70	$4.59	$4.78	$5.38	$5.38
2015	$7.32	$6.07	$6.04	$4.73	$4.74	$5.00	$3.80
2016	$7.45	$6.30	$6.30	$4.85	$4.76	$4.94	$3.95
2017	$7.65	$6.51	$6.53	$4.99	$4.81	$4.97	$4.20
2018	$7.91	$6.68	$6.74	$5.12	$4.89	$5.14	$4.37
2019	$8.05	$6.86	$6.97	$5.21	$5.00	$5.36	$4.57
2020	$8.04	$7.04	$7.19	$5.38	$5.13	$5.58	$4.79
2021	$8.07	$7.21	$7.38	$5.61	$5.29	$5.76	$5.04
2022	$8.17	$7.29	$7.46	$5.81	$5.45	$5.92	$5.29
2023	$8.45	$7.27	$7.44	$5.99	$5.63	$6.01	$5.51
2024	$8.78	$7.30	$7.48	$6.13	$5.80	$6.10	$5.71
2025	$9.08	$7.43	$7.61	$6.33	$5.92	$6.23	$5.93
2026	$9.37	$7.57	$7.75	$6.50	$6.06	$6.34	$6.06
2027	$9.63	$7.76	$7.95	$6.49	$6.13	$6.44	$6.15
2028	$9.82	$7.99	$8.18	$6.42	$6.24	$6.60	$6.31
2029	$9.99	$8.23	$8.43	$6.47	$6.36	$6.85	$6.55
2030	$10.04	$8.32	$8.52	$6.66	$6.49	$6.97	$6.67
2031	$10.24	$8.52	$8.76	$6.88	$6.64	$7.14	$6.84
2032	$10.24	$8.52	$8.76	$7.00	$6.74	$7.36	$7.05
2033	$10.24	$8.52	$8.76	$7.13	$7.06	$7.49	$7.18



Comparison of Water Heating Avoided Costs (2012$)

Year	Original Plan 9/28/09	FY11 IP 7/26/10	FY12 IP 3/21/11	FY13 IP 4/7/12	FY14 IP 4/7/13	FY15 IP 4/25/14	FY16 IP 3/12/15
2011	$7.62	$5.79	$5.45	$5.45	$5.45	$5.45	$5.45
2012	$7.57	$5.83	$5.61	$4.21	$4.21	$4.21	$4.21
2013	$7.54	$5.88	$5.68	$4.76	$5.29	$5.74	$5.74
2014	$7.57	$6.06	$5.98	$5.00	$5.26	$5.92	$5.92
2015	$7.65	$6.31	$6.33	$5.13	$5.23	$5.50	$4.23
2016	$7.78	$6.55	$6.61	$5.26	$5.24	$5.43	$4.39
2017	$7.99	$6.76	$6.84	$5.39	$5.28	$5.45	$4.64
2018	$8.26	$6.94	$7.05	$5.52	$5.36	$5.62	$4.82
2019	$8.40	$7.12	$7.29	$5.61	$5.46	$5.85	$5.02
2020	$8.39	$7.30	$7.52	$5.78	$5.59	$6.06	$5.24
2021	$8.42	$7.48	$7.72	$6.02	$5.74	$6.24	$5.49
2022	$8.52	$7.55	$7.80	$6.21	$5.91	$6.40	$5.74
2023	$8.81	$7.54	$7.78	$6.39	$6.08	$6.50	$5.97
2024	$9.14	$7.57	$7.82	$6.53	$6.25	$6.59	$6.17
2025	$9.45	$7.70	$7.95	$6.74	$6.36	$6.72	$6.40
2026	$9.76	$7.84	$8.09	$6.90	$6.50	$6.83	$6.53
2027	$10.02	$8.04	$8.30	$6.88	$6.58	$6.92	$6.62
2028	$10.22	$8.27	$8.54	$6.82	$6.68	$7.09	$6.78
2029	$10.39	$8.52	$8.80	$6.86	$6.80	$7.34	$7.02
2030	$10.44	$8.61	$8.89	$7.05	$6.93	$7.46	$7.14
2031	$10.65	$8.81	$9.13	$7.27	$7.08	$7.63	$7.31
2032	$10.65	$8.81	$9.13	$7.40	$7.18	$7.85	$7.52
2033	$10.65	$8.81	$9.13	$7.52	$7.50	$7.99	$7.66



B. List of Acronyms

Acronym	Meaning
ACEEE	American Council for an Energy Efficient Economy
ARRA	American Recovery and Reinvestment Act
BCR	Benefit-cost ratio
BSRP	Basic System Repair Program
CEE	Consortium for Energy Efficiency
CIRI	Commercial and Industrial Retrofit Program
CRRI	Comprehensive Residential Heating Retrofit Program
CRP	Customer Responsibility Program
CSP	Conservation Service Provider
CWP	Conservation Works Program
CY	Calendar Year
DEP	Department of Environmental Protection
DSM	Demand-Side Management
ECA	Energy Coordinating Agency
ECRS	Efficiency Cost Recovery Surcharge
ELIRP	Enhanced Low Income Program
FY	Fiscal Year (PGW's fiscal year goes from September 1 to August 31)
GEEG	Green Energy Economics Group, Inc.
HECI	High Efficiency Construction Program
Keystone HELP	Keystone Home Energy Loan Program
NAECP	National Appliance Energy Conservation Act
NDR	Nominal Discount Rate
PA	Pennsylvania
PECIEP	Commercial and Industrial Equipment Rebates Program
RHER	Premium Efficiency Heating Equipment Program
PGW	Philadelphia Gas Works
PHDC	Philadelphia Housing Development Corp.
RDR	Real Discount Rate
TRC	Total Resource Cost
TRM	Technical Reference Manual
USC	Universal Services Charge
WAP	Weatherization Assistance Program

C. Units

Dth = 10 therms
MDth = 10,000 therms
MMDth = 10,000,000 therms

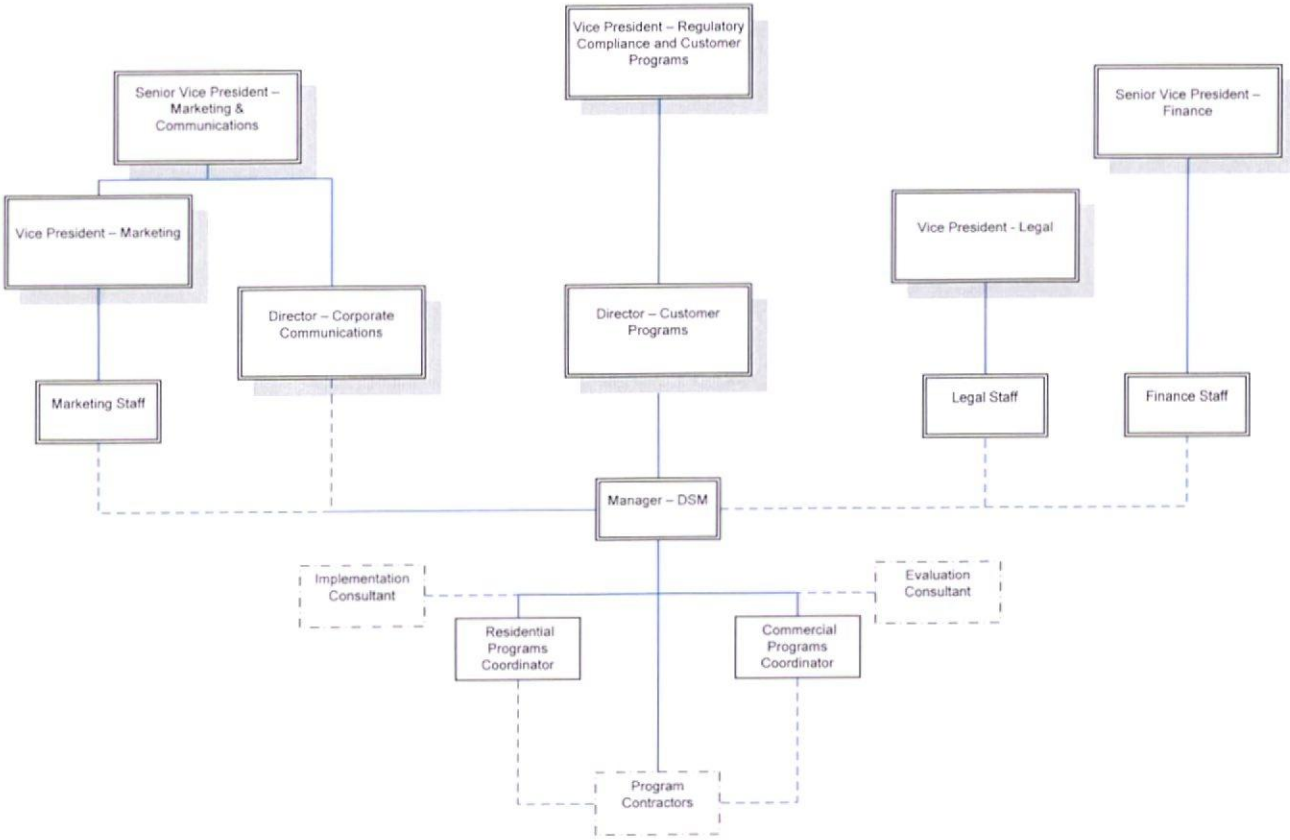
Ccf = 100 cubic feet
Mcf = 1,000 cubic feet
MMcf = 1,000,000 cubic feet
Bcf = 1,000,000,000 cubic feet

MMBtu = 1,000,000 Btu
BBtu = 1,000,000,000 Btu

kW = 1,000 watts
MW = 1,000,000 watts
GW = 1,000,000,000 watts

1 MMBtu = 1 Dth
1.03 therm = 1 ccf

D. *Organization Chart*



E. *Sales Reduction Projections*

Gas Sales Reduction Projections from FY 2016 Activity (MCF)

FY	Total	Total (excluding CRP)
2016	37,495	16,358
2017	92,034	38,992
2018	92,034	38,992
2019	92,034	38,992
2020	92,034	38,992
2021	91,786	38,744
2022	90,741	37,698
2023	90,741	37,698
2024	90,741	37,698
2025	90,741	37,698
2026	84,639	35,314
2027	84,639	35,314
2028	81,670	32,344
2029	79,885	30,560
2030	78,157	28,831
2031	78,157	28,831
2032	78,157	28,831
2033	78,157	28,831
2034	35,276	28,831
2035	35,276	28,831
2036	26,825	20,380
2037	24,841	18,396
2038	23,759	17,314
2039	23,759	17,314
2040	23,759	17,314
2041	14,236	7,792
2042	14,236	7,792
2043	14,236	7,792
2044	14,236	7,792
2045	13,441	6,996
2046	6,445	-
2047	6,445	-
2048	6,445	-
2049	6,445	-
2050	6,445	-
Lifetime	**1,674,324**	**607,510**

F. Projected Job Creation

The following table presents the range of employment-impact projects for the proposed PGW programs, using a range of jobs created per trillion BTU saved. The job figures presented here do not include the additional jobs created from the electric savings resulting from PGW's programs. Please see PGW's DSM Phase II Plan for a discussion of the research that lead to the assumptions of jobs created per TBtu.

	JOB CREATION IMPACTS OF GAS EFFICIENCY PORTFOLIO		
	30 Jobs/TBtu	**40 Jobs/TBtu**	**50 Jobs/TBtu**
RESIDENTIAL PROGRAMS			
FY 2016	43	57	71
NON-RESIDENTIAL PROGRAMS			
FY 2016	9	12	15
TOTAL PORTFOLIO			
FY 2016	52	69	86

G. Technical Reference Manual

The technical reference manual for FY 2016 has been provided as a separate document.

Technical Reference Manual

Measure Savings Algorithms

ENERGYSENSE

Your building, your savings.

PGW

June 4, 2015

Table of Contents

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

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

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

ΔkWh_{Aux} = *Annual Gas Savings (MMBtu) × Auxiliary*

ΔkWh_{Cool} = 0 kWh if house has no air conditioning
= $\Delta \mathbf{kWh_{CAC}}$ if house has central air conditioning

[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

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

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

Deemed Savings:

$$\Delta kWh = \Delta kWh_{aux} + \Delta kWh_{CAC}\,(missing) = 7.7 + 77.1 = 84.8\,kWh$$

$$\Delta kWh_{aux} = 1.53 \times 5.02 = 7.7$$

$$\Delta kWh_{CAC}\,(missing) = 83\% \times \Delta kWh_{CAC}$$
$$= 83\% \times 3 \times \left(\frac{12}{10 \times 0.8} \right) \times 1032 \times 0.02 = 77.1$$

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*

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.

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

Where:

EF_{Base} = Energy Factor of baseline water heater = 0.60
EF_{Eff} = Energy Factor of efficient water heater

Electric Savings Algorithms

There are no electric savings from this measure.

Energy Savings
ΔkWh = 0 kWh

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

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%

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: 7/29/13
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	0.60 EF

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

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)[6]

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 = 0.60
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.

[6] Based on 2014 APPRISE evaluation for boilers.

Electric Savings Algorithms

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
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.

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

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.

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[7]/day to estimate heating slope (MMbtu/HDD63) and baseload daily use (MMBtu/day) with an annual HDD63 of 4033[8] 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%

[7] 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.
[8] 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)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[9]

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.[10]

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.

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[9] 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.

[10] 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

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[11]
$SEER_{CAC}$	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

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

Term	Type	Value	Source
CF_{RAC}	Fixed	0.58	PUC Technical Reference Manual
$F_{Room,AC}$	Fixed	0.38	Calculated[12]

EFLH, CDD and HDD by City

City	$EFLH_{cool}$ (Hours)[13]	$EFLH_{cool\ RAC}$ (Hours)[14]	CDD (Base 65)[15]	HDD (Base 65)[16]
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.

3)Roof and Cavity Insulation

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

Measure Description

[12] 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). $F_{Room,AC} = (425\ ft^2 * 2.1)/(2323\ ft^2) = 0.38$
[13] PA 2010 TRM Table 2-1.
[14] PA SWE Interim Approved TRM Protocol – Residential Room AC Retirement
[15] 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
[16] Ibid.

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.

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[17].
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.[18]

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) × 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*

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[17] From NWS data for PHL from 2002-2009, HDD63=4033 and HDD62 = 3820
[18] 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

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

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

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.*

$SEER_{CAC}$ = *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[19]
$SEER_{CAC}$	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[20]

EFLH, CDD and HDD by City

City	$EFLH_{cool}$ (Hours)[21]	$EFLH_{cool\ RAC}$ (Hours)[22]	CDD (Base 65)[23]	HDD (Base 65)[24]
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.

Measure Lifetimes

Measure	Measure Lifetime

[19] "State of Ohio Energy Efficiency Technical Reference Manual," prepared for the Public Utilities Commission of Ohio by Vermont Energy Investment Corporation. August 6, 2010.
[20] 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). $F_{Room,AC} = (425\ ft^2 * 2.1)/(2323\ ft^2) = 0.38$
[21] PA 2010 TRM Table 2-1.
[22] PA SWE Interim Approved TRM Protocol – Residential Room AC Retirement
[23] 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
[24] Ibid.

Roof Insulation	40
Cavity Insulation	40

Source: NYSERDA Home Performance with Energy Star.

Water Savings
There are no water savings for this measure.

4)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.[25]

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

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

ΔkWh_{Aux} = *Annual Gas Savings (MMBtu) × 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*

[25] 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:

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.

5)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

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[26]
Ave. Wind Speed	=	0 mph
Relative Humidity	=	N/A
Dew Point	=	N/A
Condensation Control Thickness	=	N/A
Hours Per Year	=	2000[27]
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[28].

[26] Average winter temperature for Philadelphia from "Cost Savings and Comfort for Existing Buildings", 3rd Edition, by John Krigger, Saturn Resource Management. Page 255.
[27] 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
[28] NYSERDA Home Performance with Energy Star

6)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[29]
Dt	=	Design temperature difference (assume from 11° F to 70° F for properly sized boiler)[30] = 59° F

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

[29] Based on NCDC ASOS temperature data for PHL from 2002 through 2009.
[30] 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[31].

7)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[32]

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

Electric Savings Algorithms
Electric savings per 100 CFM-25 reduction:[33]

- 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[34].

8) 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[35].

24 = Hours per day

AREA = Square feet of window area.

[33] UI/CL&P Program Savigns Documentation, 2011, page 131
[34] California DEER estimage.
[35] From NWS data for PHL from 2002-2009, HDD63=4033 and HDD62 = 3820

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 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.[36]

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) × 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

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

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

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.

[36] 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[37]
$SEER_{CAC}$	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

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

Term	Type	Value	Source
$F_{Room,AC}$	Fixed	0.38	Calculated[38]

EFLH, CDD and HDD by City

City	$EFLH_{cool}$ (Hours)[39]	$EFLH_{cool\ RAC}$ (Hours)[40]	CDD (Base 65)[41]	HDD (Base 65)[42]
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

[38] 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). $F_{Room,AC} = (425\ ft^2 * 2.1)/(2323\ ft^2) = 0.38$
[39] PA 2010 TRM Table 2-1.
[40] PA SWE Interim Approved TRM Protocol – Residential Room AC Retirement
[41] 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
[42] Ibid.

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[43].

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[44]
GPM_{eff}	=	Maximum gallons per minute of the efficient showerhead
2.48	=	Average number of people per household[45]
11.6	=	Average gallons of water per person per day used for showering[46]
365	=	Days per year
1.6	=	Average number of showers per home[47]

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

43 Pennsylvania Public Utility Commission Act 129 Technical Reference Manual (June 2011)
44 The Energy Policy Act of 1992 established the maximum flow rate for showerheads at 2.5 gallons per minute (GPM)
45 Pennsylvania, Census of Population, 2000.
46 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)
47 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

		Fahrenheit)
55	=	Assumed temperature of water entering house (degrees Fahrenheit)[48]
RE_{DHW}	=	Recovery efficiency of the domestic hot water heater = 75%[49]

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[50].

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[51].

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).

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

[48] 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
[49] 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).
[50] Pennsylvania Public Utility Commission Act 129 Technical Reference Manual (June 2011)
[51] Pennsylvania Public Utility Commission Act 129 Technical Reference Manual (June 2011)

Where:

$\Delta Gallons$	=	Gallons of water saved
GPM_{base}	=	Gallons per minute of baseline showerhead = 2.2 GMP[52]
GPM_{eff}	=	Gallons per minute of the efficient showerhead
2.48	=	Average number of people per household[53]
10.9	=	verage gallons per day used by faucet[54]
365	=	Days per year
50%	=	Drain rate, the percentage of water flowing down the drain[55]
3.5	=	Average Number of Faucets per home[56]

Natural Gas Savings Algorithms

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

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

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).[57]
RE_{DHW}	=	Recovery efficiency of the domestic hot water heater = 75%[58]

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[59].

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[52] 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

[53] Pennsylvania, Census of Population, 2000.

[54] 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)

[55] Estimate consistent with Ontario Energy Board, "Measures and Assumptions for Demand Side Management Planning."

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

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

[58] See assumption for low flow shower head.

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

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.

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[60].

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[61].

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

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
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[62]
8,760	=	Number of hours in a year
RE_{DHW}	=	Recovery efficiency of the domestic hot water heater = 75%[63]
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.

[62] 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
[63] See assumption for low flow showerhead.

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[64].

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

[64] Page 410. Vermont Technical Reference Manual and New Jersey Clean Energy Program Protocols

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*[65]

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)[66]
RE_{DHW}	=	Recovery efficiency of the domestic hot water heater = 75%[67]

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

[65] 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)
[66] 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
[67] See assumption for low flow showerhead.

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.

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.[68]

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

[68] Recommendation based on method pioneered by Gary Klein expert on DHW based in California

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%[69]

"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
Outer Surface Emittance	=	0.9

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

[69] See assumption for low flow showerhead.

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[70].

7)Hot Water Storage Tank Wrap

Unique Measure Code(s): TBD
Draft date: 4/30/12
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."[71]

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[72] unless

[70] NYSERDA Home Performance with Energy Star
[71] Building Performance Institute, Inc. *Technical Standards for the Heating Professional*. Revised 11/20/07. Page 12.

		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[73]
8,760	=	Number of hours in a year
RE_{DHW}	=	Recovery efficiency of the domestic hot water heater = 75%[74]
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 (ft^2)	Surface Area of Accessed Areas (ft^2)**	Surface arc of Cylinder minus Accessed Areas (ft^2)	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[75].

[72] 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
[73] Assumed to be in unconditioned space, ambient temperature assumption based on: http://lwf.ncdc.noaa.gov/img/documentlibrary/clim81supp3/tempnormal_hires.jpg
[74] See assumption for low flow showerhead.
[75] 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[76]/day to estimate heating slope *(MMbtu/HDD63) and baseload daily use (MMBtu/day) with an annual HDD63 of 4033*[77] *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
ΔkW = 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%

[76] 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.
[77] 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)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[78]

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.[79]

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) × Auxiliary*

ΔkWh_{Cool} = 0 kWh if house has no air conditioning
= $\Delta \mathbf{kWh_{CAC}}$ if house has central air conditioning
= $\Delta \mathbf{kWh_{RAC}}$ if house has room air conditioning
= 83% × $\Delta \mathbf{kWh_{CAC}}$ 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
= $\Delta \mathbf{kW_{CAC}}$ *if house has central air conditioning*
= $\Delta \mathbf{kW_{RAC}}$ 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.

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[78] 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.

[79] 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

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[80]
$SEER_{CAC}$	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

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

Term	Type	Value	Source
CF_{RAC}	Fixed	0.58	PUC Technical Reference Manual
$F_{Room,AC}$	Fixed	0.38	Calculated[81]

EFLH, CDD and HDD by City

City	$EFLH_{cool}$ (Hours)[82]	$EFLH_{cool\ RAC}$ (Hours)[83]	CDD (Base 65)[84]	HDD (Base 65)[85]
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.

3)Roof and Cavity Insulation

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

Measure Description

[81] 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). $F_{Room,AC} = (425\ ft^2 * 2.1)/(2323\ ft^2) = 0.38$

[82] PA 2010 TRM Table 2-1.

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

[84] 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

[85] Ibid.

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.

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[86].
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.*[87]

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)* × *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

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[86] From NWS data for PHL from 2002-2009, HDD63=4033 and HDD62 = 3820
[87] 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

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

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

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.*

$SEER_{CAC}$ = *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[88]
$SEER_{CAC}$	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[89]

EFLH, CDD and HDD by City

City	$EFLH_{cool}$ (Hours)[90]	$EFLH_{cool\ RAC}$ (Hours)[91]	CDD (Base 65)[92]	HDD (Base 65)[93]
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.

Measure Lifetimes

Measure	Measure Lifetime

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

[89] 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). $F_{Room,AC} = (425\ ft^2 * 2.1)/(2323\ ft^2) = 0.38$

[90] PA *2010* TRM Table 2-1.

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

[92] 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

[93] Ibid.

Roof Insulation	40
Cavity Insulation	40

Source: NYSERDA Home Performance with Energy Star.

Water Savings
There are no water savings for this measure.

4)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.[94]

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

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

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

ΔkWh_{Cool} = 0 kWh if house has no air conditioning
= ΔkWh_{CAC} *if house has central air conditioning*
= 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*

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[94] 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:

11. Average size of residential air conditioner.
12. Minimum Federal Standard for new Central Air Conditioners/Heat Pumps between 1990 and 2006.
13. New York Standard Approach for Estimating Energy Savings from Energy Efficiency Measures in Commercial and Industrial Programs, September 1, 2009.
14. DEER 2005 cooling savings for climate zone 16, assumes a variety of thermostat usage patterns.
15. 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.

5)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
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[95]
Ave. Wind Speed	=	0 mph
Relative Humidity	=	N/A
Dew Point	=	N/A
Condensation Control Thickness	=	N/A
Hours Per Year	=	2000[96]
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[97].

6)Heating Pipe Insulation

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

[95] Average winter temperature for Philadelphia from "Cost Savings and Comfort for Existing Buildings", 3rd Edition, by John Krigger, Saturn Resource Management. Page 255.
[96] 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
[97] NYSERDA Home Performance with Energy Star

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[98]
Dt	=	Design temperature difference (assume from 11° F to 70° F for properly sized boiler)[99] = 59° F

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

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

[98] Based on NCDC ASOS temperature data for PHL from 2002 through 2009.
[99] 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.

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[100].

7)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[101]

Electric Savings Algorithms
Electric savings per 100 CFM-25 reduction:[102]

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

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

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[103].

8)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[104].
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 replacement precedes the air sealing work. Use default AFUE of 80% if actual AFUE is not available.

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

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.[105]

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) × 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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[105] 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[106]
$SEER_{CAC}$	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[107]

[106] "State of Ohio Energy Efficiency Technical Reference Manual," prepared for the Public Utilities Commission of Ohio by Vermont Energy Investment Corporation. August 6, 2010.
[107] 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)[108]	$EFLH_{cool\ RAC}$ (Hours)[109]	CDD (Base 65)[110]	HDD (Base 65)[111]
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

9)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.

[108] PA 2010 TRM Table 2-1.
[109] PA SWE Interim Approved TRM Protocol – Residential Room AC Retirement
[110] 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
[111] 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*[112].

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[113]
GPM_{eff}	=	Maximum gallons per minute of the efficient showerhead
2.48	=	Average number of people per household[114]
11.6	=	Average gallons of water per person per day used for showering[115]
365	=	Days per year
1.6	=	Average number of showers per home[116]

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

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

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)[117]
RE_{DHW}	=	Recovery efficiency of the domestic hot water heater = 75%[118]

[112] Pennsylvania Public Utility Commission Act 129 Technical Reference Manual (June 2011)
[113] The Energy Policy Act of 1992 established the maximum flow rate for showerheads at 2.5 gallons per minute (GPM)
[114] Pennsylvania, Census of Population, 2000.
[115] 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)
[116] 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

[117] 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

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[119].

10) 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[120].

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[121]
GPM_{eff}	=	Gallons per minute of the efficient showerhead

[118] 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).
[119] Pennsylvania Public Utility Commission Act 129 Technical Reference Manual (June 2011)
[120] Pennsylvania Public Utility Commission Act 129 Technical Reference Manual (June 2011)
[121] 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

2.48	=	Average number of people per household[122]
10.9	=	Average gallons per day used by faucet[123]
365	=	Days per year
50%	=	Drain rate, the percentage of water flowing down the drain[124]
3.5	=	Average Number of Faucets per home[125]

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).[126]
RE_{DHW}	=	Recovery efficiency of the domestic hot water heater = 75%[127]

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[128].

11) Efficient Natural Gas Water Heater

Unique Measure Code(s): TBD
Draft date: 6/21/11
Effective date: TBD
End date: TBD

Measure Description

[122] Pennsylvania, Census of Population, 2000.
[123] 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)
[124] Estimate consistent with Ontario Energy Board, "Measures and Assumptions for Demand Side Management Planning."
[125] East Bay Municipal Utility District; "Water Conservation Market Penetration Study" http://www.ebmud.com/sites/default/files/pdfs/market_penetration_study_0.pdf
[126] Pennsylvania Public Utility Commission Act 129 Technical Reference Manual (June 2011)
[127] See assumption for low flow shower head.
[128] Pennsylvania Public Utility Commission Act 129 Technical Reference Manual (June 2011)

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[129].

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[130].

12) Hot Water Heater Tank Temperature Turn-down

Unique Measure Code(s): TBD
Draft date: 6/21/11

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

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[131]
8,760	=	Number of hours in a year
RE_{DHW}	=	Recovery efficiency of the domestic hot water heater = 75%[132]
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

[131] 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
[132] See assumption for low flow showerhead.

* *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[133].

13) 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.

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*[134]

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

[133] Page 410. Vermont Technical Reference Manual and New Jersey Clean Energy Program Protocols
[134] 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)

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

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)[135]
RE_{DHW}	=	Recovery efficiency of the domestic hot water heater = 75%[136]

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

14) DHW Pipe Insulation

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

[135] 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
[136] See assumption for low flow showerhead.

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.[137]

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

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

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%[138]

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

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

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
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[139].

[139] NYSERDA Home Performance with Energy Star

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.

15) 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."[140]

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 ft²/Btu)
R_{base}	=	Original R-value of the hot water heater (h °F ft²/Btu) = 5.0[141] unless other information provided
Area	=	Surface area of the hot water heater covered by the insulating blanket

[140] Building Performance Institute, Inc. *Technical Standards for the Heating Professional*. Revised 11/20/07. Page 12.
[141] 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

		(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[142]
8,760	=	Number of hours in a year
RE_{DHW}	=	Recovery efficiency of the domestic hot water heater = 75%[143]
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 (ft^2)	Surface Area of Accessed Areas (ft^2)**	Surface are of Cylinder minus Accessed Areas (ft^2)	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[144].

[142] Assumed to be in unconditioned space, ambient temperature assumption based on: http://lwf.ncdc.noaa.gov/img/documentlibrary/clim81supp3/tempnormal_hires.jpg

[143] See assumption for low flow showerhead.

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

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:

$Capacity_{Out}$	= *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[145]
Dt	= Design temperature difference (assume from 0° F to 70° F)

Equivalent Full Load Heating Hours by Building Type

Building Type	EFLH
Multifamily	854
Education	910
Food Sales	1,099
Food Service	1,203
Health Care	1,654
Lodging	463
Retail	904
Office	867
Public Assembly	1,043
Public Order/Safety	744
Religious Worship	898
Service	1,475
Warehouse/Storage	623

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
Gas Boilers	25

[145] Based on NCDC ASOS temperature data for PHL from 2002 through 2009.

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.

1)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)[146]	Heat of Vaporization Hv (Btu/lb)[147]	Default Boiler Efficiency B[148]	Operating Hours, H[149]	Adjustment Factor, A[150]	Leaking & Blow-thru factor for unaudited traps, L[151]
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
Steam Traps	0%	0%

[146] Resource Solutions Group "Steam Traps Revision #1" dated August 2011.

[147] 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.

[148] California Energy Commission Efficiency Data for Steam Boilers as sited in Resource Solutions Group "Steam Traps Revision #1" dated August 2011.

[149] 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.

[150] 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.

[151] 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%.

Persistence
The persistence factor is assumed to be one.

Measure Lifetime
6 years[152]

Water Savings
There may be water savings for this measure, but the amount has not been calculated.

B. Commercial Kitchen End Uses

2)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.

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Definition of Baseline Condition
Cooking energy efficiency of 44% and Idle Energy Rate of 15,100 Btu/h[153].

Definition of Efficient Condition
Cooking energy efficiency greater than or equal to 46%[154] and an Idle Energy Rate less than or equal to 12,000 Btu/h

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[152] 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.
[153] 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.[155]

$$\textit{Annual Gas Savings (MMBtu)} = 12.90\ MMBtu$$

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 Convection Oven	0%	0%

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes

[154] Using ASTM Standard F1496-99 (Reapproved 2005) based on heavy load (potato) cooking test.
[155] 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.

3)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.[156]

Standard Fryer (per frypot):
$\textit{Annual Gas Savings (MMBtu)} = 50.80\ \textit{MMBtu}$

[156] 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.

4)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[157].

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.[158]

# 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
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.

[157] The baseline comes from PG&E's online calculator at http://www.fishnick.com/saveenergy/tools/calculators/gsteamercalc.php

[158] http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COO
4 pan is interpolated between 3 and 5 pan.

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.

5)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[159].

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.

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.[160]

[159] From the Energy Star calculator

[160] *http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COO*

$Annual\ Gas\ Savings\ (MMBtu) = \mathbf{13.10}\ MMBtu$

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 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.

6)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.[161]

$$Annual\ Gas\ Savings\ (MMBtu) = 6.38\ MMBtu$$

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
Pre-rinse Spray Valve	0%	0%

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes

Equipment Type	Measure Lifetime
Pre-rinse Spray Valve	5[162]

[161] ENERGY STAR calculator 4/14.
[162] *Massachusetts 2011 Technical Reference Manual.*

Water Savings
Expected water savings would be 62,305 gallons per year.[163]

C. Commercial Domestic Hot Water End Use

7)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:

$$BaselineUse = A \times E_b$$

For multifamily buildings:

$$BaselineUse = U \times E_b$$

All building types:

$$EfficientUse = \frac{[(GPY_{W} \times \Delta T \times 8.33\, Btu/Gal°F) + (SLR_e \times H)]}{1{,}000{,}000 \frac{Btu}{MMBtu} \times \eta_e}$$

$$GPY_W = \frac{[(BaselineUse \times 1{,}000{,}000\, Btu/MMBtu \times \eta_b) + (SLR_b \times H)]}{\Delta T \times 8.33\, Btu/Gal°F}$$

$$SLR_b = CAP_{H,e} \times \frac{1000}{800} + 110 \times \sqrt{CAP_{W,e}}$$

[163] *Massachusetts 2011 Technical Reference Manual.*

$$H = \frac{\left[\left(8760\ \frac{hr}{yr} \times CAP_{H,b} \times 1{,}000\frac{Btu}{MBtu}\right) - \left(BaselineUse \times 1{,}000{,}000\frac{Btu}{MMBtu}\right)\right]}{\left(CAP_{H,b} \times 1000\ Btu/MBtu\right) - \frac{SLR_b}{\eta_b}}$$

$$CAP_{H,b} = CAP_{H,e} \times \frac{\eta_e}{\eta_b}$$

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.
GPY_w	=	Annual building hot water usage (gal/yr)
ΔT	=	Differential temperature rise (**75°F**)
SLR_e	=	Proposed efficient water heater standby loss rate (Btu/hr), input
H	=	Number of annual standby hours (Hrs/yr)
η_e	=	Thermal efficiency of proposed efficient water heater (%)
η_b	=	Thermal efficiency of baseline water heater (80%)[164]
$CAP_{H,e}$	=	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

Building Type	Annual Baseline Gas Usage Rate, E_b (MMBtu/ft2/yr)[165]
Education	0.00494
Grocery/Convenience Store	0.00299
Restaurant/Cafeteria	0.03739
Inpatient Health Care	0.03677
Outpatient Health Care	0.00330
Lodging	0.02730
Retail (other than in mall)	0.00093
Retail (in mall)	0.00288
Office	0.00155
Police/Fire Station/Jail	0.01411
Other	0.00093

164 ASHRAE 90.1-2007, Table 7.8.

165 U.S. Energy Information Administration Table E8A. Natural Gas Consumption and Energy Intensities by End Use for All Buildings, 2003.

	Annual Baseline Gas Usage Rate, E_b (MMBtu/unit/yr)[166]
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%

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

[166] GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachussetts. Prepared for GasNetworks.*

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.

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

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.

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.[167]

$AFUE_{eff}$ = 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

[167] *Developed by Practical Energy Solutions using simulation modeling.*

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
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

2)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
$\Delta kWh = BaselinekWh - EfficientkWh$

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.

CERTIFICATE OF SERVICE

I hereby certify that this day I served a copy of PGW's Sixth Year Implementation Plan Fiscal Year 2016 upon the persons listed below in the manner indicated in accordance with the requirements of 52 Pa. Code Section 1.54.

Via Email and/or First Class Mail

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Date: June 5, 2015

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