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December 27, 2016

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

Re: Petition of Philadelphia Gas Works for Approval of Demand Side Management Plan for FY 2016-2020 and Philadelphia Gas Works Universal Service and Energy Conservation Plan for 2014-2016 52 Pa. Code § 62.4 – Request for Waivers – Docket No. P-2014-2459362

Dear Secretary Chiavetta:

On behalf of Philadelphia Gas Works ("PGW") enclosed for filing please its EnergySense Demand Side Management Portfolio Compliance Plan, Fiscal Years 2017-2020 and Technical Reference Manual for FY 2017 with regard to the above-referenced matter. These documents are being submitted consistent with the directives of the Commission in its tentative opinion and order entered August 4, 2016 and its final opinion and order entered November 1, 2016 at this docket. Copies to be served in accordance with the attached Certificate of Service.

Sincerely,

Deanne M. O'Dell

Deanne M. O'Dell
DMO/lww
Enclosure

cc: Hon. Christopher Pell w/enc.
Hon. Marta Guhl w/enc.
Cert. of Service w/enc.

{L0662269.1}

PHILADELPHIA GAS WORKS

ENERGYSENSE DEMAND SIDE MANAGEMENT PORTFOLIO
PHASE II

COMPLIANCE PLAN

FISCAL YEARS 2017-2020

DECEMBER 27, 2016

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I. DSM PORTFOLIO COMPLIANCE PLAN

A. Introduction

This Compliance Plan, which amends the implementation plan filed on December 23, 2014 ("Proposed Phase II Plan") consistent with PUC directive,[1] describes the processes and steps that Philadelphia Gas Works ("PGW" or "the Company") will follow to implement its EnergySense Phase II Demand-Side Management Portfolio ("DSM Portfolio") (collectively, "Final Phase II Plan") as approved by the Pennsylvania Public Utility Commission ("PUC") by tentative opinion and order entered August 4, 2016 ("Tentative Order") and final opinion and order entered November 1, 2016 at docket P-2014-2459362 ("Final Order").[2]

The following Final Phase II Plan details the program budgets and cost effectiveness projections, and implementation details that have been updated from what was included in the Proposed Phase II Plan in order to comply with the PUC's directives. The changes made from the Proposed Phase II Plan are as follows:

B. CRP Home Comfort Program and Associated Budget Moved to USECP

The most significant change in this Final Phase II Plan from the Proposed Phase II Plan is to PGW's Low Income Usage Reduction Program ("LIURP"), CRP Home Comfort[3]. In its Final Order, the PUC referred CRP Home Comfort to the Commission's Bureau of Consumer Services for further review and re-inclusion as part of the Philadelphia Gas Works' Universal Service and Energy Conservation Plan ("USECP") for 2017-2020, at Docket No. M-2016-2542415. CRP Home Comfort is therefore not included in the Final Phase II Plan.

Given the cost efficiencies that are achieved by handling the portfolio administrative costs of LIURP through PGW's DSM Portfolio, PGW proposed in its response to the Tentative Order entered at Docket No. P-2014-2459362 that the administrative costs of the LIURP budget continue to remain combined with the DSM Plan and allocated across

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1 The full implementation details for PGW's DSM Portfolio are detailed in the Proposed Phase II Plan, "PGW's Phase II: Five-Year Implementation Plan" filed on December 23, 2014.

2 In its August 4, 2016 Tentative Opinion and Order, the Commission resolved issues regarding the programs of the DSM plan but sought further comment regarding PGW's LIURP. The Final Order entered November 1, 2016 exclusively addressed issues related to LIURP.

3 Consistent with the PUC's Tentative Order, PGW's proposed Low-Income Multifamily ("LIME") program will be included with PGW's LIURP.

the programs as done historically (for now). In its Final Order, the PUC directed PGW to submit an amendment to its currently pending Universal Service and Energy Conservation Plan 2017-2020 ("USECP") regarding the LIURP budget and return of the LIURP to USECP. Pursuant to this directive, PGW filed its First Amended Universal Service and Energy Conservation Plan 2017-2020 on November 16, 2016 at Docket No. M-2016-2542415. Final approval of that plan, including the proposed future budget is still pending.

C. Timeline and Budgets

The period of time covered by this Final Phase II Plan is four years from FY 2017 to FY 2020, September 1, 2016 to August 31, 2020. FY 2017 will be the first year of Phase II, and will follow the budget proposed for the first program year, which was initially to be FY 2016. PGW will continue to file an implementation plan four months prior to the upcoming fiscal year, but only when proposing major program changes that would modify the portfolio budget caps from the plans documented herein.[4] PGW will continue to file its annual report four months after the close of the fiscal year.

As set forth in the Proposed Phase II Plan, DSM programming beyond FY 2020 (if any) will be effectuated by PGW's filing with the Commission ongoing triennial implementation plans, with an opportunity for parties to propose a termination on an anniversary date by filing 180 days in advance of the close of the fiscal year. PGW reserves the right to re-evaluate the appropriateness and effectiveness of maintaining the ongoing DSM programs based on future developments, and respond accordingly, including possibly announcing a termination of the programs.

D. Additional Updates

In addition to the above updates, PGW will comply with the following items to address variances between the Proposed Phase II Plan and what was approved.

- Benefits realized from demand-reduction-induced price effect ("DRIPE") are included in the avoided costs used for the calculation of the Total Resource Cost ("TRC").
- Retail internalized cost of carbon calculations are not included in the avoided costs used for the calculation of the TRC, though these benefits are tracked separately.
- Removal of PGW's proposal to utilize the Conservation Adjustment Mechanism ("CAM") for cost recovery, and implementation of the "base scenario" budget pro-rated for four years beginning with FY 2016 as year one. This included a phase out of the Home Rebates Program.

[4] Program goals are subject to change based on market activity and deviation from the Phase II Plan budgets documented herein.

- Removal of the proposed performance incentive mechanism.
- Removal of the proposed Efficient Fuel Switching program.
- Removal of the on-bill repayment proposal.
- Removal of the home e-audit tool proposal.

E. Portfolio Budgets, Savings, and Cost-Effectiveness

1. Budgets[5]

The following are PGW's Final Phase II Plan budget, beginning in FY 2017 and running through FY 2020.

Table 1 – Projected Budgets by Program for FY 2017 – FY 2020 (Nominal) [6]

Program	FY2017	FY2018	FY2019	FY2020	Total
Residential Equipment Rebates	$ 777,000	$ 727,000	$ 782,000	$ 727,000	$ 3,013,000
Efficient Building Grants	$ 284,200	$ 394,850	$ 366,300	$ 488,550	$ 1,533,900
Commercial Equipment Rebates	$ 313,650	$ 392,650	$ 321,650	$ 405,650	$ 1,433,600
Efficient Construction Grants	$ 181,000	$ 232,000	$ 182,000	$ 242,000	$ 837,000
Home Rebates Program	$ 163,419	$ 50,000	$ -	$ -	$ 213,419
Portfolio-wide Costs	$ 920,000	$ 844,000	$ 874,000	$ 904,000	$ 3,542,000
Total	$ 2,639,269	$ 2,640,500	$ 2,525,950	$ 2,767,200	$ 10,572,919

**Portfolio-wide costs will be allocated across the DSM programs and CRP Home Comfort proportionally*

Table 2 – Projected Portfolio Budget by Cost Category for FY 2017 – FY 2020 (Nominal)

Program	FY2017	FY2018	FY2019	FY2020	Total
Customer Incentives & Measure Installation Costs	$ 1,346,969	$ 1,294,550	$ 1,319,550	$ 1,344,550	$ 5,305,619
Administration and Management	$ 670,000	$ 694,000	$ 714,000	$ 734,000	$ 2,812,000
Marketing and Business Development	$ 250,000	$ 150,000	$ 160,000	$ 170,000	$ 730,000
Contractor Costs	$ 259,000	$ 210,800	$ 227,100	$ 243,900	$ 940,800
Inspection and Verification	$ 63,300	$ 46,150	$ 50,300	$ 54,750	$ 214,500
On-site Technical Assessment	$ -	$ -	$ -	$ -	$ -
Evaluation	$ 50,000	$ 245,000	$ 55,000	$ 220,000	$ 570,000
TOTAL:	$ 2,639,269	$ 2,640,500	$ 2,525,950	$ 2,767,200	$ 10,572,919

**Portfolio-wide costs will be allocated across the DSM programs and CRP Home Comfort proportionally*

5 While these budgets represent current plans for spending within the individual programs to ensure compliance with that overall portfolio cap, as in prior fiscal years, PGW reserves the flexibility to shift funding across the EnergySense programs based on the programs' relative effectiveness and market reception while maintaining the overall portfolio cap as set forth by the Final Order. Shifts in funding among programs will result in corresponding changes to program goals.

6 The projected budget factors in the Commission's rejection of PGW's proposed Conservation Adjustment Mechanism and the removal of PGW's proposed Efficient Fuel-Switching Program and CRP Home Comfort. In addition the budget for the Home Rebates Program reflects a phasing out of that program. These changes are consistent with the PUC's directives in its orders.

2. Savings

a) Gas savings

Table 3 – Projected Annual Natural Gas Savings (MMBtu) for FY 2017 – FY 2020

Program	FY 2017	FY 2018	FY 2019	FY 2020	Total
Residential Equipment Rebates	13,558	13,558	13,558	13,558	54,231
Efficient Building Grants	4,817	5,399	5,981	6,563	22,760
Commercial Equipment Rebates	10,056	10,056	10,056	10,056	40,223
Efficient Construction Grants	2,778	2,778	2,778	2,778	11,111
Home Rebates Program	1,422	-	-	-	1,422
Total	32,630	31,790	32,372	32,954	129,746

Table 4 – Projected Lifetime Natural Gas Savings (MMBtu) for FY 2017 - 2020

Program	FY 2017	FY 2018	FY 2019	FY 2020	Total
Residential Equipment Rebates	296,175	296,175	296,175	296,175	1,184,698
Efficient Building Grants	89,405	100,628	111,850	123,073	424,956
Commercial Equipment Rebates	156,427	156,427	156,427	156,427	625,706
Efficient Construction Grants	50,586	50,586	50,586	50,586	202,343
Home Rebates Program	37,549	-	-	-	37,549
Total	630,141	603,815	615,037	626,260	2,475,253

b) Non-Gas Savings

Table 5 – Projected Incremental Net Annual Electricity Savings (MWh) for FY 2017 – FY 2020

Program	FY 2017	FY 2018	FY 2019	FY 2020	Total
Residential Equipment Rebates	57	57	57	57	228
Efficient Building Grants	62	73	83	94	312
Commercial Equipment Rebates	-	-	-	-	-
Efficient Construction Grants	7	7	7	7	29
Home Rebates Program	17	-	-	-	17
Total	143	137	147	158	586

Table 6 – Projected Incremental Lifetime Electricity Savings (MWh) for FY 2017 – FY 2020

Program	FY 2017	FY 2018	FY 2019	FY 2020	Total
Residential Equipment Rebates	1,138	1,138	1,138	1,138	4,550
Efficient Building Grants	1,322	1,550	1,778	2,006	6,656
Commercial Equipment Rebates	-	-	-	-	-
Efficient Construction Grants	213	213	213	213	851
Home Rebates Program	463	-	-	-	463
Total	3,136	2,900	3,128	3,356	12,520

Table 7 – Projected Incremental Net Annual Water Savings (Millions of Gallons) for FY 2017 – FY 2020

Program	FY2017	FY2018	FY2019	FY2020	Total
Residential Equipment Rebates	-	-	-	-	-
Efficient Building Grants	1.25	1.38	1.50	1.63	5.76
Commercial Equipment Rebates	1.01	1.01	1.01	1.01	4.03
Efficient Construction Grants	1.07	1.07	1.07	1.07	4.30
Home Rebates Program	0.01	-	-	-	0.01
Total	3.34	3.46	3.59	3.71	14.10

3. Cost-Effectiveness

Table 8 presents PGW's projected cost-effectiveness results, including the additional value estimated by Resource Insight, Inc. for DRIPE. DRIPE calculates the impact of 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. Pursuant to the PUC's Tentative Order, PGW's Final Phase II Plan cost effectiveness calculations include DRIPE in the primary cost effectiveness scenario.[7] Using the primary TRC test, the programs have a combined present value of net benefits, in 2014 dollars, of $5.27 million with a BCR of 1.47.

As mentioned previously, the portfolio-wide costs will be allocated between the market-rate programs and PGW's LIURP, the CRP Home Comfort program. However, Table 8 demonstrates that even if all portfolio-wide costs were allocated to the market-rate programs, the total market-rate portfolio would be cost-effective with net benefits of $2.37 million and a BCR of 1.17.

Table 9 presents PGW's projected TRC results with the internalized market price of carbon (CO_2) included as well as DRIPE, as originally proposed in the Proposed Phase II Plan but, consistent with the PUC's directive, this is provided for information only and is not included in PGW's primary TRC.[8] Under this test, all programs have a combined present value of net benefits, in 2014 dollars, of $8.18 million with a BCR of 1.73. If all portfolio-wide costs are allocated to the market-rate programs, as currently shown in Table 9, then the total market-rate portfolio has net benefits of $5.28 million with a BCR of 1.38.[9]

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[7] Tentative Order at 13.

[8] Tentative Order at 13-14.

[9] *Ibid.*

a) Projected Performance

Table 8 – Projected Cost-Effectiveness Results FY 2017-FY 2020 (2014$)[10]

Program	Total Resource				% of Total	
	PV Benefits	PV Costs	PV Net Benefits	BCR	PV Benefits	PV Costs
Residential Equipment Rebates	$ 7,634,987	$ 6,255,638	$ 1,379,350	1.22	46%	44%
Efficient Building Grants	$ 3,386,763	$ 2,020,083	$ 1,366,680	1.68	21%	14%
Commercial Equipment Rebates	$ 3,675,211	$ 1,549,779	$ 2,125,432	2.37	22%	11%
Efficient Construction Grants	$ 1,477,991	$ 1,016,863	$ 461,128	1.45	9%	7%
Home Rebates Program	$ 260,759	$ 324,259	$ (63,499)	0.80	2%	2%
All Programs	**$ 16,435,711**	**$ 11,166,621**	**$ 5,269,090**	**1.47**	**100%**	**79%**
Portfolio-wide Costs	$ -	$ 2,898,656	$ (2,898,656)	-	0%	21%
Total Portfolio	**$ 16,435,711**	**$ 14,065,277**	**$ 2,370,434**	**1.17**	**100%**	**100%**

Table 9 – Projected Cost-Effectiveness Results FY 2017-FY 2020 (2014$), including CO_2

Program	Total Resource				% of Total	
	PV Benefits	PV Costs	PV Net Benefits	BCR	PV Benefits	PV Costs
Residential Equipment Rebates	$ 9,092,866	$ 6,255,638	$ 2,837,228	1.45	47%	44%
Efficient Building Grants	$ 3,875,791	$ 2,020,083	$ 1,855,708	1.92	20%	14%
Commercial Equipment Rebates	$ 4,365,205	$ 1,549,779	$ 2,815,427	2.82	23%	11%
Efficient Construction Grants	$ 1,702,882	$ 1,016,863	$ 686,019	1.67	9%	7%
Home Rebates Program	$ 306,319	$ 324,259	$ (17,940)	0.94	2%	2%
All Programs	**$ 19,343,063**	**$ 11,166,621**	**$ 8,176,442**	**1.73**	**100%**	**79%**
Portfolio-wide Costs	$ -	$ 2,898,656	$ (2,898,656)	-	0%	21%
Total Portfolio	**$ 19,343,063**	**$ 14,065,277**	**$ 5,277,786**	**1.38**	**100%**	**100%**

F. Portfolio Implementation and Management

During Phase II, PGW will oversee portfolio strategic oversight and management roles, however day-to-day administration of the DSM programs may be assigned to a new portfolio implementation consultant firm or firms. This change will be part of PGW's effort to improve service delivery and cost-effectiveness by coordinating more activities at the portfolio level to a smaller number of vendors, rather than isolating each program to an individual vendor. The vendor will be selected through a competitive bidding process. The vendor may provide one or all of the following roles:

- Market-rate Program Implementer – in this role, the vendor will be responsible for application intake and processing, verification of customer information and eligibility, issuance of rebates, post-installation rebate program inspections, and

[10] TRC Net Benefits and BCR will be higher than projected here, as portfolio-wide costs will be allocated proportionally between the CRP Home Comfort and the DSM portfolio.

reporting of program activity to PGW. The vendor may also oversee the technical assistance provider and marketing support providers if multiple firms are selected.

- Commercial and Industrial Technical Assistance Provider – in this role, the vendor will be responsible for application intake, processing, technical review and verification in the Efficient Building Grants, Efficient Construction Grants, and custom Commercial Equipment Rebate programs.
- Marketing and Outreach Support Provider – in this role, the vendor will work with PGW's EnergySense team and communications departments to develop and implement communications strategies to promote EnergySense programs and drive customer participation.

G. 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 Phase II PGW expects to continue the following coordination activities (subject to modification):

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.
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 Residential Heating Equipment Rebate program may use HEELP to finance their projects.
Philadelphia Energy Authority ("PEA") The Philadelphia Energy Authority is an independent municipal authority focused on issues of energy affordability and sustainability for Philadelphia's government and its citizens. In February 2016, PEA launched the Philadelphia Energy Campaign, a 10-year initiative to leverage $1 billion in investment in energy efficiency and clean energy across four key sectors. PGW held preliminary collaboration meetings with PEA and may coordinate to promote EnergySense rebate and grant programs to the commercial building owners and tenants, particularly multifamily, small businesses and restaurants that PEA will be working with over the course of its campaign.

Program/Organization & Description of Coordination
Delaware Valley Green Building Council ("DVGBC")
DVGBC is the local chapter of the U.S. Green Building Council, and dedicated to environmentally responsible practices in the building industry. DVGBC has launched the Philadelphia 2030 District, which sets goals for energy reduction in buildings. PGW has partnered with DVGBC for events in the past and is exploring future opportunities for EnergySense programs to serve as a resource for building owners to achieve these reductions.

H. Marketing

PGW's EnergySense marketing activities will be conducted as described in the Proposed Phase II Plan. The only change will be that PGW's portfolio implementation consultant will be the primary vendor to provide strategic and implementation support for PGW's EnergySense communications and marketing activities.

I. Evaluation, Monitoring, and Verification

1. Verification

There will be no changes to the verification strategy described in the Proposed Phase II Plan.

In Phase II, PGW may hire a single vendor that will perform portfolio implementation services, including technical assistance and project verification for all EnergySense programs. This will be part of PGW's effort to improve service delivery by coordinating more activities at the portfolio level to a smaller number of vendors, rather than isolating each program to an individual vendor. The vendor will be selected through a competitive bidding process.

There will be no changes to the Portfolio Evaluator role described in the Proposed Phase II Plan.

2. Data Management

As described in the Proposed Phase II Plan, PGW will evaluate its programs and data management systems to improve data tracking and savings calculations, and provide customized reporting. Pending the outcome of this review, PGW may hire a consultant to implement an updated program and portfolio data management system.

3. Evaluations

There will be no changes to the portfolio evaluations strategy described in the Proposed Phase II Plan. The evaluation cycles, however, will be shifted so the first year begins in FY 2017.

J. Reporting Updates

The Proposed Phase II Plan, as amended by this Compliance Plan, provides implementation details for the next four years of the DSM program. During Phase II, PGW will continue to file its annual implementation plan four months prior to the upcoming fiscal year, but only when proposing major program changes that would increase the portfolio budget caps. PGW will continue to file its annual report four months after the close of the fiscal year.

DSM programming beyond FY 2020 will be effectuated by PGW's filing with the Commission ongoing triennial implementation plans, with an opportunity for parties to propose a termination on an anniversary date by filing 180 days in advance of the close of the fiscal year. PGW reserves the right to re-evaluate the appropriateness and effectiveness of maintaining the ongoing DSM programs based on future developments, and respond accordingly, including possibly announcing a planned termination of the programs. The triennial plans will provide proposed program implementation details and modifications. Program activity details would continue to be filed with the Commission in annual reports filed four months following the close of PGW's fiscal year. Figure 1 provides the anticipated continuation and reporting process for Phase II.

Figure 1 – Timeline For Continuation & Reporting Process

Fiscal Year	Continuation or Reporting Activity
2017	• FY 2016 Annual Report (January) • FY 2017 – FY 2020 Compliance Plan (January) • FY 2018 Implementation Plan (May, if warranted)
2018	• FY 2017 Annual Report (December/January) • FY 2019 Implementation Plan (May, if warranted)
2019	• FY 2018 Annual Report (December/January) • FY 2020 Implementation Plan (May, if warranted)
2020	• FY 2019 Annual Report (December/January) • Objection Deadline to Continued DSM Programming (February) • FY 2021 – 2024 Triennial Implementation Plan (May, if warranted)

K. Key Assumptions

1. Avoided Costs

PGW's Avoided Costs, updated for the FY 2016 Implementation Plan, will be used to evaluate project and program cost-effectiveness. In compliance with the PUC's Tentative Order on the Proposed Phase II Plan, PGW will include DRIPE in its primary avoided costs. PGW will separately calculate portfolio-level cost effectiveness with avoided costs utilizing the internalized CO_2 projections, though these calculations will not be used in the primary program evaluations.

2. Benefit-Cost Analysis

There are no updates to Benefit-Cost Analysis described in Proposed Phase II Plan.

3. Technical Reference Manual

PGW has filed an updated TRM as Appendix F to this plan. It includes the following updates:

- Commercial Hot Water Heaters: an update to the baseline case assumption.
- Air Sealing: A new protocol for estimating air sealing savings for situations where blower door tests cannot be properly or safely be performed, by multiplying square feet of air sealing performed by 7.495 to determine a CFM50 reduction equivalent.
- Duct Sealing: A new protocol for estimating savings for situations where duct blaster tests cannot be properly or safely performed, by assigning a CFM25 reduction equivalent for specific improvements to ducts in unconditioned spaces.
- Efficient Space Heating System: In situations where a heater is inoperable and a baseline AFUE or Steady State Efficiency cannot be determined, the heater installation can be modeled as a natural replacement by applying an 80% AFUE as the baseline condition.

II. Phase II Program Plans

This section provides an overview of the Phase II implementation activities, planned for FY 2017-2020 for all five DSM programs comprising PGW's EnergySense Portfolio:

- The Residential Equipment Rebates
- The Efficient Building Grants Program
- The Commercial Equipment Rebate Program
- The Efficient Construction Grants Program
- The Home Rebates Program

A. Residential Equipment Rebates Program

1. Program Description

The Residential Equipment Rebates program, previously referred to as the Residential Heating Equipment Rebates 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 residential-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 use their own contractor to install the premium efficiency equipment and receive cash rebates to offset most of the incremental cost of the higher efficiency equipment and installation.

2. Costs, Savings, and Benefits

Projections

The program aims to serve 4,120 customers in Phase II, with associated annualized gas savings of 54,231 MMBtu. The program is projected to cost $3,013,000. The following table shows a detailed breakout of participation, costs, and savings.

Table 10 – Projected RER Impacts for FY 2017 – FY 2020

Fiscal Year	FY2017	FY2018	FY2019	FY2020	Total
Projected Budgets (Nominal)					
Customer Incentives	$ 671,000	$ 671,000	$ 671,000	$ 671,000	$ 2,684,000
Contractor Costs	48,000	48,000	48,000	48,000	$ 192,000
Inspection and Verification	8,000	8,000	8,000	8,000	$ 32,000
Evaluation	50,000	-	55,000	-	$ 105,000
TOTAL:	**$ 777,000**	**$ 727,000**	**$ 782,000**	**$ 727,000**	**$ 3,013,000**
Natural Gas Savings (MMBtus)					
Incremental Annual	13,558	13,558	13,558	13,558	54,231
Incremental Lifetime	296,175	296,175	296,175	296,175	1,184,698
Projected Participation					
Rebates	1,030	1,030	1,030	1,030	4,120

3. Workflow

The RER program will be implemented as described in the Proposed Phase II Plan.

4. Target Market and Program Eligibility

There are no updates to program eligibility.

5. Target End-use Measures

During Phase II, PGW will continue its residential-sized equipment rebate offerings targeting high efficiency furnaces, boilers and combination boilers. The following table shows the rebate schedule for the outset of Phase II.

Table 11 – FY 2017 – FY 2020 Planned Residential Equipment Rebates

Measure	First Rebate Per-Project	Additional Rebates Per-Project[11]
Natural Gas Furnace 94% AFUE	$500	$250
Natural Gas Water Boiler, 94% AFUE	$1,500	$800
Natural Gas Combination Boiler, 94% AFUE	$1,700	$900

As described in the Proposed Phase II Plan, PGW will continue to monitor promising natural gas technologies that could provide efficient, cost-effective alternatives for PGW's residential customer base to consider for new rebate opportunities. To spur market interest in bringing new measures to PGW for consideration, new equipment will be eligible for custom equipment rebates after demonstrating cost-effectiveness. As additional opportunities are identified PGW will update program projections to accommodate these new measures.

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

Projections

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

Table 12 – Projected Rebates for FY 2017 – FY 2020 by Equipment Type

Product	FY2017	FY2018	FY2019	FY2020	Total
Natural Gas Furnace	760	760	760	760	3,040
Natural Gas Boiler	240	240	240	240	960
Combi Boiler	30	30	30	30	120

6. Incentive Strategy

There are no updates to the incentive strategy described in the Proposed Phase II Plan.

7. Roles and Responsibilities

There are no updates to roles and responsibilities described in the Proposed Phase II Plan.

8. Evaluation, Monitoring, and Verification

PGW's evaluation and verification activities will remain consistent with the strategy described in the Proposed Phase II Plan, with two slight changes. The evaluation schedule in the Proposed Phase II plan will be shifted so the first study is conducted in FY 2017, or the first year of Phase II. The second change will be that the Portfolio Implementation consultant through its Technical Assistance Provider role will conduct the verification inspections.

B. *Efficient Building Grants Program*

1. Program Description

The Efficient Building Grants program, previously referred to as the Commercial and Industrial Retrofit Incentives program, promotes natural gas energy efficiency retrofit investments by PGW's multifamily 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 collaboration with third-party lenders. The program has the following objectives:

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

Efficient Building Grants seeks to convince facility managers, department heads, and financial officers to identify and install cost-effective energy saving retrofit opportunities. PGW then provides an incentive for completing the installation of the identified savings measures. The program targets energy efficiency opportunities in multifamily, commercial and industrial buildings.

2. Costs, Savings, and Benefits

Projections

The Efficient Building Grants program aims to serve 60 customers in Phase II, with associated annualized gas savings of 22.76 BBtu. The program is projected to cost $1,533,900 over Phase II.

Table 13 – Projected Efficient Building Grants Impacts for FY 2017 – FY 2020

Fiscal Year	FY2017	FY2018	FY2019	FY2020	Total
Projected Budgets (Nominal)					
Customer Incentives	$ 202,900	$ 227,900	$ 252,900	$ 277,900	$ 961,600
Contractor Costs	70,000	82,800	96,100	109,900	358,800
Inspection and Verification	11,300	14,150	17,300	20,750	63,500
Evaluation	-	70,000	-	80,000	150,000
TOTAL:	**$ 284,200**	**$ 394,850**	**$ 366,300**	**$ 488,550**	**$ 1,533,900**
Natural Gas Savings (MMBtus)					
Incremental Annual	4,817	5,399	5,981	6,563	22,760
Incremental Lifetime	89,405	100,628	111,850	123,073	424,956
Projected Participation					
Projects	12	14	16	18	60

3. Workflow

The Efficient Building Grants program will be implemented as described in the Proposed Phase II Plan. One update that will be made in the program implementation will be that the Market Rate Program Implementer and Technical Assistance Provide will have greater responsibility for ushering customers into and through the Efficient Building Grants program. The vendor may also provide walk-through building assessments and additional assistance with project design to facilitate increased participation and more comprehensive projects

4. Target Market and Program Eligibility

There are no updates to the target market and program eligibility described in the Proposed Phase II Plan.

5. Target End-use Measures

There are no updates to the target end-use measures described in the Proposed Phase II Plan.

6. Incentive Strategy

There are no updates to the incentive strategy described in the Proposed Phase II Plan.

7. Roles and Responsibilities

There are no updates to roles and responsibilities described in the Proposed Phase II Plan.

8. Evaluation, Monitoring, and Verification

PGW's evaluation and verification activities will remain consistent with the strategy described in the Proposed Phase II Plan, with two slight changes. The evaluation schedule in the Final Phase II plan will be shifted so the first study is conducted in FY 2018, or the first year of Phase II. The second change will be that the Portfolio Implementation consultant through its Technical Assistance Provider role will conduct the verification inspections.

C. Commercial Equipment Rebates Program

1. Program Description

The Commercial Equipment Rebates program, previously referred to as the Commercial and Industrial Equipment Rebates 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 multifamily customers. The program has the following objectives:

- Promote the selection of premium efficiency models at the time of purchase of commercial and industrial sized gas heating equipment;
- Increase consumers' awareness of the breadth of energy efficiency opportunities;
- 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 use their own contractor to install the premium efficiency equipment and receive cash rebates to offset most of the incremental cost of the higher efficiency equipment.

2. Costs, Savings, and Benefits

Projections

The program aims to serve 576 customers in Phase II, with associated annualized gas savings of 40 BBtu. The program is projected to cost $1,433,600. The following table shows a detailed breakout of participation, costs, and savings.

Table 14 – Projected CER Impacts for FY 2017 – FY 2020

Fiscal Year	FY2017	FY2018	FY2019	FY2020	Total
Projected Budgets (Nominal)					
Customer Incentives	$ 238,650	$ 238,650	$ 238,650	$ 238,650	$ 954,600
Contractor Costs	60,000	63,000	66,000	69,000	258,000
Inspection and Verification	15,000	16,000	17,000	18,000	66,000
Evaluation	-	75,000	-	80,000	155,000
TOTAL:	**$ 313,650**	**$ 392,650**	**$ 321,650**	**$ 405,650**	**$ 1,433,600**
Natural Gas Savings (MMBtus)					
Incremental Annual	10,056	10,056	10,056	10,056	40,223
Incremental Lifetime	156,427	156,427	156,427	156,427	625,706
Projected Participation					
Rebates	144	144	144	144	576

3. Workflow

The CER program will be implemented as described in the Proposed Phase II Plan.

4. Target Market and Program Eligibility

There are no updates to the program eligibility described in the Proposed Phase II Plan.

5. Target End-use Measures

There are no changes to the end-use measures referenced in the Proposed Phase II Plan. In addition to the end-use measures reference in the Proposed Phase II Plan, PGW will continue to offer custom commercial rebates for cost-effective upgrades in commercial properties for individual measures that are not part of the prescriptive rebates and would not be candidates for Efficient Building Grants. PGW first launched this custom equipment rebate offer in FY 2014 of Phase I. Custom rebate measures will be evaluated for cost-effectiveness on an individual basis. The incentives will not exceed 33% of the total installed cost for retrofits, or 80% of the incremental cost of equipment replacements. The maximum rebate will continue to be $75,000 or the value of gas benefits. Examples of equipment that may be included as custom measures include infrared heaters, unit heaters, or low-flow fixtures.

PGW updated the Commercial Domestic Hot Water Heater measure in its TRM, filed as Appendix F. The baseline storage capacity is now assumed to be 60 gallons or the same capacity of the efficient water heater, whichever amount is greater. This revision accounts for the savings from reduced standby losses in tankless water heaters.

6. Incentive Strategy

Table 15 – FY 2017 CER 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% Thermal Efficiency (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

7. Roles and Responsibilities

There are no updates to the roles and responsibilities described in the Proposed Phase II Plan.

8. Evaluation, Monitoring, and Verification

PGW's evaluation and verification activities will remain consistent with the strategy described in the Proposed Phase II Plan, with two slight changes. The evaluation schedule in the Final Phase II plan will be shifted so the first study is conducted in FY 2018, or the first year of Phase II. The second change will be that the Portfolio Implementation consultant through its Technical Assistance Provider role will conduct the verification inspections.

D. Efficient Construction Grants Program

1. Program Description

The Efficient Construction Grants program, previously referred to as the High Efficiency Construction Incentives program, promotes natural gas energy efficiency in the new construction and gut rehabilitation markets, both for residential and non-residential new construction projects. The program provides technical assistance and prescriptive financial incentives for projects that go beyond building codes in reducing energy usage. A prescriptive incentive path has been developed for residential projects to streamline program delivery given the limited savings available. For commercial projects, incentives increase for projects the more a project saves natural gas compared to the code baseline, due to the greater opportunity for energy savings. The program has the following objectives:

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

Efficient Construction Grants 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 reaching a certain level of efficiency.

2. Costs, Savings, and Benefits

Projections

The program aims to serve 120 single-family residential units, 40 multifamily buildings, and eight commercial new construction projects in Phase II, with associated annualized gas savings of 11.1 BBtu, or 66.4 MMBtu/customer. The program is projected to cost approximately $837,000.

Table 16 – Projected Efficient Construction Grants Impacts for FY 2017 – FY 2020

Fiscal Year	FY2017	FY2018	FY2019	FY2020	Total
Projected Budgets (Nominal)					
Customer Incentives	$ 157,000	$ 157,000	$ 157,000	$ 157,000	$ 628,000
Contractor Costs	16,000	17,000	17,000	17,000	67,000
Inspection and Verification	8,000	8,000	8,000	8,000	32,000
Evaluation	-	50,000	-	60,000	110,000
TOTAL:	**$ 181,000**	**$ 232,000**	**$ 182,000**	**$ 242,000**	**$ 837,000**
Natural Gas Savings (MMBtus)					
Incremental Annual	2,778	2,778	2,778	2,778	11,111
Incremental Lifetime	50,586	50,586	50,586	50,586	202,343
Projected Participation					
Single Family Projects	30	30	30	30	120
Multifamily Projects	10	10	10	10	40
Commercial Projects	2	2	2	2	8
Total Projects	**42**	**42**	**42**	**42**	**168**

3. Workflow

There are no updates to the workflow in the Efficient Construction Grants program described in the Proposed Phase II Plan.

4. Target Market and Program Eligibility

There are no updates to target market and program eligibility in the Efficient Construction Grants program described in the Proposed Phase II Plan.

5. Target End-use Measures

There are no updates to target end-use measures in the Efficient Construction Grants program described in the Proposed Phase II Plan.

6. Incentive Strategy

There are no updates to the incentive strategy in the Efficient Construction Grants program described in the Proposed Phase II Plan.

7. Roles and Responsibilities

There are no updates to roles and responsibilities in the Efficient Construction Grants program described in the Proposed Phase II Plan.

8. Evaluation, Monitoring, and Verification

PGW's evaluation and verification activities will remain consistent with the strategy described in the Proposed Phase II Plan, with two slight changes. The evaluation schedule in the Final Phase II plan will be shifted so the first study is conducted in FY 2018, or the first year of Phase II. The second change will be that the Portfolio

Implementation consultant through its Technical Assistance Provider role will conduct the verification inspections.

E. Home Rebates Program

1. 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 Home Rebates program will be discontinued in Phase II. The following sections provide an overview of the steps taken to wind-down the program during FY 2017 at the outset of Phase II.

2. Costs, Savings, and Benefits

Projections
PGW aims to complete 49 Home Rebates projects in FY 2017, with associated annualized gas savings of 1,422 MMBtu.[12] The program is projected to cost $213,419.

[12] Average job cost assumptions were revised in the Final Phase II Plan to maintain the program budget detailed in the Proposed Phase II Plan, resulting in one less job than originally projected.

Table 17 – Projected Home Rebates Impacts for FY 2017 - 2020

Fiscal Year	FY2017	FY2018	FY2019	FY2020	Total
Projected Budgets (Nominal)					
Customer Incentives	$ 77,419	$ -	$ -	$ -	$ 77,419
Contractor Costs	65,000	-	-	-	$ 65,000
Inspection and Verification	21,000	-	-	-	$ 21,000
Evaluation	-	50,000	-	-	$ 50,000
TOTAL:	**$ 163,419**	**$ 50,000**	**$ -**	**$ -**	$ 213,419
Natural Gas Savings (MMBtus)					$ -
Incremental Annual	1,422	-	-	-	$ 1,422
Incremental Lifetime	37,549	-	-	-	$ 37,549
Projected Participation					$ -
Projects	49	-	-	-	$ 49

3. Workflow

PGW will stop offering the Home Rebates program to customers in FY 2017. The company's Home Rebates program implementation activities in Phase II will consist of ensuring a steady wind-down of activity and providing customers who are interested in participating, with a chance to do so. Below are the timelines for winding the program down:

- Fall 2016: Marketing and outreach to communicate the program's end date to the general public and also to customers that had received energy assessments but had not completed measures.
- November, 2016: Deadline for customers to schedule an energy assessment as a first-step to participate in the program.
- December, 2016: All projects must be completed and submitted for approval in order to remain eligible for a rebate.
- February, 2017: Program closed out, with all rebates paid to customers, and program reporting, data transfers and post-assessment completed.
- FY 2018: Evaluation conducted to calculate final program results.

4. Evaluation, Monitoring, and Verification

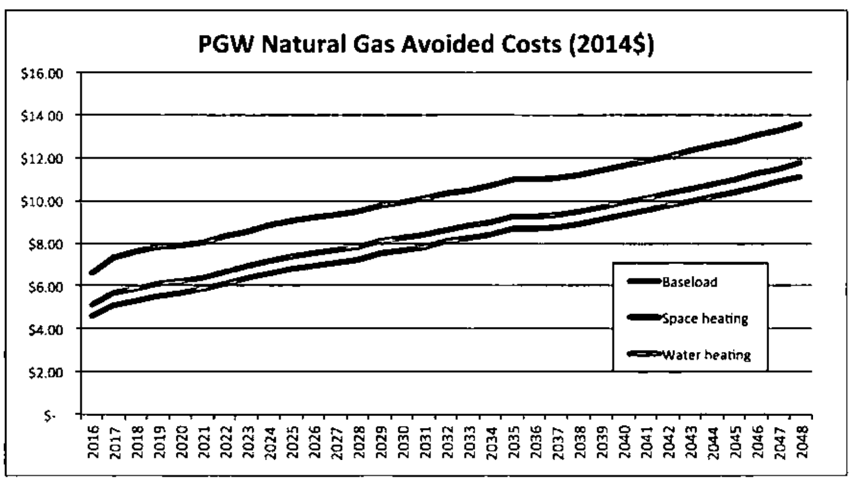
There are no updates to evaluation, monitoring, and verification in the Home Rebates program

III. Appendices

A. PGW Avoided Gas Costs Over Time

Natural Gas Avoided Costs, including DRIPE (2014$)

Calendar Year	Baseload $/MMBtu	Space Heating $/MMBtu	DHW $/MMBtu
2016	$4.59	$6.58	$5.09
2017	$5.08	$7.36	$5.65
2018	$5.31	$7.63	$5.89
2019	$5.53	$7.85	$6.11
2020	$5.68	$7.91	$6.24
2021	$5.87	$8.01	$6.40
2022	$6.14	$8.30	$6.68
2023	$6.39	$8.57	$6.93
2024	$6.61	$8.81	$7.16
2025	$6.85	$9.07	$7.40
2026	$6.99	$9.22	$7.55
2027	$7.09	$9.32	$7.65
2028	$7.27	$9.50	$7.83
2029	$7.53	$9.78	$8.09
2030	$7.66	$9.91	$8.22
2031	$7.85	$10.11	$8.41
2032	$8.08	$10.35	$8.65
2033	$8.23	$10.50	$8.79
2034	$8.41	$10.70	$8.98
2035	$8.68	$10.98	$9.25
2036	$8.71	$11.00	$9.28
2037	$8.74	$11.02	$9.31
2038	$8.89	$11.19	$9.47
2039	$9.13	$11.43	$9.70
2040	$9.33	$11.64	$9.90
2041	$9.53	$11.86	$10.11
2042	$9.74	$12.08	$10.33
2043	$9.96	$12.31	$10.55
2044	$10.18	$12.55	$10.77
2045	$10.41	$12.80	$11.01
2046	$10.64	$13.05	$11.25
2047	$10.89	$13.31	$11.49
2048	$11.13	$13.58	$11.74



List of Acronyms

Acronym	Meaning
ACEEE	American Council for an Energy Efficient Economy
BCR	Benefit-cost ratio
CEE	Consortium for Energy Efficiency
CER	Commercial Equipment Rebates Program
CSP	Conservation Service Provider
CY	Calendar Year
DEP	Department of Environmental Protection
DRIPE	Demand-Reduction-Induced Price Effect
DSM	Demand-Side Management
ECRS	Efficiency Cost Recovery Surcharge
FY	Fiscal Year (PGW's fiscal year goes from September 1 to August 31)
GEEG	Green Energy Economics Group, Inc.
Keystone HELP	Keystone Home Energy Loan Program
NDR	Nominal Discount Rate
PA	Pennsylvania
PGW	Philadelphia Gas Works
RDR	Real Discount Rate
TRC	Total Resource Cost
TRM	Technical Reference Manual
USC	Universal Services Charge
USECP	Universal Service and Energy Conservation Plan
WAP	Weatherization Assistance Program

B. Units

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

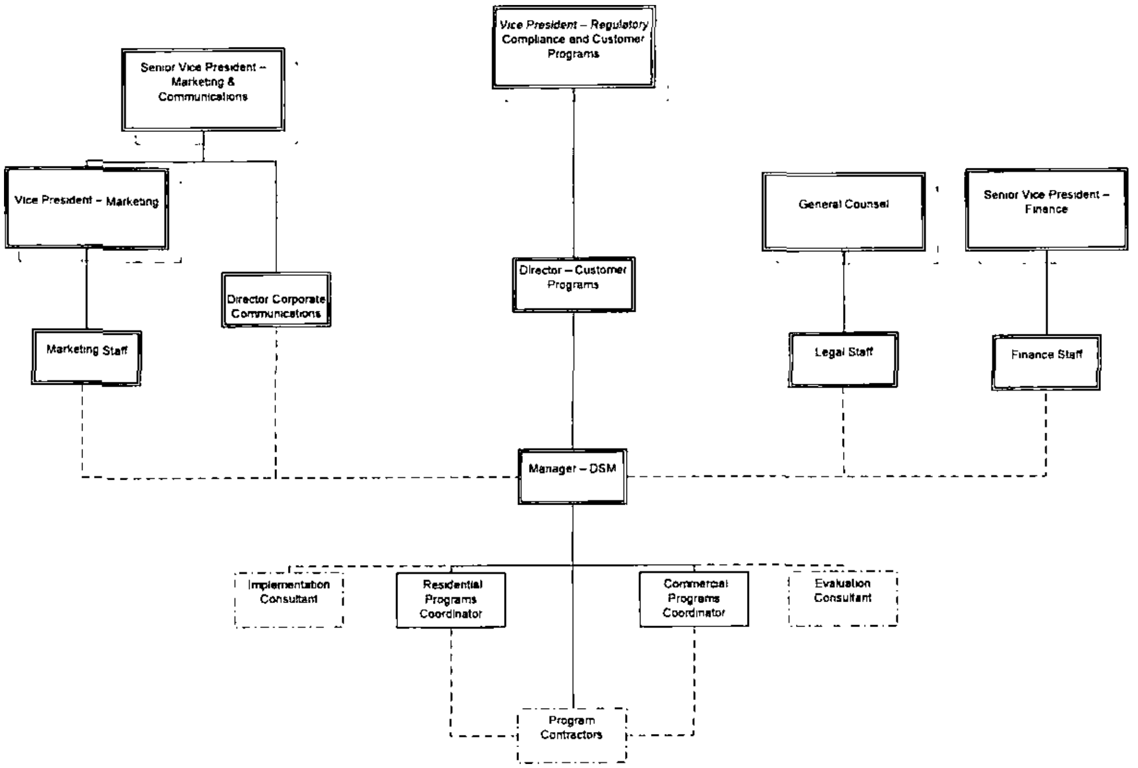
Ccf = 100 cubic feet
Mcf = 1,000 cubic feet
MMcf = 1,000,000 cubic feet
Bcf = 1,000,000,000 cubic feet

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

C. Organization Chart



D. Sales Reduction Projections

Gas Sales Reduction Projections from FY 2017 – FY 2020 Activity (MCF)

FY	Total
2017	6,222
2018	21,299
2019	35,547
2020	49,795
2021	58,361
2022	58,361
2023	58,361
2024	58,361
2025	58,361
2026	58,361
2027	58,314
2028	58,314
2029	58,314
2030	58,029
2031	57,078
2032	56,127
2033	55,177
2034	54,511
2035	54,511
2036	54,511
2037	46,373
2038	38,235
2039	30,096
2040	21,958
2041	21,958
2042	17,197
2043	12,435
2044	6,352
2045	1,590
2046	1,193
2047	795
2048	398
Lifetime	**2,366,703**

E. Projected Job Creation

The following table presents the range of employment-impact projects for the proposed PGW EnergySense programs (not including CRP Home Comfort), 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 Proposed 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 2017	9	13	16
FY 2018	9	13	16
FY 2019	9	13	16
FY 2020	9	13	16
TOTAL	**36**	**52**	**64**
NON-RESIDENTIAL PROGRAMS			
FY 2017	8	11	14
FY 2018	9	12	14
FY 2019	9	12	15
FY 2020	9	12	16
TOTAL	**35**	**47**	**59**
TOTAL PORTFOLIO			
FY 2017	18	24	30
FY 2018	18	24	30
FY 2019	18	25	31
FY 2020	19	25	31
TOTAL	**73**	**98**	**122**

F. Technical Reference Manual

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

Technical Reference Manual

Measure Savings Algorithms

PGW

December 27, 2016

Table of Contents

Prepared by: GreenEnergy EconomicsGroup

I. Residential Time of Replacement Market

A. Space Heating End Use

1) Efficient Space Heating System

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

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

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

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

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

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

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

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

Where:

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

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

Electric Savings Algorithms

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

Energy Savings
$\Delta kWh = 700\ kWh$

Demand Savings
$\Delta kW = 0\ kW$

Where:

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

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

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

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes

Equipment Type	Measure Lifetime
Gas Furnaces	20
Gas Boilers	25

Source: Lifetime estimates used by Efficiency Vermont.

Water Savings
There are no water savings for this measure.

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

2) Programmable Thermostat

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

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

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

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

Gas Savings Algorithms

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

Where:

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

Electric Savings Algorithms

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

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

Energy Savings

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

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

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

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

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

Deemed Savings:

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

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

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

Demand Savings

$\Delta \text{kW} = 0\ \text{kW}$

Where:

ΔkWh = gross customer annual kWh savings for the measure.

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

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

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

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

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

EFLH = *equivalent full load hours*

Residential Electric HVAC Calculation Assumptions

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

Sources:

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

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

Equipment Type	Free Ridership	Spillover
Programmable Thermostat	0%	0%

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes

Equipment Type	Measure Lifetime
Programmable Thermostat	15

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

Water Savings
There are no water savings for this measure.

B. Water Heating End Use

1) Tankless Water Heater

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

Measure Description
This measure is an on-demand gas water heater.

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

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

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

Equipment Type	Minimum EF
Gas Tankless Water Heater	0.82

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

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

Where:

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

Electric Savings Algorithms

There are no electric savings from this measure.

Energy Savings
ΔkWh = 0 kWh

Demand Savings
ΔkW = 0 kW

Where:

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

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

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

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

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes

Equipment Type	Measure Lifetime
Tankless Water Heater	20

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

Water Savings
There are no water savings for this measure.

C.Combined Space and Domestic Hot Water Usage

1) Combination Boiler - Space Heating and DHW

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

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

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

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

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

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

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

Gas Savings Algorithms

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

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

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

Where:

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

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

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

Where:

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

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

Electric Savings Algorithms

Energy Savings

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.

[7] Based on 2014 APPRISE evaluation for boilers.

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

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes

Equipment Type	Measure Lifetime
Gas Combi Boiler	20

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

Water Savings
There are no water savings for this measure.

D.All End Uses

1) Custom Measure

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

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

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

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

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

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

Where:

BaselineUse = The gas usage of baseline equipment or building.

EfficientUse = The gas usage of efficient equipment or building.

Electric Savings Algorithms

Energy Savings

ΔkWh = *BaselinekWh - EfficientkWh*

Demand Savings

ΔkW = *BaselinekW - EfficientkW*

Where:

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

Freeridership/Spillover

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

Equipment Type	Free Ridership	Spillover
Custom Measure	0%	0%

Persistence

The persistence factor is assumed to be one.

Measure Lifetimes

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

Water Savings

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

II. Residential New Construction

A. All End Uses

1) Custom Measures

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

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

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

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

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

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

Where:

BaselineUse	=	The gas usage of baseline equipment or building.
EfficientUse	=	The gas usage of efficient equipment or building.

Electric Savings Algorithms

Energy Savings
ΔkWh = *BaselinekWh - EfficientkWh*

Demand Savings
ΔkW = *BaselinekW - EfficientkW*

Where:

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

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

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

Equipment Type	Free Ridership	Spillover
Custom Measure	0%	0%

Persistence
The persistence factor is assumed to be one.

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

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

III. Residential Retrofit Market (Non-Low Income)

A. Space Heating End Use

1) Efficient Space Heating System

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

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

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

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

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

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

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

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

Where:

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

Heating Use weather normalization methods (HeatingUse):

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

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

Electric Savings Algorithms

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

Energy Savings

$\Delta kWh = 700\ kWh$

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%

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

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

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes

Equipment Type	Measure Lifetime
Gas Furnaces	20
Gas Boilers	25

Source: Lifetime estimates used by Efficiency Vermont.

Water Savings
There are no water savings for this measure.

2) Space Heating System Tune-Up

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

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

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

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

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

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

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

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

Where:

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

Heating Use weather normalization methods (HeatingUse):

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

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

Electric Savings Algorithms

There are no electricity savings for this measure.

Energy Savings
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.

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

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

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

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes

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

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

Water Savings
There are no water savings for this measure.

3) Infiltration Reduction

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

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

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

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

Gas Savings Algorithms

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

Where:

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

24 = hours/day

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

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

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

Electric Savings Algorithms

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

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

Energy Savings

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

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

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

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

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

Demand Savings

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

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

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

Where:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

EFLH, CDD and HDD by City

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

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

Measure	Free Ridership	Spillover
Infiltration Reduction	0%	0%

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes

Measure	Measure Lifetime
Infiltration Reduction	20

Source: NYSERDA Home Performance with Energy Star.

Water Savings
There are no water savings for this measure.

4) Roof and Cavity Insulation

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

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

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

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

Definition of Efficient Condition

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

Gas Savings Algorithms

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

Where:

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

Electric Savings Algorithms

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

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

Energy Savings

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

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

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

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

[20] From NWS data for PHL from 2002-2009. HDD63=4033 and HDD62 = 3820

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

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

Demand Savings

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

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

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

Where:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

EFLH, CDD and HDD by City

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

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

Measure	Free Ridership	Spillover
Insulation	0%	0%

Persistence
The persistence factor is assumed to be one.

[22] "State of Ohio Energy Efficiency Technical Reference Manual," prepared for the Public Utilities Commission of Ohio by Vermont Energy Investment Corporation. August 6, 2010.
[23] From PECO baseline study, average home size = 2323 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). $F_{Room,AC} = (425\ ft^2 * 2.1)/(2323\ ft^2) = 0.38$
[24] PA 2010 TRM Table 2-1.
[25] PA SWE Interim Approved TRM Protocol – Residential Room AC Retirement
[26] Climatography of the United States No. 81. Monthly Station Normals of Temperature, Precipitation, and Heating and Cooling Degree Days 1971-2000, 36 Pennsylvania. NOAA. http://cdo.ncdc.noaa.gov/climatenormals/clim81/PAnorm.pdf
[27] Ibid.

Measure Lifetimes

Measure	Measure Lifetime
Roof Insulation	40
Cavity Insulation	40

Source: NYSERDA Home Performance with Energy Star.

Water Savings
There are no water savings for this measure.

5) Programmable Thermostat

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

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

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

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

Gas Savings Algorithms

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

Where:

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

HDD_{62} = 3820

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

HDD_{63} = 4033

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

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

Electric Savings Algorithms

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

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

Energy Savings

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

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

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

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

Demand Savings

$\Delta kW = 0$ kW

Where:

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

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

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

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

$EFLH$ = *equivalent full load hours*

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

Residential Electric HVAC Calculation Assumptions

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

Sources:

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

Freeridership/Spillover

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

Equipment Type	Free Ridership	Spillover
Programmable Thermostat	0%	0%

Persistence

The persistence factor is assumed to be one.

Measure Lifetimes

Equipment Type	Measure Lifetime
Programmable Thermostat	15

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

Water Savings

There are no water savings for this measure.

6) Duct Work Insulation

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

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

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

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

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

Natural Gas Savings Algorithms

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

Where:

Length = Number of linear feet of duct work insulated

$EFLH_{heat}$ = Equivalent full load heating hours = 730

Th_{base} = Thickness of base condition insulation (inches)

Th_{eff} = Thickness of efficient condition insulation (inches)

HeatLoss(x) = Heat loss through duct work as a function of insulation thickness x (Btu/ft /yr)

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

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

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

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

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

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

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

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

Persistence
The persistence factor is assumed to be one.

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

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

7) Heating Pipe Insulation

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

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

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

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

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

Natural Gas Savings Algorithms

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

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

Where:

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

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

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

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

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

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

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

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

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

Persistence
The persistence factor is assumed to be one.

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

8) Duct Work Sealing

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

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

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

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

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

Natural Gas Savings Algorithms

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

Where:

CFMpre = Reading from duct-blaster test at 25 pascals, before sealing performed

CFMpost = Reading from duct-blaster test at 25 pascals, after sealing performed

DSFgas = Duct sealing factor for gas systems, 0.035 MMBtus/CFM-25[35]

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

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

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

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

Persistence
The persistence factor is assumed to be one.

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

9) High Efficiency Window

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

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

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

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

Gas Savings Algorithms

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

Where:

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

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

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

Electric Savings Algorithms

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

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

Energy Savings

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

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

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*

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

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

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

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

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

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

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

EFLH, CDD and HDD by City

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

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

Measure	Free Ridership	Spillover
Window	0%	0%

Persistence
The persistence factor is assumed to be one.

Measure Lifetime

Measure	Measure Lifetime
Window	30

Source: NREL Measure Database.

Water Savings
There are no water savings for this measure.

B. Domestic Hot Water End Use

1) Low Flow Showerhead

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

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

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

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

Definition of Efficient Condition

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

Water Savings Algorithms

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

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

Where:

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

Natural Gas Savings Algorithms

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

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

Where:

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

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

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

[48] Pennsylvania, Census of Population, 2000.

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

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

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

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

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

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

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

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

Persistence
The persistence factor is assumed to be one.

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

2) Low Flow Faucet Aerators

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

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

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

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

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

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

Where:

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

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

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

Natural Gas Savings Algorithms

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

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

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)
25	=	The difference between the temperature of the water entering the house and the temperature leaving the faucet (degrees Fahrenheit).[60]
RE_{DHW}	=	Recovery efficiency of the domestic hot water heater = 75%[61]

Electric Savings Algorithms

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

Freeridership/Spillover

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

Persistence

The persistence factor is assumed to be one.

Measure Lifetimes

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

3) Efficient Natural Gas Water Heater

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

Measure Description

This measure relates to an efficient natural gas water heater.

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

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

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

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

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

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

Where:

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

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

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

Persistence
The persistence factor is assumed to be one.

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

4) Hot Water Heater Tank Temperature Turn-down

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

Measure Description

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

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

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

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

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

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

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

Where:

$\Delta MMBtu$	=	MMBtu of saved gas per year
$Area$	=	Surface area of hot water heater (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[65]
8,760	=	Number of hours in a year
RE_{DHW}	=	Recovery efficiency of the domestic hot water heater = 75%[66]
1,000,000	=	Btu to MMBtu

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

Water Heater Size (Gal)	Height (Inches)*	Diameter (Inches)*	Total Surface Area (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

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

There are no electric savings associated with this measure.

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

Persistence
The persistence factor is assumed to be one.

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

5) Repair Hot Water Leaks/Plumbing Repairs

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

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

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

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

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

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

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

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

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

Where:

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

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

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

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

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

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

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

Persistence
The persistence factor is assumed to be one.

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

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

6) DHW Pipe Insulation

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

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

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

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

Definition of Efficient Condition

The efficient condition is any insulation on the hot water pipe.

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

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

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

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

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

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

Water Savings Algorithms

This measure has no water savings associated with it.

Natural Gas Savings Algorithms

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

Where:

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

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

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

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

[72] See assumption for low flow showerhead.

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

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

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

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

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

Persistence
The persistence factor is assumed to be one.

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

7) Hot Water Storage Tank Wrap

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

[73] NYSERDA Home Performance with Energy Star

Measure Description

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

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

Definition of Baseline Condition

The baseline is the hot water heater tank without the insulating blanket.

Definition of Efficient Condition

The efficient condition is the hot water heater tank with the insulating blanket.

Water Savings Algorithms

There are no water savings due to this measure.

Natural Gas Savings Algorithms

Gas energy savings result from the reduction in standby losses.

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

Where:

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

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

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

Water Heater Size (Gal)	Height (Inches)*	Diameter (Inches)*	Surface Area of Cylinder (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[78].

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

IV. Low Income Retrofit Market

A. Space Heating End Use

1) Efficient Space Heating System

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

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

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

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

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

If a heater is inoperable and a baseline AFUE or Steady State Efficiency cannot be determined, the heater installation can be modeled as a natural replacement by applying an 80% AFUE as the baseline condition.

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

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

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

Where:

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

Heating Use weather normalization methods (HeatingUse):

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

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

Electric Savings Algorithms

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

Energy Savings
$\Delta kWh = 700\ kWh$

Demand Savings
$\Delta kW = 0\ kW$

Where:

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

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

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

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

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.

2) Space Heating System Tune-Up

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

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

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

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

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

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

Gas Savings Algorithms

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

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

Where:

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

Heating Use weather normalization methods (HeatingUse):

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

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

Electric Savings Algorithms

There are no electricity savings for this measure.

Energy Savings

$\Delta kWh = 0\ kWh$

Demand Savings

$\Delta kW = 0\ kW$

Where:

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

Freeridership/Spillover

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

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

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

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

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes

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

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

Water Savings
There are no water savings for this measure.

3) Infiltration Reduction

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

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

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

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

Gas Savings Algorithms

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

Where:

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

24 = hours/day

$CFM50_{pre}$ = CFM50 of building shell leakage as measured by a blower door test before treatment. If a blower door test cannot be performed due to health and safety reasons, the CFM50 pre will be estimated based on a comparison of similar housing stock.

$CFM50_{post}$ = CFM50 of building shell leakage as measured by a blower door test after treatment. If a blower door cannot be performed due to health and safety reasons, the CFM50 post will be calculated based on industry best practices as the estimated CFM50 pre value – (square inches of air sealing performed x 7.495). [83]

21.5 = factor to convert CFM50 value to Btu/hrF heat loss rate, calculated from hourly infiltration modeling[84]

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.[85]

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

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

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

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

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

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

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

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

[83] "Operating Instructions for the DG-700 Pressure and Flow Gauge," The Energy Conservancy. 2007. P. 16. From: http://toollending.com/tll_software/EnergyConservatory/dg700%20manual.pdf

[84] 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.

[85] 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

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

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[86]
$SEER_{CAC}$	Variable	Default values: Early Replacement = 10 Replace on Burnout = 13	PUC Technical Reference Manual
		Nameplate	Contractor Data Gathering

[86] "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
$\overline{EER}_{RAC}$	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[87]

EFLH, CDD and HDD by City

City	$EFLH_{cool}$ (Hours)[88]	$EFLH_{cool\ RAC}$ (Hours)[89]	CDD (Base 65)[90]	HDD (Base 65)[91]
Philadelphia	1032	320	1235	4759

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

Measure	Free Ridership	Spillover
Infiltration Reduction	0%	0%

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes

Measure	Measure Lifetime
Infiltration Reduction	20

Source: NYSERDA Home Performance with Energy Star.

Water Savings
There are no water savings for this measure.

4) Roof and Cavity Insulation

[87] 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). $F_{Room,AC} = (425\ ft^2 * 2.1)/(2323\ ft^2) = 0.38$
[88] PA 2010 TRM Table 2-1.
[89] PA SWE Interim Approved TRM Protocol – Residential Room AC Retirement
[90] 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
[91] Ibid.

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

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

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

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[92].
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.[93]

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

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

[92] From NWS data for PHL from 2002-2009, HDD63=4033 and HDD62 = 3820
[93] 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

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.*

$SEER_{CAC}$ = *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[94]
$SEER_{CAC}$	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[95]

EFLH, CDD and HDD by City

City	$EFLH_{cool}$ (Hours)[96]	$EFLH_{cool,RAC}$ (Hours)[97]	CDD (Base 65)[98]	HDD (Base 65)[99]
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%

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

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

[96] PA 2010 TRM Table 2-1.

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

[98] 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

[99] Ibid.

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes

Measure	Measure Lifetime
Roof Insulation	40
Cavity Insulation	40

Source: NYSERDA Home Performance with Energy Star.

Water Savings
There are no water savings for this measure.

5) Programmable Thermostat

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

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

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

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

Gas Savings Algorithms

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

Where:

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

HDD_{62} = 3820

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

HDD_{63} = 4033

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

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

Electric Savings Algorithms

If the type of air conditioning is known, then use the appropriate algorithm below. If the type or existence of air-conditioning is not known, then assume that 83% have air-conditioning and estimate the cooling savings as 83% of a house with central air conditioning.[100]

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

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

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

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)*

[100] 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

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:

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

Freeridership/Spillover

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

Equipment Type	Free Ridership	Spillover
Programmable Thermostat	0%	0%

Persistence

The persistence factor is assumed to be one.

Measure Lifetimes

Equipment Type	Measure Lifetime
Programmable Thermostat	15

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

Water Savings
There are no water savings for this measure.

6) Duct Work Insulation

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

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

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

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

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

Natural Gas Savings Algorithms

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

Where:

Length	=	Number of linear feet of duct work insulated
$EFLH_{heat}$	=	Equivalent full load heating hours = 730 hours
Th_{base}	=	Thickness of base condition insulation (inches)
Th_{bff}	=	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[101]
Ave. Wind Speed	=	0 mph
Relative Humidity	=	N/A
Dew Point	=	N/A
Condensation Control Thickness	=	N/A
Hours Per Year	=	2000[102]
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.

[101] Average winter temperature for Philadelphia from "Cost Savings and Comfort for Existing Buildings", 3rd Edition, by John Krigger, Saturn Resource Management. Page 255.
[102] 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

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes
The measure life is assumed to 18 years[103].

[103] NYSERDA Home Performance with Energy Star

7) Heating Pipe Insulation

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

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

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

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

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

Natural Gas Savings Algorithms

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

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

Where:

Length	=	Number of linear feet of heating pipe insulated
H_{heat}	=	Heating hours for a properly sized boiler. Used as an estimate of the hours in which the space-heating pipe would be hotter than the ambient temperature and would therefore experience heat loss.
Th_{base}	=	Thickness of base condition insulation (inches)
Th_{eff}	=	Thickness of efficient condition insulation (inches)
HeatLoss(x)	=	Heat loss through pipe as a function of insulation thickness x (Btu/ft /hr)
AFUE	=	Rated AFUE of heating system. If no rating is available then use the method described in the Efficient Space Heating System section for calculating the AFUE. The AFUE of replacement equipment should be used if the heating system replacement precedes the pipe insulation.
HDD	=	Base 63° F Heating Degree Days for Philadelphia = 4,033[104]
Dt	=	Design temperature difference (assume from 11° F to 70° F for properly sized boiler)[105] = 59° F

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

[104] Based on NCDC ASOS temperature data for PHL from 2002 through 2009.
[105] 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[106].

8) Duct Work Sealing

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

Measure Description
This measure provides estimates for stand-along savings from sealing ducts in a retrofit project and preventing heated air from leaking into unconditioned spaces. A duct blaster test shall be performed to calculate savings. If a duct blower test cannot be safely or properly performed, savings may be estimated by attributing a CFM25 reduction to specific duct issues identified and corrected, based on the table below. If duct sealing savings are estimated, the CFM25 reduction cannot exceed 500 CFM25.[107]

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[108]
CFMpost	=	Reading from duct-blaster test at 25 pascals, after sealing performed
DSFgas	=	Duct sealing factor for gas systems, 0.035 MMBtus/CFM-25[109]

[106] NYSERDA Home Performance with Energy Star
[107] Residential Energy, 5th edition, John Krigger and Chris Dorsi, p 89
[108] In scenarios where duct blower tests cannot be performed and CFMpre is estimated, it cannot exceed 500 CFM25
[109] Based on 3.5 MMBtus savings per 100 CFM reduction for duct sealing from UI/CL&P Program Savings Documentation – 2011, page 131

CFM25 equivalent savings for duct work sealing in unconditioned spaces, when duct blaster tests cannot be performed:

	CFM25 Equivalent	
Action	**Supply**	**Return**
Reconnect disconnected duct	300	150
Repair duct requiring a MAJOR patch job	200	100
Repair duct requiring a MINOR patch job	100	50
Seal all leaky seams/connections with silicone or mastic	100	50
Install additional RETURN capacity		200
Remove major obstruction in duct		100
Relocate existing duct to improve t-stat management	100	

Electric Savings Algorithms
Electric savings per 100 CFM-25 reduction:[110]

- 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

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[111].

9) High Efficiency Window

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

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

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

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

[110] UI/CL&P Program Savigns Documentation, 2011, page 131
[111] California DEER estimage.

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[112].
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.

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.[113]

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

Energy Savings

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

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

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

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

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

112 From NWS data for PHL from 2002-2009, HDD63=4033 and HDD62 = 3820

113 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

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[114]

[114] "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
$SEER_{CAC}$	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[115]

EFLH, CDD and HDD by City

City	$EFLH_{cool}$ (Hours)[116]	$EFLH_{cool\ RAC}$ (Hours)[117]	CDD (Base 65)[118]	HDD (Base 65)[119]
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.

[115] 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). $F_{Room,AC} = (425\ ft^2 * 2.1)/(2323\ ft^2) = 0.38$
[116] PA 2010 TRM Table 2-1.
[117] PA SWE Interim Approved TRM Protocol – Residential Room AC Retirement
[118] 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
[119] Ibid.

B. Domestic Hot Water End Use

1) Low Flow Showerhead

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

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

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

Definition of Efficient Condition
The flow rate of the efficient showerhead should be greater than the flow rate of the baseline condition. If this value is not available it is assumed to be 1.5 GPM[120].

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[121]
GPM_{eff}	=	Maximum gallons per minute of the efficient showerhead
2.48	=	Average number of people per household[122]
11.6	=	Average gallons of water per person per day used for showering[123]
365	=	Days per year
1.6	=	Average number of showers per home[124]

Natural Gas Savings Algorithms

[120] Pennsylvania Public Utility Commission Act 129 Technical Reference Manual (June 2011)
[121] The Energy Policy Act of 1992 established the maximum flow rate for showerheads at 2.5 gallons per minute (GPM)
[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 based on review of a number of studies:

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

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

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

Where:

$\Delta MMBtu$	=	MMBtu of saved natural gas
8.3	=	Constant to convert gallons to pounds (lbs)
c_p	=	Average specific heat of water at temperature range (1.00 Btu/lb·°F)
105	=	Assumed temperature of water coming out of showerhead (degrees Fahrenheit)
55	=	Assumed temperature of water entering house (degrees Fahrenheit)[125]
RE_{DHW}	=	Recovery efficiency of the domestic hot water heater = 75%[126]

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[127].

2) Low Flow Faucet Aerators

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

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

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

Definition of Efficient Condition
The efficient condition is a faucet aerator that has a flow rate lower than the baseline condition. If this value is not available than the flow rate is assumed to be 1.5 GPM[128].

[125] 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
[126] 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).
[127] Pennsylvania Public Utility Commission Act 129 Technical Reference Manual (June 2011)
[128] Pennsylvania Public Utility Commission Act 129 Technical Reference Manual (June 2011)

Water Savings Algorithms

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

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

Where:

$\Delta Gallons$	=	Gallons of water saved
GPM_{base}	=	Gallons per minute of baseline showerhead = 2.2 GMP[129]
GPM_{eff}	=	Gallons per minute of the efficient showerhead
2.48	=	Average number of people per household[130]
10.9	=	Average gallons per day used by faucet[131]
365	=	Days per year
50%	=	Drain rate, the percentage of water flowing down the drain[132]
3.5	=	Average Number of Faucets per home[133]

Natural Gas Savings Algorithms

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

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

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)
25	=	The difference between the temperature of the water entering the house and the temperature leaving the faucet (degrees Fahrenheit).[134]
RE_{DHW}	=	Recovery efficiency of the domestic hot water heater = 75%[135]

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.

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[129] 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

[130] Pennsylvania, Census of Population, 2000.

[131] 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)

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

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

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

[135] See assumption for low flow shower head.

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes
The measure life of a faucet aerator is assumed to be 12 years[136].

3) Efficient Natural Gas Water Heater

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

Measure Description
This measure relates to an efficient natural gas water heater.

Definition of Baseline Condition
The baseline is the energy factor (EF) of the existing water heater. If possible, the EF of the existing water heater should be used. If the EF of the existing water heater is unknown, 0.575 should be used[137].

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.

[136] Pennsylvania Public Utility Commission Act 129 Technical Reference Manual (June 2011)
[137] From Mass Save "Massachusetts Technical Reference Manual for Estimating Savings from Energy Efficiency Measures: 2011 Program Year – Plan Version." October 2010. Page 242.

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

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes
The measure life of a natural gas water heater is assumed to be 15 years[138].

4) Hot Water Heater Tank Temperature Turn-down

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

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

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

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

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

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

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

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[139]
8,760	=	Number of hours in a year

[138] DEER values. updated October 10, 2008
http://www.deeresources.com/deer0911planning/downloads/EUL_Summary_10-1-08.xls
[139] Calculated using the base conductive heat loss co-efficient and surface areas from: *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs* (October 15, 2010). Page 98

RE_{DHW}	=	Recovery efficiency of the domestic hot water heater = 75%[140]
1,000,000	=	Btu to MMBtu

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

Water Heater Size (Gal)	Height (Inches)*	Diameter (Inches)*	Total Surface Area (ft^2)	Annual Savings (MMBtu)
30	60	16	29.7	1.04
40	61	16.5	31.3	1.10
50	53	18	31.9	1.12
66	58	20	39.0	1.37
80	58	22	44.4	1.56

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

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

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

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes
The measure life of a natural gas water heater is assumed to be 2 years[141].

5) Repair Hot Water Leaks/Plumbing Repairs

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

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

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

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

[140] See assumption for low flow showerhead.
[141] Page 410. Vermont Technical Reference Manual and New Jersey Clean Energy Program Protocols

Water Savings Algorithms

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

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

** A drip is assumed to be 0.0001 gallons*[142]

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)[143]
RE_{DHW}	=	Recovery efficiency of the domestic hot water heater = 75%[144]

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.

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[142] 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)

[143] 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

[144] See assumption for low flow showerhead.

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

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

6) DHW Pipe Insulation

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

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

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

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

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

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

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

The thickness of the DHW pipe insulation should be equivalent to the diameter of the piping. For example, a 1" diameter pipe should be insulated with 1" thick insulation; a 2-1/2" diameter pipe with 2-1/2" thick insulation.[145]

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

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

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

Where:

Length = Number of linear feet of steam pipe insulated

Th_{base} = Thickness of base condition insulation (inches)

Th_{eff} = Thickness of efficient condition insulation (inches)

HeatLoss(x) = Heat loss through hot water pipe as a function of insulation thickness x (Btu/ft /yr)

RE_{DHW} = Recovery efficiency of the hot water heater = 75%[146]

"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

[146] See assumption for low flow showerhead.

Outer Surface Emittance = 0.9

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

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

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes
The measure life is assumed to be 20 years[147].

Measure Cost
The measure cost is the actual cost of installing the insulation, both materials and labor.

O&M Cost Adjustments
It is assumed that there are no O&M cost differences between the efficient and baseline equipment.

7) Hot Water Storage Tank Wrap

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

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

> "Water heater insulation wraps shall not cover the top of oil or gas systems, and shall not obstruct the pressure relief valve, thermostats, hi-limit switch, plumbing pipes, or access plates. A minimum 2-inch clearance is required from the access door for gas burners.
>
> Water heater insulation wraps shall not be installed where forbidden by the manufacturer's instructions found on the nameplate."[148]

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

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

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

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

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

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

Where:

$\Delta MMBtu$	=	MMBtu of saved gas per year
R_{eff}	=	R-value of the hot water heater with the insulating blanket (h °F ft²/Btu)
R_{base}	=	Original R-value of the hot water heater (h °F ft²/Btu) = 5.0[149] unless other information provided
Area	=	Surface area of the hot water heater covered by the insulating blanket (ft²)
T_{tank}	=	Temperature inside the tank (°F) = Assume 120 °F if no other information provided
T_{amb}	=	Temperature outside the tank (°F) = 55 °F[150]
8,760	=	Number of hours in a year
RE_{DHW}	=	Recovery efficiency of the domestic hot water heater = 75%[151]
1,000,000	=	Btu to MMBtu

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

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

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

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

Electric Savings Algorithms

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

Freeridership/Spillover

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

Persistence

The persistence factor is assumed to be one.

Measure Lifetimes

The measure life is assumed to be 5 years[152].

[149] 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

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

[151] See assumption for low flow showerhead.

V. Non-Residential Time of Replacement Market

A. Space Heating End Use

1) Efficient Space Heating System

Unique Measure Code(s): TBD
Draft date: 4/27/12
Effective date: TBD
End date: TBD

Measure Description
This measure applies to non-residential-sized (≥300MBH) gas boilers purchased at the time of natural replacement. A qualifying boiler must meet minimum efficiency requirements (Thermal Efficiency).

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

Equipment Type	Baseline Thermal Efficiency
Gas Boiler	80%

Definition of Efficient Condition
The installed gas boiler must have a Thermal Efficiency greater than that shown in the table below. Efficient model minimum Thermal Efficiency requirements are detailed below.

Equipment Type	Minimum Thermal Efficiency
Gas Boiler Tier 1	90%
Gas Boiler Tier 2	85%

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

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

Where:

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

$Capacity_{Out}$	= Output capacity of equipment to be installed (kBtu/hr)
1,000	= Conversion from kBtu to MMBtu
TE_{Base}	= Thermal Efficiency of new baseline equipment
TE_{Eff}	= Thermal Efficiency of new equipment
$EFLH_{Heat}$	= Equivalent Full Load Heating Hours
HDD	= Base 63° F Heating Degree Days for Philadelphia = 4,033[153]
Dt	= Design temperature difference (assume from 0° F to 70° F)

Equivalent Full Load Heating Hours by Building Type

Building Type	EFLH[154]
Multifamily	1435
Education	1529
Food Sales	1846
Food Service	2021
Health Care	2779
Lodging	778
Retail	1519
Office	1457
Public Assembly	1752
Public Order/Safety	1250
Religious Worship	1509
Service	2478
Warehouse/Storage	1047

Electric Savings Algorithms

Not applicable.

Freeridership/Spillover

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

Equipment Type	Free Ridership	Spillover
Gas Boiler	0%	0%

Persistence

The persistence factor is assumed to be one.

Measure Lifetimes

Equipment Type	Measure Lifetime

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

[154] From NJ Protocols for Philadelphia, adjusted for the PGW evaluation. The evaluation estimated realization rates using 3 methods and found savings to be 317%, 166% and 169%. PGW adjusted the EFLH based on the two lowest realization rates and adjusted the NJ Protocols EFLH by 168%.

Gas Boilers	25

Source: Consortium for Energy Efficiency, High Efficiency Commercial Boiler Systems Initiative Description, May 16, 2011, p. 17. Lifetimes range from 24-35 years.

Water Savings
There are no water savings for this measure.

2) Steam Trap

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

Measure Description
This measure applies to replacing non-residential steam traps on heating systems or repair of the steam trap by replacing the internal working parts with a new insert.

Definition of Baseline Condition
The baseline criterion is a faulty steam trap in need of replacing. No minimum leak rate is required. Any leaking or blow through trap can be repaired or replaced. If a customer chooses to repair or replace all the steam traps at the facility without verification, the savings are adjusted. Savings for full replacement projects are reduced by the percentage of traps found to be leaking on average from the studies listed. If an audit is performed on a site, then the leaking and blowdown can be adjusted.

Definition of Efficient Condition
Customers must have leaking traps to qualify. However, if a customer opts to replace all traps without inspection, the savings are discounted to take into consideration the fact that some traps are being replaced that have not yet failed. This measure may consist of either installation of a whole new steam trap or replacement of the internal working parts with an insert.

Gas Savings Algorithms

$$\Delta MMBtu = S \times \left(\frac{Hv}{B}\right) \times Hr \times A \times L\,/1{,}000{,}000$$

Where:

$\Delta MMBtu$	=	MMBtu of saved gas per year
S	=	Maximum theoretical steam loss per trap (lb/hr/trap). See table of values.
Hv	=	Heat of vaporization of steam, (Btu/lb). See table of values.
B	=	Boiler efficiency, (%)
Hr	=	Annual operating hours of steam plant. See table of values.
A	=	Adjustment factor to account for reducing the maximum theoretical steam flow (S) to the average steam flow (the Enbridge factor).
L	=	Leaking and blow-thru factor. If the steam trap has been audited and is known to be leaking, then this factor is 100%, if unaudited and unknown if leaking, then see table of values below.

1,000,000 = Btu to MMBtu

Steam Trap Algorithm Input Values

Steam Trap Application and Pressure	Avg Steam Loss, S (lb/hr/trap)[155]	Heat of Vaporization Hv (Btu/lb)[156]	Default Boiler Efficiency B[157]	Operating Hours, H[158]	Adjustment Factor, A[159]	Leaking & Blow-thru factor for unaudited traps, L[160]
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

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

[156] 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.

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

[158] 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.

[159] 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.

[160] Dry cleaners survey data as referenced in Resource Solutions Group "Steam Traps Revision #1" dated August 2011. If trap is known to be leaking, then this factor is 100%.

Steam Traps	0%	0%

Persistence
The persistence factor is assumed to be one.

Measure Lifetime
6 years[161]

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

B.Commercial Kitchen End Uses

1) Commercial Convection Ovens

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

Measure Description
A general-purpose chamber designed for heating, roasting, or baking food by forcing hot dry air over the surface of the food product. The rapidly moving hot air strips away the layer of cooler air next to the food and enables the food to absorb the heat energy. For the purposes of this specification, convection ovens do not include ovens that have the ability to heat the cooking cavity with saturated or superheated steam. Maximum water consumption within the oven cavity must not exceed 0.25 gallons/hour. Ovens that include a hold feature are eligible under this specification as long as convection is the only method used to fully cook the food.

- Full-Size Convection Oven: A convection oven that is able to accept a minimum of five standard full-size sheet pans measuring 18 x 26 x 1-inch.

This does not cover ovens designed for residential or laboratory applications; hybrid ovens, such as those incorporating steam and/or microwave settings in addition to convection; other oven types, as defined in Section 1, including combination, conventional or standard, conveyor, slow cook-and-hold, deck, mini-rack, rack, range, rapid cook, and rotisserie ovens.

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Definition of Baseline Condition
Cooking energy efficiency of 44% and Idle Energy Rate of 15,100 Btu/h[162].

Definition of Efficient Condition
Cooking energy efficiency greater than or equal to 46%[163] and an Idle Energy Rate less than or equal to 12,000 Btu/h

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[161] 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.
[162] 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.[164]

$$Annual\ Gas\ Savings\ (MMBtu) = 12.90\ MMBtu$$

Electric Savings Algorithms

There are no electric savings from this measure.

Energy Savings

$\Delta kWh = 0\ kWh$

Demand Savings

$\Delta kW = 0\ kW$

Where:

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

Freeridership/Spillover

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

Equipment Type	Free Ridership	Spillover
Commercial Convection Oven	0%	0%

Persistence

The persistence factor is assumed to be one.

Measure Lifetimes

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

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

Equipment Type	Measure Lifetime
Commercial Convection Oven	12

Sources: CA DEER, MA 2011 TRM, ENERGY STAR.

Water Savings
There are no water savings for this measure.

2) Commercial Gas Fryer

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

Measure Description
An appliance, including a cooking vessel, in which oil is placed to such a depth that the cooking food is essentially supported by displacement of the cooking fluid rather than by the bottom of the vessel. Heat is delivered to the cooking fluid by heat transfer from gas burners through either the walls of the fryer or through tubes passing through the cooking fluid.

- Standard Fryer: A fryer with a vat that measures >12 inches and < 18 inches wide, and a shortening capacity > 25 pounds and < 65 pounds.
- Large Vat Fryer: A fryer with a vat that measures > 18 inches and < 24 inches wide, and a shortening capacity > 50 pounds.

Definition of Baseline Condition
Heavy Load (French Fry) Cooking Energy Efficiency of 35%.
Idlle energy rate:

- 14,000 Btu/h for Standard Fryer
- 16,000 Btu/h for Large Vat Fryer

Definition of Efficient Condition
Heavy Load (French Fry) Cooking Energy Efficiency greater than or equal to 50%.
Idle energy rate less than or equal to:

- 9,000 Btu/h for Standard Fryer
- 12,000 Btu/h for Large Vat Fryer

All criteria are the same as the ENERGY STAR label.

Gas Savings Algorithms
The following shows the expected gas savings from Energy Star commercial fryers meeting the above specifications. These savings come from the Energy Star calculator.[165]

Standard Fryer (per frypot):

$$Annual\ Gas\ Savings\ (MMBtu) = 50.80\ MMBtu$$

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

Large Vat Fryer (per frypot):

$$Annual\ Gas\ Savings\ (MMBtu) = 79.50\ MMBtu$$

Electric Savings Algorithms

There are no electric savings from this measure.

Energy Savings

ΔkWh = 0 kWh

Demand Savings

ΔkW = 0 kW

Where:

ΔkWh = gross customer annual kWh savings for the measure.

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

Freeridership/Spillover

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

Equipment Type	Free Ridership	Spillover
Commercial Fryer	0%	0%

Persistence

The persistence factor is assumed to be one.

Measure Lifetimes

Equipment Type	Measure Lifetime
Commercial Fryer	12

Sources: CA DEER, MA 2011 TRM, ENERGY STAR.

Water Savings

There are no water savings for this measure.

3) Commercial Gas Steamers (Cooking)

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

Measure Description
Also referred to as a "compartment steamer," a device with one or more food steaming compartments in which the energy in the steam is transferred to the food by direct contact. Models may include countertop models, wall-mounted models and floor-models mounted on a stand, pedestal or cabinet-style base.

Definition of Baseline Condition
Cooking energy efficiency of 18% and Idle Energy Rate of 3,000 Btu/h per pan[166].

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.[167]

# of Pans	Annual Gas Savings (MMBtu)
3 pans	76.6
4 pans	86.4
5 pans	96.2
6 pans	105.4
7 + pans	105.4+ 14.2 per pan > 6 pans

Electric Savings Algorithms

There are no electric savings from this measure.

Energy Savings
$\Delta kWh = 0\ kWh$

Demand Savings

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

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

$\Delta kW = 0\ kW$

Where:

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

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

Equipment Type	Free Ridership	Spillover
Commercial Steam Cooker	0%	0%

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes

Equipment Type	Measure Lifetime
Commercial Steam Cooker	12

Sources: CA DEER, MA 2011 TRM, ENERGY STAR.

Water Savings
According to the Energy Star calculator the water savings would be 162,060 gallons per year for an Energy Star steamer compared to a baseline steamer.

4) Commercial Gas Griddle

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

Measure Description
Single or double sided gas griddle.

Definition of Baseline Condition
Cooking energy efficiency of 32% and Normalized Idle Energy Rate of 3,500 Btu/h per square foot[168].

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.

[168] From the Energy Star calculator

Gas Savings Algorithms

The following shows the expected gas savings from a commercial gas griddle meeting the above specifications. These savings come from the Energy Star calculator.[169]

$$Annual\ Gas\ Savings\ (MMBtu) = 13.10\ MMBtu$$

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.

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

5) Pre-rinse Spray Valve

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

Measure Description
Commercial dishwasher pre-rinse spray valves use hot water under pressure to clean food items off plates, flatware, and other kitchen items before they are placed into a commercial dishwasher. Pre-rinse valves are handheld devices, consisting of a spray nozzle, a squeeze lever that controls the water flow, and a dish guard bumper. Often they include a spray handle clip, allowing the user to lock the lever in the full spray position for continual use. The pre-rinse valve is part of the pre-rinse unit assembly that typically includes an insulated handle, a spring supported metal hose, a wall bracket, and dual faucet valves. Pre-rinse valves are inexpensive and frequently interchangeable within different manufacturers' hose assemblies. They are usually placed at the entrance to a dishwasher and can also be located over a sink, used in conjunction with a faucet fixture.

Definition of Baseline Condition
The baseline is a standard pre-rinse spray valve using approximately 1.6 gpm.

Definition of Efficient Condition
An efficient pre-rinse spray valve uses an average of 1.28 gpm.

Gas Savings Algorithms
The following shows the expected gas savings from an energy efficient pre-rinse spray valve meeting the above specifications.[170]

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

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%

[170] ENERGY STAR calculator 4/14.

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes

Equipment Type	Measure Lifetime
Pre-rinse Spray Valve	5[171]

Water Savings
Expected water savings would be 62,305 gallons per year.[172]

C.Commercial Domestic Hot Water End Use

1) Commercial Domestic Hot Water Heater

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

Measure Description
Installation of high-efficiency, gas-fired, storage-type or tankless, domestic hot water heaters greater than 75,000 Btu/hr.

Definition of Baseline Condition
Base case heater is a code-compliant storage gas heater as specified in ASHRAE 90.1-2007.

Definition of Efficient Condition
The efficient heater is a storage or tankless gas heater with equal to or exceeding 94% thermal efficiency.

Gas Savings Algorithms
If multiple heaters are used, they are treated as a single unit, with system input capacity and standby loss rate equal to the sum of all units.

$$\Delta MMBtu = BaselineUse - EfficientUse$$

For commercial buildings other than multifamily:
The maximum of:

$$BaselineUse = A \times E_b$$

or

$$BaselineUse = \frac{SLR_b \times 8760}{10^6}$$

[171] Massachusetts 2011 Technical Reference Manual.
[172] Massachusetts 2011 Technical Reference Manual.

For multifamily buildings:
The maximum of:

$$BaselineUse = U \times E_b$$

or

$$BaselineUse = \frac{SLR_b \times 8760}{10^6}$$

All building types:

$$EfficientUse = \left(BaselineUse - 8760 \times \frac{(SLR_b - SLR_e)}{10^6} \times \eta_b\right) \times \frac{\eta_b}{\eta_e}$$

$$SLR_b = CAP_{H,b} \times \frac{1000}{800} + 110 \times \sqrt{CAP_{W,b}}$$ [173]

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

Where:

$\Delta MMBtu$	=	MMBtu of saved gas per year
$BaselineUse$	=	Baseline DHW gas usage (MMBtu)
$EfficientUse$	=	Efficient DHW gas usage (MMBtu)
A	=	Building floor area (ft^2), input
E_b	=	For commercial buildings other than multifamily this is the annual baseline gas energy usage rate per building ft^2 (MMBtu/ft^2/yr). For multifamily this is the annual baseline gas energy usage rate per apartment unit (MMBtu/unit/yr). See table of values by building type.
U	=	Number of apartment units in multifamily building, input.
ΔT	=	Differential temperature rise (75°F)
SLR_e	=	Proposed efficient water heater standby loss rate (Btu/hr), input. Equal to zero if tankless. If unavailable, assume the same as SLR_b
η_e	=	Thermal efficiency of proposed efficient water heater (%)
η_b	=	Thermal efficiency of baseline water heater (80%)[174]
$CAP_{H,e}$	=	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
$CAP_{W,b}$	=	Water Storage capacity of baseline water heater (gal), equal to the maximum of $CAP_{W,e}$ or 60 gal, whichever is greater, since it is assumed that the baseline water heater is of the storage type.
$CAP_{H,b}$	=	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

[173] ASHRAE 90.1-2007, Table 7.8.
[174] ASHRAE 90.1-2007, Table 7.8.

Building Type	Annual Baseline Gas Usage Rate, E_b (MMBtu/ft2/yr)[175]
Education	0.00525
Grocery/Convenience Store	0.00319
Restaurant/Cafeteria	0.03996
Inpatient Health Care	0.03935
Outpatient Health Care	0.00350
Lodging	0.02915
Retail (other than in mall)	0.00103
Retail (in mall)	0.00309
Office	0.00165
Police/Fire Station/Jail	0.01514
Other	0.00165
	Annual Baseline Gas Usage Rate, E_b (MMBtu/unit/yr)[176]
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%

[175] U.S. Energy Information Administration Table E8A. Natural Gas Consumption and Energy Intensities by End Use for All Buildings, 2003.
[176] GDS Associates, Inc. (2009). Natural Gas Energy Efficiency Potential in Massachusetts. Prepared for GasNetworks.

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes

Equipment Type	Measure Lifetime
Commercial DHW Heater	12

Sources: CA DEER, MA 2011 TRM, ENERGY STAR.

Water Savings
There are no water savings for this measure.

D.All End Uses

1) Custom Measure

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

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

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

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

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

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

Where:

BaselineUse = The gas usage of baseline equipment or building.

EfficientUse = The gas usage of efficient equipment or building.

Electric Savings Algorithms

Energy Savings

$\Delta kWh = BaselinekWh - EfficientkWh$

Demand Savings

$\Delta kW = BaselinekW - EfficientkW$

Where:

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

Freeridership/Spillover

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

Equipment Type	Free Ridership	Spillover
Custom Measure	0%	0%

Persistence

The persistence factor is assumed to be one.

Measure Lifetimes

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

Water Savings

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

VI. Non-Residential New Construction

A.All End Uses

1) Custom Measures

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

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

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

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

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

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

Where:

BaselineUse	=	The gas usage of baseline equipment or building.
EfficientUse	=	The gas usage of efficient equipment or building.

Electric Savings Algorithms

Energy Savings
ΔkWh = *BaselinekWh - EfficientkWh*

Demand Savings
ΔkW = *BaselinekW - EfficientkW*

Where:

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

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

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

Equipment Type	Free Ridership	Spillover
Custom Measure	0%	0%

Persistence
The persistence factor is assumed to be one.

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

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

VII. Non-Residential Retrofit

A.Space Heating End Use

1) Efficient Space Heating System

Unique Measure Code(s): TBD
Draft date: 5/6/14
Effective date: TBD
End date: TBD

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

Definition of Baseline Condition
The baseline represents the existing equipment that is currently installed. The efficiency level and capacity are based on measurements or nameplate information.

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

Gas Savings Algorithms
The following equation accounts for differences between the baseline and efficient space heating equipment efficiencies and capacities.

$$Annual\ Gas\ Savings\ (MMBtu) = \frac{Capacity_{base}}{1{,}000} \times \left[\frac{1}{AFUE_{base}} - \frac{SR \times (1 + A_{avg})}{AFUE_{eff}}\right] \times EFLH_{Heat,base}$$

$$SR = \frac{Capacity_{eff}}{Capacity_{base}}$$

$$EFLH_{Heat,base} = \frac{Annual\ Gas\ Use_{base} \times AFUE_{base}}{Capacity_{base}}$$

Where:

$Annual\ Gas\ Savings\ (MMBtu)$	=	The annual gas savings of the efficient space heating equipment compared to the existing equipment.
$Capacity_{base}$	=	The existing space heating equipment output capacity (MBH)
$AFUE_{base}$	=	Efficiency of existing space heating equipment (Annual Fuel Utilization Efficiency)
SR	=	Sizing ratio of new efficient relative to the existing baseline equipment (See algorithm above).
A_{avg}	=	Runtime percent change adjustment. See table of values below based on SR value.[177]

[177] Developed by Practical Energy Solutions using simulation modeling.

$AFUE_{eff}$ = Efficiency of proposed efficient space heating equipment (Annual Fuel Utilization Efficiency)

$EFLH_{Heat,base}$ = Equivalent full load heating hours for existing baseline equipment (See algorithm above).

$Capacity_{eff}$ = The proposed efficient space heating equipment output capacity (MBH)

$Annual\ Gas\ Use_{base}$ = The annual gas usage of the existing space heating equipment, based on weather-normalized gas bills (kBtu).

Sizing Ratio (SR)	Run Time Adjustment (A_{avg})
50%	78%
55%	65%
60%	54%
65%	45%
70%	36%
75%	28%
80%	21%
85%	15%
90%	10%
95%	5%
100%	0%
105%	-4%
110%	-8%
115%	-12%
120%	-15%
125%	-18%
130%	-21%
135%	-23%
140%	-26%
145%	-28%
150%	-30%
155%	-32%
160%	-34%
165%	-36%
170%	-37%
175%	-39%
180%	-40%
185%	-42%
190%	-43%
195%	-44%
200%	-46%

Electric Savings Algorithms

Energy Savings

ΔkWh = *BaselinekWh - EfficientkWh*

Demand Savings

$\Delta kW = BaselinekW - EfficientkW$

Where:

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

Freeridership/Spillover

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

Equipment Type	Free Ridership	Spillover
Space Heating Equipment	0%	0%

Persistence

The persistence factor is assumed to be one.

Measure Lifetimes

Equipment Type	Measure Lifetime
Gas Furnaces	20
Gas Boilers	25

Source: Lifetime estimates used by Efficiency Vermont.

Water Savings

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

B.All End Uses

1) Custom Measures

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

Measure Description

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

Definition of Baseline Condition

The baseline represents the existing equipment that is currently installed. The efficiency level is based on measurements or nameplate information.

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

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

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

Where:

BaselineUse	=	The gas usage of baseline equipment or building.
EfficientUse	=	The gas usage of efficient equipment or building.

Electric Savings Algorithms

Energy Savings
$\Delta kWh = BaselinekWh - EfficientkWh$

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 EnergySense Demand Side Management Portfolio Phase II Compliance Plan, Fiscal Years 2017-2020 and Technical Reference Manual for FY 2017 upon the parties and persons listed below in the manner indicated in accordance with the requirements of 52 Pa. Code Section 1.54.

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Date: December 27, 2016