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January 4, 2018

VIA HAND DELIVERY

Rosemary Chiavetta, Secretary
Pennsylvania Public Utility Commission
Commonwealth Keystone Building
400 North Street, 2nd Floor North
P.O. Box 3265
Harrisburg, PA 17105-3265

Re: Pennsylvania Public Utility Commission v. UGI Utilities, Inc. - Gas Division
Docket No. R-2015-2518438

Office of Consumer Advocate, Office of Small Business Advocate, UGI Industrial Intervenors, Joseph Sandoski, Vicki L. East and Tom Harrison
Docket Nos. C-2016-2527150, C-2016-2528559, C-2016-2529436, C-2016-2529638, C-2016-2534010, C-2016-2534992

Dear Secretary Chiavetta:

Enclosed for filing on behalf of UGI Utilities, Inc. – Gas Division ("UGI Gas") is the Annual Report for the period October 1, 2016, through September 30, 2017, Program Year 1 of UGI Gas's Energy Efficiency and Conservation Plan. The Annual Report is being submitted to the Pennsylvania Public Utility Commission as required by Paragraph 41 of the Settlement approved in UGI Gas's 2016 base rate proceeding.

Respectfully submitted,

Garrett P. Lent

GPL/skr
Enclosures

cc: Certificate of Service
Bureau of Technical Utility Services

CERTIFICATE OF SERVICE
Docket No. R-2015-2518438

I hereby certify that a true and correct copy of the foregoing has been served upon the following persons in accordance with the requirements of 52 Pa. Code § 1.54 (relating to service by a participant).

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Date: January 4, 2018

Garrett P. Lent

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Report to the
Pennsylvania Public Utility Commission

UGI Utilities, Inc. – UGI Gas Division
Energy Efficiency and Conservation Plan
Program Year 1 (PY1)
October 1, 2016 - September 30, 2017

Prepared by UGI Utilities, Inc. - Gas Division
Filing Date: January 4, 2018

Table of Contents

1 EXECUTIVE SUMMARY

This Annual Report covers the first year of the UGI Utilities, Inc. – Gas Division (UGI Gas) Energy Efficiency and Conservation (EE&C) Plan, approved as part of UGI Gas's 2016 Rate Case (Docket No. R-2015-2518438). Program Year 1 (PY1) covers the period of October 1, 2016 through September 30, 2017. The EE&C Plan experienced a strong start in PY1:

- UGI Gas launched two energy efficiency (EE) programs in PY1: the Residential Prescriptive (RP) and Nonresidential Prescriptive (NP), UGI Gas also launched its Combined Heat and Power (CHP) Program. UGI Gas also had a soft launch of a third EE program - its Nonresidential Retrofit (NR) Program - with a project that received the Small Business Project of the Year Award by the Central Pennsylvania Chapter of the U.S. Green Building Council.
- Costs in PY1 for the EE&C Portfolio were $1.99 million, which equaled 75% of projected costs. Of PY1 costs, UGI Gas spent $1.25 million on incentives, (160% of projections) and $736,155 on non-incentive costs (40% of projections).
- PY1 savings for the EE programs were 32,661 MMBtus (221% of projections) while costs were $1.98 million (87% of projections). The EE programs also resulted in electric savings of 507 MWh in PY1.
- *There was no participation in the CHP Program in PY1, however, a project was pre-approved* for PY2. UGI Gas spent approximately $7,000 on administration and marketing for the CHP program in PY1.
- The total EE&C Portfolio provided $2.07 million in net benefits to customers with a benefit-to-cost ratio (BCR) of 1.74 as calculated under the Total Resource Cost (TRC) Test, including Demand Reduction Induced Price Effect (DRIPE) and the market price for CO_2. Under the TRC Test without DRIPE and CO_2, the Portfolio provided $1.20 million in net benefits to customers with a BCR of 1.43.
- In January 2018, UGI Gas plans to launch the two remaining EE programs - Residential Retrofit (RR) and New Construction (NC) - as well as fully launch the NR Program.

2 PORTFOLIO OVERVIEW

2.1 Background

In January 2016, UGI Gas proposed a voluntary, five-year EE&C Plan as part of its Rate Case (Docket No. R-2015-2518438). By its order entered October 14, 2016, the Commission approved the EE&C Plan (as amended by settlement in the proceeding). UGI Gas respectfully submits this report documenting the results of its EE&C Plan for PY1 in compliance with the agreed-upon settlement provisions to provide an annual report. The results set forth below represent a portfolio of cost-effective EE&C programs that benefit the customer through decreased energy costs while maintaining cost-effectiveness under the TRC test.

UGI Gas has six natural gas EE programs in its EE&C Portfolio and one program focused on CHP. These programs are:

- Residential Prescriptive (RP) Program
- Nonresidential Prescriptive (NP) Program
- New Construction (NC) Program
- Residential Retrofit (RR) Program
- Nonresidential Retrofit (NR) Program
- Behavior and Education (BE) Program
- Combined Heat and Power (CHP) Program

These programs follow the designs and goals established in UGI Gas's 2016 rate case. All of the EE&C programs are voluntary and offer UGI Gas customers a wide range of energy efficiency and conservation measures to decrease natural gas consumption and, in turn, customers' annual energy costs.

2.2 Summary of Activity

UGI Gas had a strong start to its EE&C Plan in PY1. Starting January 1, 2017, UGI Gas launched the RP Program, the NP Program, and the CHP Program, as well as had a soft-launch of its NR Program. Near the end of PY1, UGI Gas started on the development of the RR and NC Programs, which are scheduled to launch January 2018. Portfolio spending of $1.99 million was only 75% of projected PY1 spending, but first year savings of 32,661 MMBtus were more than twice first year projections. The high savings were mainly due to a strong PY1 for the RP Program. There were no CHP projects completed in PY1; however, there are a few active prospects in the pipeline that are considering CHP installations in 2018-2019. The EE&C Portfolio had a present value TRC net benefits of $2.07 million, with a BCR of 1.74 where the market price of CO_2 and DRIPE were counted. Where DRIPE and CO_2 were excluded from the calculation, the EE&C Portfolio had a present value TRC net benefit of $1.20 million, with a BCR of 1.43. The following tables provide a high-level overview of the EE&C Portfolio's spending and savings for PY1 and the current phase.

Table 1. EE&C PORTFOLIO SUMMARY - PY1			
Program	**Actual**	**Projected**	**%**
Portfolio Spending	$1,989,967	$2,658,506	75%
EE Programs	$1,983,191	$2,271,006	87%
CHP Program	$6,776	$387,500	2%
EE Program Natural Gas Savings			
Annual (MMBtus)	32,661	14,769	221%
Lifetime ((MMBtus)	627,915	268,207	234%
CHP Net Primary Energy Savings			
Annual (MMBtus)	0	169,855	0%
Lifetime ((MMBtus)	0	2,547,828	0%

Table 2. EE&C PORTFOLIO SUMMARY - PHASE I			
Program	**Actual**	**Projected**	**%**
Portfolio Spending	$1,989,967	$27,000,000	7%
EE Programs	$1,983,191	$24,204,900	8%
CHP Program	$6,776	$2,795,100	0%
EE Program Natural Gas Savings			
Annual (MMBtus)	32,661	647,407	5%
Lifetime ((MMBtus)	627,915	7,384,990	9%
CHP Net Primary Energy Savings			
Annual (MMBtus)	0	1,706,090	0%
Lifetime ((MMBtus)	0	25,591,350	0%

2.2.1 Summary of Program Costs

Table 3. PORTFOLIO COSTS BY PROGRAM – PY1			
Program	**Total**	**Incentive**	**Non-Incentive**
Residential Prescriptive (RP)	$1,448,148	$1,171,100	$277,048
Nonresidential Prescriptive (NP)	$108,419	$31,712	$76,707
Residential Retrofit (RR)	$19,814	$-	$19,814
Nonresidential Retrofit (NR)	$51,030	$51,000	$30
New Construction (NC)	$6,047	$-	$6,047
Behavior and Education (BE)	$-	$-	$-
Portfoliowide Costs	$349,733	$-	$349,733
Energy Efficiency Total	**$1,983,191**	**$1,253,812**	**$729,379**
CHP	$6,776	$-	$6,776
Portfolio Total	**$1,989,967**	**$1,253,812**	**$736,155**

Table 4. PORTFOLIO COSTS BY PROGRAM – Inception to Date			
Program	**Total**	**Incentive**	**Non-Incentive**
Residential Prescriptive (RP)	$1,448,148	$1,171,100	$277,048
Nonresidential Prescriptive (NP)	$108,419	$31,712	$76,707
Residential Retrofit (RR)	$19,814	$-	$19,814
Nonresidential Retrofit (NR)	$51,030	$51,000	$30
New Construction (NC)	$6,047	$-	$6,047
Behavior and Education (BE)	$-	$-	$-
Portfoliowide Costs	$349,733	$-	$349,733
Energy Efficiency Total	**$1,983,191**	**$1,253,812**	**$729,379**
CHP	$6,776	$-	$6,776
Portfolio Total	**$1,989,967**	**$1,253,812**	**$736,155**

2.2.2 Summary of Program Savings

Table 5. ENERGY EFFICIENCY PROGRAM SAVINGS – PY1							
	Natural Gas (MMBtus)		Electric Energy (MWh)		Capacity	Water Savings (Million Gal)	
Program	Annual	Lifetime	Annual	Lifetime	MW-yr.	Annual	Lifetime
Residential Prescriptive (RP)	26,872	512,870	507.0	9,836.4	0.111	0	0
Nonresidential Prescriptive (NP)	3,216	64,325	0.0	0.0	0.000	0	0
Residential Retrofit (RR)	0	0	0.0	0.0	0.000	0	0
Nonresidential Retrofit (NR)	2,573	50,720	0.0	0.0	0.000	0	0
New Construction (NC)	0	0	0.0	0.0	0.000	0	0
Behavior and Education (BE)	0	0	0.0	0.0	0.000	0	0
Energy Efficiency Total	**32,661**	**627,915**	**507.0**	**9,836.4**	**0.111**	**0**	**0**

Table 6. ENERGY EFFICIENCY PROGRAM SAVINGS – Inception to Date							
	Natural Gas (MMBtus)		Electric Energy (MWh)		Capacity	Water Savings (Million Gal)	
Program	Annual	Lifetime	Annual	Lifetime	MW-yr.	Annual	Lifetime
Residential Prescriptive (RP)	26,872	512,870	507.0	9,836.4	0.111	0	0
Nonresidential Prescriptive (NP)	3,216	64,325	0.0	0.0	0.000	0	0
Residential Retrofit (RR)	0	0	0.0	0.0	0.000	0	0
Nonresidential Retrofit (NR)	2,573	50,720	0.0	0.0	0.000	0	0
New Construction (NC)	0	0	0.0	0.0	0.000	0	0
Behavior and Education (BE)	0	0	0.0	0.0	0.000	0	0
Energy Efficiency Total	**32,661**	**627,915**	**507.0**	**9,836.4**	**0.111**	**0**	**0**

Table 7. CHP PROGRAM SAVINGS				
	PY1		Inception to Date	
Savings	Annual	Lifetime	Annual	Lifetime
Net Primary Fuel Savings (MMBtus)	0	0	0	0

2.2.3 Summary of Program Cost-Effectiveness

Table 8. PORTFOLIO COST-EFFECTIVENESS BY PROGRAM - PY1 (2015$)								
	TRC Test - Base Case + DRIPE & CO2				TRC Test - Base Case			
Program	**NPV Benefits**	**NPV Costs**	**NPV Net**	**BCR**	**NPV Benefits**	**NPV Costs**	**NPV Net**	**BCR**
Residential Prescriptive (RP)	$4,167,589	$2,257,330	$1,910,258	1.85	$3,424,726	$2,257,330	$1,167,395	1.52
Nonresidential Prescriptive (NP)	$443,933	$106,056	$337,877	4.19	$375,326	$106,056	$269,270	3.54
Residential Retrofit (RR)	$-	$17,175	$(17,175)	0.00	$-	$17,175	$(17,175)	0.00
Nonresidential Retrofit (NR)	$257,883	$108,220	$149,664	2.38	$203,788	$108,220	$95,568	1.88
New Construction (NC)	$-	$5,241	$(5,241)	0.00	$-	$5,241	$(5,241)	0.00
Behavior and Education (BE)	$-	$-	$-	N/A	$-	$-	$-	N/A
Portfoliowide Costs	$-	$303,142	$(303,142)	0.00	$-	$303,142	$(303,142)	0.00
Energy Efficiency Total	**$4,869,406**	**$2,797,164**	**$2,072,241**	**1.74**	**$4,003,840**	**$2,797,164**	**$1,206,675**	**1.43**
CHP	$-	$6,400	$(6,400)	0.00	$-	$6,400	$(6,400)	0.00
Portfolio Total	**$4,869,406**	**$2,803,564**	**$2,065,841**	**1.74**	**$4,003,840**	**$2,803,564**	**$1,200,276**	**1.43**

Table 9. PORTFOLIO COST-EFFECTIVENESS BY PROGRAM – Inception to Date (2015$)								
	TRC Test - Base Case + DRIPE & CO2				TRC Test - Base Case			
Program	**NPV Benefits**	**NPV Costs**	**NPV Net**	**BCR**	**NPV Benefits**	**NPV Costs**	**NPV Net**	**BCR**
Residential Prescriptive (RP)	$4,167,589	$2,257,330	$1,910,258	1.85	$3,424,726	$2,257,330	$1,167,395	1.52
Nonresidential Prescriptive (NP)	$443,933	$106,056	$337,877	4.19	$375,326	$106,056	$269,270	3.54
Residential Retrofit (RR)	$-	$17,175	$(17,175)	0.00	$-	$17,175	$(17,175)	0.00
Nonresidential Retrofit (NR)	$257,883	$108,220	$149,664	2.38	$203,788	$108,220	$95,568	1.88
New Construction (NC)	$-	$5,241	$(5,241)	0.00	$-	$5,241	$(5,241)	0.00
Behavior and Education (BE)	$-	$-	$-	N/A	$-	$-	$-	N/A
Portfoliowide Costs	$-	$303,142	$(303,142)	0.00	$-	$303,142	$(303,142)	0.00
Energy Efficiency Total	**$4,869,406**	**$2,797,164**	**$2,072,241**	**1.74**	**$4,003,840**	**$2,797,164**	**$1,206,675**	**1.43**
CHP	$-	$6,400	$(6,400)	0.00	$-	$6,400	$(6,400)	0.00
Portfolio Total	**$4,869,406**	**$2,803,564**	**$2,065,841**	**1.74**	**$4,003,840**	**$2,803,564**	**$1,200,276**	**1.43**

2.3 Progress Against Goals

UGI Gas made significant progress towards savings goals, achieving 221% of its PY1 annual MMBtu projections, while only spending 75% of its PY1 projections. Administration costs came in below projections, partially due to the amortization of portfolio design and startup costs over the five-year life of the Plan. The strong start in PY1 can be primarily attributed to the success of the RP Program where customer incentives were 248% higher than initially projected. Overall, UGI Gas spent $1,989,967 in PY1, or approximately 7% of the approved settlement cap of $27 million.

UGI Gas also has kept the commitments it made in the settlement of its 2016 Base Rate Case. Paragraph 42 of the settlement for UGI Gas' 2016 Rate Case requires UGI Gas to limit the percentage of costs spent by the utility on the NP, NR, and Nonresidential New Construction Programs to 55% or less of the total cost to the utility and customer over the five-year life of the plan. The following table shows that for the phase-to-date, this value is 65%. UGI Gas is confident that this percentage will fall as the nonresidential programs ramp up and more customers participate.

Table 10. NONRESIDENTIAL PROGRAM UTILITY COST PERCENTAGES

Program	Utility Cost	Incremental Participant Cost	Total Cost	% Utility
NP	$108,419	$13,936	$122,356	89%
NR	$51,030	$73,822	$124,852	41%
NNC	$0	$0	$0	N/A
Total	**$159,449.42**	**$87,758.45**	**$247,208**	**65%**

In addition, per Paragraph 39 of the settlement for UGI Gas's 2016 Base Rate Case, UGI Gas agreed to: (1) develop targeted marketing materials for existing residential multi-family customers and new multi-family residential construction, including master-metered multi-family residences; (2) coordinate with the Pennsylvania Housing Alliance and the Pennsylvania Housing Finance Authority (PHFA); and (3) track participation for buildings with more than one unit. In compliance with the settlement, in PY1, UGI Gas identified 35 rebates in the RP and NP program that were tied to buildings with more than one unit. This represented $36,800 incentive dollars and 1,721 MMBtus in first year savings. PY1 activity specifically targeted at the multifamily market involved engagement with stakeholders ready for the launch of the NR and NC Programs in PY2. UGI Gas was a sponsor at the Pennsylvania Housing Finance Authority (PHFA) Housing Summit on May 11th and 12th, 2017 and UGI Energy Efficiency Staff had a table at the summit offering information on UGI Gas's energy efficiency programs. In addition to the PHFA Summit, UGI Gas held a webinar for members of the

Housing Alliance of Pennsylvania. This multi-family development organization holds well attended webinars throughout the year.

Moreover, paragraph 40 of the settlement for UGI Gas's 2016 Base Rate Case requires UGI Gas to: (1) inform customers who contact UGI Gas or its CSPs with interest in participating in the EE&C Plan that they might qualify for the Company's Low Income Usage Reduction Program (LIURP) if they are income qualified; (2) refer such customers to LIURP; and (3) refer confirmed low-income customers to LIURP. In PY1, UGI Gas referred 10 customers to the Company's LIURP Team, none of which ultimately qualified for LIURP.

2.3.1 Portfolio Costs

Table 11. EE&C PORTFOLIO COSTS BY CATEGORY - PY1			
Component (Nominal $)	**Actual**	**Projected**	**%**
Direct Utility Costs	**$1,989,967**	**$2,658,506**	**75%**
Customer Incentives	$1,253,812	$782,252	160%
Administration	$468,875	$1,447,765	32%
Marketing	$259,690	$382,806	68%
Inspections	$7,590	$25,683	30%
Evaluations	$0	$20,000	0%
Incremental Participant Costs	**$1,243,872**	**$8,864,503**	**14%**

Table 12. EE&C PORTFOLIO COSTS BY CATEGORY - PHASE I			
Component (Nominal $)	**Actual**	**Projected**	**%**
Direct Utility Costs	**$1,989,967**	**$27,000,000**	**7%**
Customer Incentives	$1,253,812	$16,909,824	7%
Administration	$468,875	$6,790,090	7%
Marketing	$259,690	$2,039,329	13%
Inspections	$7,620	$600,476	1%
Evaluations	$0	$660,281	0%
Incremental Participant Costs	**$1,243,872**	**$86,246,453**	**1%**

2.3.2 Portfolio Savings

Table 13. EE&C PROGRAM SAVINGS - PY1			
Type	**Actual**	**Projected**	**%**
EE Programs			
Natural Gas (MMBtus)			
Annual	32,661	14,769	221%
Lifetime	627,915	268,207	234%
Electric Energy (MWh)			
Annual	507.0	248.3	204%
Lifetime	9,836.4	4,819.1	204%
Capacity Savings (MW)	0.111	0.055	204%
Water Savings (Million Gal)			
Annual	0	573,340	0%
Lifetime	0	3,440,040	0%
CHP Program			
Net Primary Energy Savings			
Annual (MMBtus)	0	169,855	0%
Lifetime (MMBtus)	0	2,547,828	0%

Table 14. EE&C PROGRAM SAVINGS - PHASE I			
Type	**Actual**	**Projected**	**%**
EE Programs			
Natural Gas (MMBtus)			
Annual	32,661	647,407	5%
Lifetime	627,915	7,384,990	9%
Electric Energy (MWh)			
Annual	507.0	4,722.6	11%
Lifetime	9,836.4	92,459.8	11%
Capacity Savings (MW)	0.111	1.052	11%
Water Savings (Million Gal)			
Annual	0	26,189,579	0%
Lifetime	0	248,471,774	0%
CHP Program			
Net Primary Energy Savings			
Annual (MMBtus)	0	1,706,090	0%
Lifetime (MMBtus)	0	25,591,350	0%

2.4 Updates

2.4.1 Portfolio Updates

- The Technical Reference Manual (TRM) used by the EE&C Portfolio has been updated to account for changes to federal standards and updates in program design. A redlined version is included as an attachment to this report.

2.4.2 Program Updates

- UGI Gas will be launching an online marketplace where customers can purchase Wi-Fi-enabled thermostats and receive an instant rebate. UGI Gas anticipates leveraging this marketplace to offer promotional deals to further drive customer participation.
- Wi-Fi thermostats within the RP Program will be required to be ENERGY STAR Certified starting in January 2018.
- UGI Gas is removing the 85% Et level incentive for commercial boilers in the NP Program and only allowing incentives for ENERGY STAR Certified commercial boilers, which equate to the 90%+ Et (thermal efficiency) tier currently offered.
- The NC Program is launching in January 2018. Residential New Construction incentives will be $20 per MMBtu for homes achieving savings 30% above code based on a Home Energy Rating System (HERS) rating. Homes that are 30% above code and are also ENERGY STAR Certified can receive $30 per MMBtu.
- Under the RR Program, launching in January 2018, customers will be eligible for a comprehensive home audit at a cost of $150. Contractors will receive an additional $150 from UGI Gas for audits they perform. UGI Gas will then offer customers an incentive based on the list of recommended measures from the audit. The incentives were designed to be higher and more comprehensive than what customers could receive through the RP Program. The list of measures and incentives is provided in Section 3.4.3.
- The NR Program will have a broader launch in January of 2018 and be managed in-house by the UGI Gas Energy Efficiency Staff.

3 PROGRAM RESULTS

3.1 Residential Prescriptive Program

(Rate Classes R/RT, N/NT)

3.1.1 Program Description

The RP program is designed to overcome market barriers to energy efficient space and water heating equipment in the residential sector through rebates and customer awareness. The objective of the program is to avoid lost opportunities by encouraging consumers to install the most efficient gas heating technologies available when replacing older, less efficient equipment. The program also aims to strengthen UGI Gas's relationship with heating, ventilation and air conditioning (HVAC) contractors, suppliers, and other trade allies.

3.1.2 Program Highlights

The RP Program spent $1,448,148 in PY1, of which $1,171,100 were customer incentives. The Program provided first year gas savings of 26,872 MMBtus, 225% of plan projections. The Program provided lifetime gas savings of 512,870 MMBtus, 231% of plan projections. Under the TRC Test, including DRIPE and CO_2, the RP Program provided $1.9 million in present value of net benefits (2015$) with a BCR of 1.85. Without DRIPE or CO_2, the RP Program provided $1.2 million in present value of net benefits (2015$) with a BCR of 1.52

In July 2016, a request for proposal (RFP) was put out to all Conservation Service Providers (CSPs) registered with the PA PUC, requesting rebate processing service proposals for the newly developed UGI Gas prescriptive rebate programs. In October 2016, UGI Gas hired Energy Federation, Inc. (EFI) to process rebates, provide customer service and quality assurance inspections. The program implementation process took place from October through December 2016. During this time, the procedures and verification protocols were put into place, the rebate applications were developed and the inspection protocols were established. The final piece of the implementation was the completion of the online application portal, which gives customers real time rebate tracking. On January 1, 2017, the RP Program officially launched.

The RP Program saw participation increase each month throughout PY1. The customer participation increases went hand in hand with contractor participation as program buy-in continued to show growth and the Program exceeded its first year participation and savings targets by a significant margin. In total, 1,892 customers participated in the RP Program in PY1 - some of them receiving more than one rebate. For example, customers installing heating equipment may have also chosen to install a Wi-Fi thermostat. Below is a chart that highlights rebates issued by equipment type.

Table 15. RP Participation	
Equipment	**Rebates Issued**
Wi-Fi Thermostat	1,530
ENERGY STAR Furnace	1,062
94+ AFUE Combi-Boiler	188
ENERGY STAR Tankless Water Heater	137
94+ AFUE Boiler	64
Total	**2,981**

3.1.2.1 Marketing Activity

Marketing activity began in November 2016 with an announcement on upcoming programs to local HVAC contractors in each region. Informational overview sessions were held in Harrisburg, Lancaster, Bethlehem and Reading and were attended by approximately 60 different HVAC Companies.

In addition to the contractor overview sessions, press releases were issued and an article was published in UGI's December issue of First Line. First Line is a monthly UGI publication provided to each member of the Pennsylvania General Assembly and the Pennsylvania Governor's office as well as the PA Congressional delegation, so that legislators may pass the information on to their constituents. Multiple newspapers across the region picked up the article, further broadening the customer reach.

Program marketing also included monthly bill inserts and radio advertising which aired during drive times throughout the region's most prominent radio stations. The announcements were focused on educating customers on the various energy efficiency options available, along with energy saving tips.

The majority of the marketing focus for the RP Program was spent on digital advertising. The website, www.ugi.com/savesmart was redesigned to include all of the new gas program offerings. The website included easy to follow navigation for either paper or online rebate applications. Additional digital advertising included various social media channels and google key word searches. UGI's social media team regularly promoted the RP Program while leveraging platforms such as Facebook, Instagram, Twitter and Pinterest.

3.1.2.2 Inspection Activity

EFI, the CSP responsible for processing rebates, has also been retained to provide inspections on a subset of applications. The purpose of these inspections is to confirm that the equipment on the rebate application matches the equipment that has been installed in the customer's home. Payment of the rebate is withheld from applications flagged for inspection until such activity has been completed. In PY1, 94 inspections were performed, with only six inspections failing. Of the six failed inspections, five were for eligible equipment, but they had model numbers that did not match application information. These model numbers were updated and the rebates were issued to customers.

3.1.2.3 Evaluation Activity

A program evaluator will be hired in 2018 to perform an impact evaluation on the RP Program.

3.1.3 Program Updates

Beginning January 1, 2018, the qualification for a Wi-Fi Thermostat rebate will be updated from any internet connected thermostat to only Wi-Fi Thermostats that are ENERGY STAR Certified. In working closely with the Regional Representatives from the U.S. Environmental Protection Agency, it has been determined that in January 2018, there will be at least eight ENERGY STAR Certified Wi-Fi Thermostats available on the market. Given this information, UGI Gas feels that customers will have sufficient product offerings, thus, the RP Program will require ENERGY STAR Certification for all Wi-Fi Thermostats.

3.1.4 Residential Prescriptive Program Results

Table 16. PROGRAM COSTS

Component (Nominal $)	PY1 - Actual	PY1 - Projected	%
Direct Utility Costs	**$1,448,148**	**$691,638**	**209%**
Customer Incentives	$1,171,100	$471,396	248%
Administration	$84,894	$108,189	78%
Marketing	$185,138	$95,631	194%
Inspections	$7,015	$16,422	43%
Evaluations	$0	$0	
Incremental Participant Costs	**$1,156,114**	**$494,391**	**234%**

Table 17. PROGRAM SAVINGS			
Type	**PY1 - Actual**	**PY1 - Projected**	**%**
Natural Gas (MMBtus)			
Annual	26,872	11,969	225%
Lifetime	512,870	222,047	231%
Electric Energy (MWh)			
Annual	507.0	248.3	204%
Lifetime	9,836.4	4,819.1	204%
Capacity Savings (MW)	0.111	0.055	204%
Water Savings (Million Gal)			
Annual	0	0	
Lifetime	0	0	

Table 18. PROGRAM COST-EFFECTIVENESS (BASE CASE + DRIPE & CO_2)		
Benefits/Cost Component (2015$)	**PY1**	**Inception to Date**
TRC NPV Benefits	$4,167,589	$4,167,589
TRC NPV Costs	$2,257,330	$2,257,330
TRC Net Benefits	$1,910,258	$1,910,258
TRC Benefit/Cost Ratio	1.85	1.85

Table 19. PROGRAM COST-EFFECTIVENESS (BASE CASE)		
Benefits/Cost Component (2015$)	**PY1**	**Inception to Date**
TRC NPV Benefits	$3,424,726	$3,424,726
TRC NPV Costs	$2,257,330	$2,257,330
TRC Net Benefits	$1,167,395	$1,167,395
TRC Benefit/Cost Ratio	1.52	1.52

3.2 Nonresidential Prescriptive Program

(Rate Classes R/RT, N/NT)

3.2.1 Program Description

The Nonresidential Prescriptive (NP) Program is designed to overcome market barriers to energy efficient equipment in the small business and commercial sector through rebates and customer outreach. The objective of the program is to encourage business owners to install the most efficient gas heating technologies available to replace older, less efficient equipment. The program also aims to strengthen UGI Gas's relationship with HVAC contractors, suppliers, and other trade allies.

3.2.2 Program Highlights

The NP Program spent $108,419 in PY1, of which $31,712 were customer incentives. The Program provided first year gas savings of 3,216 MMBtus, 115% of plan projections. The Program provided lifetime gas savings of 64,325 MMBtus, 139% of plan projections. Under the TRC Test, including DRIPE and CO_2, the NP Program provided $338 thousand in present value of net benefits (2015$) with a BCR of 4.19. Without factoring in DRIPE or CO_2, the RP Program provided $269 thousand in present value of net benefits (2015$) with a BCR of 3.54.

In late July 2016, an RFP was put out to all CSPs registered with the PA PUC, requesting rebate processing service proposals for the newly developed UGI Gas prescriptive rebate programs. In October 2016, UGI Gas hired Energy Federation, Inc. (EFI) to process rebates, provide customer service and quality assurance inspections for the UGI Gas prescriptive rebate programs. The program implementation process took place from October through December, 2016. During this time, the program designs were put into place, the rebate applications were developed, and the inspection protocols were established. The final piece of the implementation was the completion of the online application, which gives customers real time rebate tracking. On January 1, 2017, the NP Program was officially launched.

The program got off to a slow start, as can be expected with nonresidential programs. However, the NP program saw participation increase with key projects at churches, non-profit organizations and small businesses. Six customers participated in the NP Program in FY 2017. Below is a chart that outlines those customer's participation by equipment type.

Table 20. NP Participation

Equipment	Rebates Issued
Steam Trap 15 – 74 PSI	24
90+ Et Commercial Boiler	5
ENERGY STAR Commercial Water Heater	4
Total	**33**

3.2.2.1 *Marketing Activity*

Marketing activity for the NP program was conducted in conjunction with the marketing activity for the RP program, including contractor outreach, along with bill inserts, digital and radio advertising.

In addition, the NP program marketed specifically toward non-profit organizations and places of worship. These customers are often overlooked due to a perceived lack of funding. In reality, these customers might benefit from EE&C programs by reducing their overhead through bill reduction, which provides more direct service to their respective causes. In PY1, the NP program provided two large and efficient commercial boiler rebates to St. Patrick's Cathedral and St. Lawrence chapel, both within the Cathedral Parish of Saint Patrick in Harrisburg, Pennsylvania. A press release was developed, highlighting these projects in order to reach out directly to this market.

Another market that was directly targeted was the commercial kitchen industry. In order to better reach this community, UGI has enhanced its membership with the Pennsylvania Restaurant and Lodging Association (PRLA). The NP Program was featured in their monthly circulation, titled Quick Bites, which informed PRLA members of the various rebates available through the NP Program.

3.2.2.2 *Inspection Activity*

EFI, the CSP responsible for processing rebates has also been retained to provide inspections on a subset of applications. The purpose of these inspections is to confirm that the equipment on the rebate application matches the equipment that has been installed in the customer's business. Payment of the rebate is withheld from applications flagged for inspection until such activity has been completed. In PY1, inspections were performed on the majority of rebates, with two inspections initially failing due to an invoice model number error. Subsequently, the inspections were corrected and the rebates were approved.

3.2.2.3 *Evaluation Activity*

A program evaluator will be hired in 2018 to perform an impact evaluation on the NP Program.

3.2.3 <u>Program Updates</u>

Beginning January 1, 2018, the standard for a qualifying commercial boiler will be increased to require ENERGY STAR Certification. The NP Program currently offers an incentive of $2/MBH for an 85% efficient commercial boiler and offers the same per MBH rebate with a $2,000 bonus for a 90% or greater efficient commercial boiler. With the increased qualifying standard of ENERGY STAR Certified, the 85% efficient level of incentive will be removed. An ENERGY STAR Certified commercial boiler will have a base incentive level of $2,000 plus an additional $2/MBH of capacity.

3.2.4 Nonresidential Prescriptive Program Results

Table 21. PROGRAM COSTS			
Component (Nominal $)	**PY1 - Actual**	**PY1 - Projected**	**%**
Direct Utility Costs	**$108,419**	**$241,494**	**45%**
Customer Incentives	$31,712	$60,856	52%
Administration	$6,402	$96,597	7%
Marketing	$69,731	$77,278	90%
Inspections	$575	$6,762	9%
Evaluations	$0	$0	
Incremental Participant Costs	**$13,936**	**$82,530**	**17%**

Table 22. PROGRAM SAVINGS			
Type	**PY1 - Actual**	**PY1 - Projected**	**%**
Natural Gas (MMBtus)			
Annual	3,216	2,800	115%
Lifetime	64,325	46,161	139%
Electric Energy (MWh)			
Annual	0.0	0.0	
Lifetime	0.0	0.0	
Capacity Savings (MW)	0.000	0.000	
Water Savings (Million Gal)			
Annual	0	573,340	0%
Lifetime	0	3,440,040	0%

Table 23. PROGRAM COST-EFFECTIVENESS (BASE CASE + DRIPE & CO_2)		
Benefits/Cost Component (2015$)	**PY1**	**Inception to Date**
TRC NPV Benefits	$443,933	$443,933
TRC NPV Costs	$106,056	$106,056
TRC Net Benefits	$337,877	$337,877
TRC Benefit/Cost Ratio	4.19	4.19

Table 24. PROGRAM COST-EFFECTIVENESS (BASE CASE)		
Benefits/Cost Component (2015$)	**PY1**	**Inception to Date**
TRC NPV Benefits	$375,326	$375,326
TRC NPV Costs	$106,056	$106,056
TRC Net Benefits	$269,270	$269,270
TRC Benefit/Cost Ratio	3.54	3.54

3.3 New Construction Program

(Rate Classes R/RT, N/NT)

3.3.1 Program Description

The NC Program is designed to overcome market barriers to energy efficient space and water heating equipment, as well as high efficiency thermal envelopes, in both the residential and nonresidential new construction sector through rebates offered to builders and developers. The objective of the program is to avoid lost opportunities by encouraging builders and developers to install the most efficient gas heating technologies available instead of less efficient baseline equipment, as well as promote thermal envelope best practices. The program also aims to strengthen UGI Gas's relationship with architects, builders, HVAC contractors, suppliers, and other trade allies. The NC Program will be launched on January 1, 2018.

3.3.2 Program Highlights

In May, 2017, an RFP was released to all CSPs registered with the PA PUC. UGI hired Performance Systems Development (PSD) as the program implementer for the Residential New Construction (RNC) and Residential Retrofit (RR) Programs. In PY1, $6,047 was spent on administrative activities leading up to the launch. Program administration, incentives and marketing expenses will ramp up in PY2. Due to the minimal volume of projects anticipated in the nonresidential new construction market, the nonresidential component of the NC program will be managed by UGI EE&C Staff.

3.3.2.1 Marketing Activity

In 2018, marketing will be conducted through established builders and HERS raters that have been participants in the programs mandated for large electric distribution companies (EDCs) by Act 129 of 2008, P.L. 1592 (Act 129). The marketing plan for 2018 also includes outreach to various Home Builder Associations to educate this audience on the availability of this program. Finally, the marketing plan includes energy efficiency signage for homes that have been incentivized through the program. These signs will outline the energy efficient features of a UGI Gas Save Smart New Home.

3.3.2.2 Inspection Activity

There was no inspection activity in PY1 for the NC Program.

3.3.2.3 Evaluation Activity

There was no evaluation activity in PY1 for the NC Program.

3.3.3 Program Updates

For the residential new construction track, the Program will require builders to work with a HERS rater on their home. An incentive of $20 per annual MMBTU saved will be paid to a new home, heated with natural gas, that achieves savings of 30% over code or greater. A $30 per annual MMBTU incentive will be paid to homes that achieve savings of 30% over code and also achieve ENERGY STAR Certification. The increase in incentive is designed to move the market towards more homes being ENERGY STAR Certified and leverage the HERS rating approach taken by the EDCs under their Act 129 new construction programs.

3.3.4 New Construction Program Results

Table 25. PROGRAM COSTS

Component (Nominal $)	PY1 - Actual	PY1 - Projected	%
Direct Utility Costs	**$6,047**	**$130,407**	**5%**
Customer Incentives	$0	$0	
Administration	$6,047	$82,108	7%
Marketing	$0	$48,299	0%
Inspections	$0	$0	
Evaluations	$0	$0	
Incremental Participant Costs	**$0**	**$0**	

Table 26. PROGRAM SAVINGS

Type	PY1 - Actual	PY1 - Projected	%
Natural Gas (MMBtus)			
Annual	0	0	
Lifetime	0	0	
Electric Energy (MWh)			
Annual	0.0	0.0	
Lifetime	0.0	0.0	
Capacity Savings (MW)	0.000	0.000	
Water Savings (Million Gal)			
Annual	0	0	
Lifetime	0	0	

Table 27. PROGRAM COST-EFFECTIVENESS (BASE CASE + DRIPE & CO_2)		
Benefits/Cost Component (2015$)	**PY1**	**Inception to Date**
TRC NPV Benefits	$0	$0
TRC NPV Costs	$5,241	$5,241
TRC Net Benefits	-$5,241	-$5,241
TRC Benefit/Cost Ratio	0.00	0.00

Table 28. PROGRAM COST-EFFECTIVENESS (BASE CASE)		
Benefits/Cost Component (2015$)	**PY1**	**Inception to Date**
TRC NPV Benefits	$0	$0
TRC NPV Costs	$5,241	$5,241
TRC Net Benefits	-$5,241	-$5,241
TRC Benefit/Cost Ratio	0.00	0.00

3.4 Residential Retrofit Program

(Rate Class R/RT)

3.4.1 Program Description

The RR Program is designed to overcome market barriers to energy efficiency in the existing residential sector through rebates offered either to customers undergoing a retrofit project or to their installation contractor(s). The program encourages improvements to the thermal envelope of the structure, particularly reductions in building air leakage and increases in insulation levels, as well as installation of the most efficient gas heating technologies. The program also aims to strengthen UGI Gas's relationship with HVAC contractors, suppliers, and other trade allies. The Residential Retrofit Program will launch on January 1, 2018

3.4.2 Program Highlights

In May, 2017, an RFP was released to all CSPs registered with the PA PUC. UGI hired Performance Systems Development (PSD) as the program implementer for the Residential Retrofit (RR) Program. In PY1, $19,814 was spent on administrative activities leading up to the launch. Program administration, incentives and marketing expenses will ramp up in PY2

3.4.2.1 Marketing Activity

No marketing activity was conducted in PY1 for the RR Program.

3.4.2.2 Inspection Activity

There was no inspection activity in PY1 for the RR Program.

3.4.2.3 Evaluation Activity

There was no evaluation activity in PY1 for the RR Program.

3.4.3 Program Updates

The RR Program will incentivize customers to have a full diagnostic Building Performance Institute, Inc. (BPI) level energy audit completed on their home. The customer charge for this audit, from the contractor, will be $150. In addition to the $150 from the customer, the contractor will receive a $150 payment from UGI for each audit completed.

As a result of the audit findings, all cost effective measures will be presented to the customer in the form of a report with corresponding incentive levels. After the completion of a job, the customer will have a test-out audit performed by the contractor and a rebate will be issued for the measures that were installed. The list of efficiency measures and incentives are listed below.

Table 29. RESIDENTIAL RETROFIT INCENTIVE SCHEDULE	
Improvement Type	**Incentive to Customer**
Efficient Space Heating System	$500 - $1,800
Heating Pipe Insulation	$5 - $15 per ft.
Air Infiltration Reduction	$150 - $500
Roof/Ceiling Insulation	$0.35 - $2 per sq. ft.
Wall Insulation	$0.30 - $1.50 per sq. ft.
Duct Insulation	$5 per ft.
Duct Sealing	$75 - $300
Wi-Fi Thermostat Installation	$100
Low-Flow Fixtures	$5 - $30
Efficient Water Heater	$300 - $400
Water Heater Pipe Insulation	$15 per ft.
Tank Temperature Turn-Down	$5

3.4.4 Residential Retrofit Program Results

Table 30. PROGRAM COSTS			
Component (Nominal $)	**PY1 - Actual**	**PY1 - Projected**	**%**
Direct Utility Costs	**$19,814**	**$193,195**	**10%**
Customer Incentives	$0	$0	
Administration	$19,814	$144,896	14%
Marketing	$0	$48,299	0%
Inspections	$0	$0	
Evaluations	$0	$0	
Incremental Participant Costs	**$0**	**$0**	

Table 31. PROGRAM SAVINGS			
Type	**PY1 - Actual**	**PY1 - Projected**	**%**
Natural Gas (MMBtus)			
Annual	0	0	
Lifetime	0	0	
Electric Energy (MWh)			
Annual	0.0	0.0	
Lifetime	0.0	0.0	
Capacity Savings (MW)	0.000	0.000	
Water Savings (Million Gal)			
Annual	0	0	
Lifetime	0	0	

Table 32. PROGRAM COST-EFFECTIVENESS (BASE CASE + DRIPE & CO_2)		
Benefits/Cost Component (2015$)	**PY1**	**Inception to Date**
TRC NPV Benefits	$0	$0
TRC NPV Costs	$17,175	$17,175
TRC Net Benefits	-$17,175	-$17,175
TRC Benefit/Cost Ratio	0.00	0.00

Table 33. PROGRAM COST-EFFECTIVENESS (BASE CASE)		
Benefits/Cost Component (2015$)	**PY1**	**Inception to Date**
TRC NPV Benefits	$0	$0
TRC NPV Costs	$17,175	$17,175
TRC Net Benefits	-$17,175	-$17,175
TRC Benefit/Cost Ratio	0.00	0.00

3.5 Nonresidential Retrofit Program

(Rate Classes N/NT and R/RT as part of multi-family projects)

3.5.1 Program Description

The NR Program will provide incentives for overcoming market barriers for natural gas efficiency retrofits in existing commercial and multi-family buildings. The NR Program will launch fully on January 1, 2018.

3.5.2 Program Highlights

The NR Program spent $51,030 in PY1, of which $51,000 were customer incentives. The Program provided first year gas savings of 2,573 MMBtus and lifetime gas savings of 50,720 MMBtus. Under the TRC Test, including DRIPE and CO_2, the NR Program provided $150,000 in present value of net benefits (2015$) with a BCR of 2.38. Without DRIPE or CO_2, the NR Program provided $96,000 in present value of net benefits (2015$) with a BCR of 1.88.

While the NR Program was not anticipated to launch until PY2, an opportunity was identified for a pilot project with UGI Gas customer Classic Drycleaners that would serve as an example of the types of projects available to nonresidential customers. After enlisting support from an energy engineering firm, UGI Gas provided the customer with an initial incentive to perform a comprehensive energy audit and an incentive based on the recommended measures from the audit. In total, the audit identified cost-effective opportunities to install new gas commercial dryers, dry cleaning machines, and steam pipe insulation, all of which the customer installed and an incentive was provided. The project was so successful that it was awarded the Small Business Project of the Year Award by the Central Pennsylvania Chapter of the U.S. Green Building Council.

3.5.2.1 Marketing Activity

No marketing activity was conducted during FY 2017. Marketing for the NR program will kick off in PY2. While the full marketing plan is not yet developed, the same methods used to market the NP program will be utilized for the NR program. Those methods will include, but not be limited to, digital advertising and contractor outreach.

3.5.2.2 Inspection Activity

The NR project that was completed in PY1 was inspected at multiple phases by UGI Gas staff to ensure that the project met agreed upon expectations.

3.5.2.3 Evaluation Activity

There was no evaluation activity in PY1 for the NR Program.

3.5.3 Program Updates

The NR Program will launch fully on January 1, 2018. Due to the minimal volume of projects anticipated for the NR Program, this program will be managed by UGI EE&C Staff. Each project that is processed through the NR program will be inspected by a Certified Energy Manager (CEM) UGI EE&C staff member. Additionally, UGI Gas will leverage a network of energy engineering companies to assist as needed with customer audits, data verification and energy modeling.

3.5.4 Nonresidential Retrofit Program Results

Table 34. PROGRAM COSTS			
Component (Nominal $)	**PY1 - Actual**	**PY1 - Projected**	**%**
Direct Utility Costs	**$51,030**	**$96,597**	**53%**
Customer Incentives	$51,000	$0	
Administration	$30	$48,299	0%
Marketing	$0	$48,299	0%
Inspections	$0	$0	
Evaluations	$0	$0	
Incremental Participant Costs	**$73,822**	**$0**	

Table 35. PROGRAM SAVINGS			
Type	**PY1 - Actual**	**PY1 - Projected**	**%**
Natural Gas (MMBtus)			
Annual	2,573	0	
Lifetime	50,720	0	
Electric Energy (MWh)			
Annual	0.0	0.0	
Lifetime	0.0	0.0	
Capacity Savings (MW)	0.000	0.000	
Water Savings (Million Gal)			
Annual	0	0	
Lifetime	0	0	

Table 36. PROGRAM COST-EFFECTIVENESS (BASE CASE + DRIPE & CO_2)		
Benefits/Cost Component (2015$)	**PY1**	**Inception to Date**
TRC NPV Benefits	$257,883	$257,883
TRC NPV Costs	$108,220	$108,220
TRC Net Benefits	$149,664	$149,664
TRC Benefit/Cost Ratio	2.38	2.38

Table 37. PROGRAM COST-EFFECTIVENESS (BASE CASE)		
Benefits/Cost Component (2015$)	**PY1**	**Inception to Date**
TRC NPV Benefits	$203,788	$203,788
TRC NPV Costs	$108,220	$108,220
TRC Net Benefits	$95,568	$95,568
TRC Benefit/Cost Ratio	1.88	1.88

3.6 Behavior and Education

(Rate Class R/RT)

3.6.1 Program Description

The objective of the BE program is to motivate a large group of residential customers to save energy by changing their behavior through education, outreach, and energy monitoring. The premise is that the delivery of timely, salient, and personalized information allows for informed decision-making. Small changes with noticeable results pave the way for wider program participation and increased future savings.

3.6.2 Program Highlights

The BE program is scheduled to launch October, 2018 assuming a CSP has been identified and all the necessary IT system requirements have been established. No activity took place in PY1. An RFP for program implementers is anticipated to be released early in 2018.

3.6.2.1 Marketing Activity

There was no marketing activity for the BE program in PY1.

3.6.2.2 Inspection Activity

There was no inspection activity for the BE Program in PY1.

3.6.2.3 Evaluation Activity

There was no evaluation activity for the BE Program in PY1.

3.6.3 Program Updates

There are no updates for the BE Program at this time.

3.6.4 Behavior and Education Program Results

There were no costs or savings for the BE Program in PY1.

3.7 Combined Heat and Power

(Rate Classes DS, LFD)

3.7.1 <u>Program Description</u>

The CHP Program seeks to promote the installation of cost-effective and net-primary-energy-saving CHP projects and provide meaningful CO_2 emission reductions. A CHP plant produces electricity at a commercial or industrial site while at the same time using the waste heat from the production of the electricity to serve a thermal load. Net efficiencies come from the recovered heat that is typically wasted in grid electricity production and avoided transmission and distribution losses from delivering the electricity from the generator to the customer site.

3.7.2 <u>Program Highlights</u>

The CHP Program spent $6,776 on administrative and marketing costs in PY1, but no CHP projects were completed. Each CHP project is run through a cost effectiveness test as part of the initial pre-screening. Upon completion of each project, the final project costs are evaluated to determine the final incentive level. One project has been pre-approved for PY2. Pending any major setback or scope change, UGI Gas anticipates the first CHP incentive will be issued in PY2.

3.7.2.1 Marketing Activity

UGI will leverage case studies from prior successful CHP installations, along with customer outreach via Relationship Managers who will educate customers on the potential benefits of CHP.

3.7.2.2 Inspection Activity

There was no inspection activity in PY1 for the CHP Program.

3.7.2.3 Evaluation Activity

There was no evaluation activity in PY1 for the CHP Program.

3.7.3 <u>Program Updates</u>

There are no changes or updates to the CHP Program anticipated for PY2.

3.7.4 Combined Heat and Power Program Results

Table 38. PROGRAM COSTS			
Component (Nominal $)	**PY1 - Actual**	**PY1 - Projected**	**%**
Direct Utility Costs	**$6,776**	**$387,500**	**2%**
Customer Incentives	$0	$250,000	0%
Administration	$1,955	$50,000	4%
Marketing	$4,821	$65,000	7%
Inspections	$0	$2,500	0%
Evaluations	$0	$20,000	0%
Incremental Participant Costs	**$0**	**$8,287,582**	**0%**

Table 39. PROGRAM SAVINGS			
Type	**PY1 - Actual**	**PY1 - Projected**	**%**
Net Primary Fuel Savings (MMBtus			
Annual	0	169,855	0%
Lifetime	0	2,547,828	0%

Table 40. PROGRAM COST-EFFECTIVENESS (BASE CASE + DRIPE & CO_2)		
Benefits/Cost Component (2015$)	**PY1**	**Inception to Date**
TRC NPV Benefits	$0	$0
TRC NPV Costs	$6,400	$6,400
TRC Net Benefits	-$6,400	-$6,400
TRC Benefit/Cost Ratio	0.00	0.00

Table 41. PROGRAM COST-EFFECTIVENESS (BASE CASE)		
Benefits/Cost Component (2015$)	**PY1**	**Inception to Date**
TRC NPV Benefits	$0	$0
TRC NPV Costs	$6,400	$6,400
TRC Net Benefits	-$6,400	-$6,400
TRC Benefit/Cost Ratio	0.00	0.00

ATTACHMENT 1

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Technical Reference Manual

Measure Savings Algorithms

UGI Gas

~~January~~ December 8~~19~~, 2017~~5~~

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Prepared by:

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I. Residential Time of Replacement Market

A. Space Heating End Use

1) Efficient Space Heating System

Unique Measure Code(s): TBD
Draft date: 12/14/15
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	95%
Gas Furnace with ECM Fan	95%
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 (846 hours for furnaces, 990 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
ΔkWh = 446 kWh

Demand Savings
ΔkW = 0.105 kW

Where:

ΔkWh	=	Gross customer annual kWh savings for the measure. Based on Act 129 TRM 311 kWh heating season plus 135 kWh cooling season.
ΔkW	=	Gross customer summer load kW savings for the measure. Based on Act 129 TRM.

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 and PGW.

[1] EFLH based on PGW 2014 evaluation by APPRISE. Adjusted by the ratio of HDD in UGI Gas territory relative to PGW territory. For consistency, used the HDD (base 65) from the same source – PUC Act 129 TRM. UGI territory represented by the average of Harrisburg and Allentown.

Water Savings
There are no water savings for this measure.

~~2)~~ WiFi Thermostat – ENERGY STAR®

~~2)~~

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Unique Measure Code(s): TBD
Draft date: 12/14/15
Effective date: TBD
End date: TBD

Measure Description
This is a WiFi 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 is WiFi enabled, ENERGY STAR® certified and can be programmed to automatically increase or lower the temperature setting at different times of the day and week.

Gas Savings Algorithms

$$Annual\ Gas\ Savings\ (MMBtu) = SH_{prc} \times 8\cancel{4.5}\% = (70.5 - 18.1) \times 8\cancel{4.5}\% = 4.19\cancel{2.36}\ MMBtu$$

Where:

SH_{prc}	=	Space Heat MMBtu gas usage with manual thermostat
8~~4.5~~%	=	Percentage savings from WiFi thermostat compared to manual thermostat[2]
70.5	=	Typical UGI Gas residential heating customer total gas usage in MMBtu
18.1	=	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 45% have air-conditioning and estimate the cooling savings as 45% 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.

[2] ~~Percent savings from "Energy Savings from Honeywell Connected Thermostats," Behavior, Energy, and Climate Change Conference 2014, Jim Stewart, Cadmus presentation~~Percent run time reduction required for ENERGY STAR® certification. ENERGY STAR® Program Requirements For Connected Thermostat Products, p. 10. https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Program%20Requirements%20for%20Connected%20Thermostats%20Version%201.0.pdf

[3] Non-space-heat usage assumption from UGI Gas data.

[4] Percentage of houses with air-conditioning from UGI data

Energy Savings

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

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

ΔkWh_{Cool} = 0 kWh if house has no air conditioning
= ΔkWh_{CAC} if house has central air conditioning
= 0 if house has room air conditioning
= 45% × ΔkWh_{CAC} if no information about air conditioner

ΔkWh_{CAC} = Single Family Detached = 37.9 kWh
Single Family Attached = 36.1 kWh
Multifamily = 34.8 kWh[5]

Deemed Savings:

$$\Delta kWh = \Delta kWh_{aux} + \Delta kWh_{CAC}\ (missing\ AC\ info) = 7.7 + 16.1 = 23.8\ kWh$$

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

$$\Delta kWh_{CAC}\ (missing\ AC\ info) = 45\% \times \Delta kWh_{CAC}$$
$$= 45\% \times \big((37.9 \times 75\%) + (36.1 \times 11\%) + (34.8 \times 10\%)\big) = 16.1$$

Demand Savings

$\Delta kW = 0\ kW$

Where:

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

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
WiFi Thermostat	11

Source: UGI Phase II Electric Filing.

Water Savings

[5] UGI EE&C Plan Phase II, Appendix A, page 100.

B. Water Heating End Use

1) Tankless Water Heater

Unique Measure Code(s): TBD
Draft date: 12/14/15
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	Usage Draw Pattern	Baseline UEF[6]
Gas Stand-alone Storage Water Heater	Very Small	0.27
Gas Stand-alone Storage Water Heater	Low	0.52
Gas Stand-alone Storage Water Heater	Medium	0.58
Gas Stand-alone Storage Water Heater ~~Gas Stand-alone Storage Water Heater~~	High	0.64~~0.615~~[7]

Baseline usage draw pattern is established by the capacity of the installed tankless water heater, using the table below:

Usage Draw Pattern	Max GPM	Daily Volume in Gallons (L)
Very Small	0 ≤ GPM < 1.7	10
Low	1.7 ≤ GPM < 2.8	38
Medium	2.8 ≤ GPM < 4.0	55
High	4.0 ≤ GPM	84

If the tankless water heater capacity is not available, assume medium usage draw pattern.

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

Equipment Type	Minimum UEF
Gas Tankless Water Heater	0.872

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[6] Based on the federal standard for residential gas-fired water heater as of June 2017 and assumed typical 40 gallon storage. https://www.law.cornell.edu/cfr/text/10/430.32
[7] ~~Based on the federal standard for residential gas-fired water heater as of JuneApril 16, 20125 and assumed typical 40 gallon storage.~~

Gas Savings Algorithms

The following formula for gas savings is based on the DOE test procedure for water heaters[8].

$$Annual\ Gas\ Savings\ (MMBtu) = \frac{\left(\frac{1}{UEF_{Base}} - \frac{1}{UEF_{Eff}}\right) \times V \times \rho \times c_p \times 67\cancel{41,045} \times 365}{1,000,000}$$

Where:

UEF_{Base}	=	Uniform Energy Factor of baseline water heater based on usage draw pattern
UEF_{Eff}	=	Uniform Energy Factor of efficient water heater
V	=	Daily volume of hot water usage in gallons. See table in baseline section. If usage draw pattern is unknown, assume medium (55 gallons/day)
ρ	=	Water density at 125°F (8.24 lb/gal)
c_p	=	Specific heat of water (1.00 Btu/lb °F)
67	=	°F temperature rise between inlet and outlet of water heater
365	=	Days per year
1,000,000	=	Btu per MMBtu
~~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%

Persistence

The persistence factor is assumed to be one.

Measure Lifetimes

[8] 10 CFR Appendix E to Subpart B of Part 430, Uniform Test Method for Measuring the Energy Consumption of Water Heaters

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: 12/14/15
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[9]

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

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

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

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

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

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

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 (990 hours)[10]

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 = 0.615

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

Electric Savings Algorithms

Energy Savings

$\Delta kWh = 0\ kWh$

Demand Savings

$\Delta kW = 0\ kW$

Where:

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

Freeridership/Spillover

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

Equipment Type	Free Ridership	Spillover

[10] Based on 2014 PGW APPRISE evaluation for boilers. Adjusted by the ratio of HDD in UGI Gas territory relative to PGW territory.

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: 12/14/15
Effective date: TBD
End date: TBD

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

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

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

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

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

Where:

BaselineUse = The gas usage of baseline equipment or building.

EfficientUse = The gas usage of efficient equipment or building.

Electric Savings Algorithms

Energy Savings
$\Delta kWh = BaselinekWh - EfficientkWh$

Demand Savings
$\Delta kW = BaselinekW - EfficientkW$

Where:

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

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

Equipment Type	Free Ridership	Spillover
Custom Measure	0%	0%

Persistence
The persistence factor is assumed to be one.

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

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

II. Residential New Construction

A. All End Uses

1) Custom Measures

Unique Measure Code(s): TBD
Draft date: 12/14/15
Effective date: TBD
End date: TBD

Measure Description

This measure applies to all residential new construction 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. This may also be referred to as the reference home.

Definition of Efficient Condition
The efficient measure is any equipment that uses less energy than the baseline equipment. This may be demonstrated by receiving a Home Energy Rating System (HERS) index score that is lower than the baseline or reference home score.

Gas Savings Algorithms
The savings for residential new construction may be based on the HERS score as determined by accredited HERS software such as REM/Rate. The software will need to produce separate natural gas savings by space heating, domestic hot water, and appliances end uses.

The generalized equation for a custom measure(s) 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. Where savings are stated at the end use level, lifetimes will be separately estimated by end use, based on averages weighted by the estimated percentage savings contribution for each measure.

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

~~3)~~1) Efficient Space Heating System

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Unique Measure Code(s): TBD
Draft date: 12/14/15
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. If the space heating system measure is installed concurrently with shell measures such as added insulation and air sealing and distribution measures such as duct sealing, duct insulation, and heating pipe insulation, then the gas savings from the shell and distribution measures should be subtracted from the pre-retrofit heating usage determined from the billing data before calculating the savings for the space heating to prevent double counting savings.
$AFUE_{Base}$	=	Efficiency of existing baseline equipment (Annual Fuel Utilization Efficiency)
$AFUE_{EE}$	=	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[11]/day to estimate heating slope (MMbtu/HDD63) and baseload daily use (MMBtu/day) ~~with an annual HDD63 of 5062[12]~~ to calculate annual heating load. See the Reference Tables section at the end of this document for projected HDD.

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 * (~~5062~~HDD63projected/HDD63actual).

Electric Savings Algorithms

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

Energy Savings

ΔkWh = 446 kWh

Demand Savings

ΔkW = 0.105 kW

Where:

ΔkWh	=	Gross customer annual kWh savings for the measure. Based on Act 129 TRM 311 kWh heating season plus 135 kWh cooling season.
ΔkW	=	Gross customer summer load kW savings for the measure. Based on Act 129 TRM.

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%

[11] Heating degree days are calculated using base 63°F, which was selected, based on variable-base degree day regressions of billing data from PGW's Conservation Works Program (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.

[12] ~~This value of 5062 4726 HDD62 is the average from Reading, PA for the years December 2012 through December 2016 from http://www.degreedays.net5.~~

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 and PGW.

Water Savings
There are no water savings for this measure.

~~4)~~3) Infiltration Reduction

Unique Measure Code(s): TBD
Draft date: 12/14/15
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. See the Reference Tables section at the end of this document for projected HDD.~~From Degreedays.net data for Reading, PA from December 2012 – December 2015, HDD63=5062 and HDD62 = 4834.~~

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[13]

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 45% have air-conditioning and estimate the cooling savings as 45% of a house with central air conditioning.[14]

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

Energy Savings

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

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

ΔkWh_{Cool} = 0 kWh if house has no air conditioning
= ΔkWh_{CAC} if house has central air conditioning
= ΔkWh_{RAC} if house has room air conditioning
= 45% × ΔkWh_{CAC} if no information about air conditioner

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

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

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.

[13] 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.
[14] Percentage of houses with air-conditioning from UGI data.

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

CDD = *Cooling Degree Days (Degrees F * Days). See the Reference Tables section at the end of this document for projected CDD.*

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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[15]
$SEER_{CAC}$	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

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

Term	Type	Value	Source
$F_{Room\ AC}$	Fixed	0.38	Calculated[16]

EFLH~~, CDD and HDD by City~~

Location	$EFLH_{cool}$ (Hours)[17]	$EFLH_{cool\ RAC}$ (Hours)[18]
UGI Gas Territory	519	161

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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.

~~5)~~4) Roof and Cavity Insulation

Unique Measure Code(s): TBD
Draft date: 12/14/15
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.

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

[17] PA 2015 TRM Average of Harrisburg and Allentown for CAC.

[18] PA 2015 TRM Average of Harrisburg and Allentown for RAC.

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[19]. See the Reference Tables section at the end of this document for projected HDD
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 45% have air-conditioning and estimate the cooling savings as 45% of a house with central air conditioning.[20]

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

Energy Savings

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

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

ΔkWh_{Cool} = 0 kWh if house has no air conditioning
= ΔkWh_{CAC} if house has central air conditioning
= ΔkWh_{RAC} if house has room air conditioning
= 45% × ΔkWh_{CAC} if no information about air conditioner

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

[19] ~~From Degreedays.net data for Reading, PA from December 2012 – December 2016~~5, HDD63=~~5062~~ 4726 ~~and HDD62 = 4500~~834

[20] Percentage of houses with air-conditioning from UGI data

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

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~~ See the Reference Tables section at the end of this document for projected CDD.*

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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

Term	Type	Value	Source
DUA	Fixed	0.75	OH TRM[21]
$SEER_{CAC}$	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[22]

EFLH~~, CDD and HDD by City~~

Location	$EFLH_{cool}$ (Hours)[23]	$EFLH_{cool\ RAC}$ (Hours)[24]
UGI Gas Territory	519	161

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Freeridership/Spillover

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

Measure	Free Ridership	Spillover
Insulation	0%	0%

Persistence

The persistence factor is assumed to be one.

Measure Lifetimes

Measure	Measure Lifetime
Roof Insulation	40
Cavity Insulation	40

Source: NYSERDA Home Performance with Energy Star.

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

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

[23] PA 2015 TRM Average of Harrisburg and Allentown for CAC.

[24] PA 2015 TRM Average of Harrisburg and Allentown for RAC

Water Savings
There are no water savings for this measure.

6)5) Programmable Thermostat

Unique Measure Code(s): TBD
Draft date: 12/14/15
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

$$Annual\ Gas\ Savings\ (MMBtu) = HeatingUse \times \left(1 - {HDD_{62}}/{HDD_{63}}\right) = HeatingUse \times 0.0485\cancel{3}$$

Where:

HeatingUse	=	Annual heating use (MMBtu/yr) from weather normalized usage analysis of customer billing data from the pre-treatment period (see description under heating system replacement). If the programmable thermostat is installed concurrently with shell measures such as added insulation and air sealing, distribution measures such as duct sealing, duct insulation, and heating pipe insulation, and efficient space heating system , then the gas savings from the shell, distribution, and space heating system measures should be subtracted from the pre-retrofit heating usage determined from the billing data before calculating the savings for the programmable thermostat. Accounting for the interactions between measures affecting the same end use prevents double counting savings ~~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}	=	~~4834~~[25]
		The annual heating degree days based on 62°F, representing the estimated balance point temperature of the home with the programmable thermostat. See the Reference Tables section at the end of this document for projected HDD
HDD_{63}	=	~~5062~~[26]
		The annual heating degree days based on 63°F, representing the estimated balance point temperature of the home without the programmable thermostat. See the Reference Tables section at the end of this document for projected HDD

[25] ~~From DegreeDays.net for Reading, PA, December 2012 – December 2015.~~
[26] ~~Ibid.~~

An analysis of variable base degree day billing data from PGW's Conservation Works Program (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 45% have air-conditioning and estimate the cooling savings as 45% of a house with central air conditioning.[27]

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

Energy Savings

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

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

ΔkWh_{Cool} = 0 kWh if house has no air conditioning
= ΔkWh_{CAC} if house has central air conditioning
= 0 if house has room air conditioning
= 45% × ΔkWh_{CAC} if no information about air conditioner

ΔkWh_{CAC} = Single Family Detached = 37.9 kWh
Single Family Attached = 36.1 kWh
Multifamily = 34.8 kWh[28]

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
Programmable Thermostat	0%	0%

[27] Percentage of houses with air-conditioning from UGI data.
[28] UGI EE&C Plan Phase II, Appendix A, page 100.

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes

Equipment Type	Measure Lifetime
Programmable Thermostat	11

Source: UGI Phase II Electric Filing.

Water Savings
There are no water savings for this measure.

~~7)~~6) Duct Work Insulation

Unique Measure Code(s): TBD
Draft date: 12/14/15
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 = 846[29]

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

[29] From PGW Apprise evaluation for furnaces adjusted to UGI Gas territory based on relative HDD.

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[30]
Ave. Wind Speed	=	0 mph
Relative Humidity	=	N/A
Dew Point	=	N/A
Condensation Control Thickness	=	N/A
Hours Per Year	=	2000[31]
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.

[30] Average winter temperature for Philadelphia from "Cost Savings and Comfort for Existing Buildings", 3rd Edition, by John Krigger, Saturn Resource Management. Page 255.
[31] 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

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[32].

~~8)~~7) Heating Pipe Insulation

Unique Measure Code(s): TBD
Draft date: 12/14/15
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)

[32] NYSERDA Home Performance with Energy Star

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. See the Reference Tables section at the end of this document for projected HDD.~~for Reading, PA = 5,062~~[33]
Dt	=	Design temperature difference (assume from 11° F to 70° F for properly sized boiler)[34] = 59° F

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

Insulation Thickness (inches)	Steam Heat Loss (Btu/ft/hr)	Hot Water Heat Loss (Btu/ft/hr)
Bare	201.4	72.12
0.5	47.75	15.24
1.0	31.15	11.2
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

[33] ~~Based on Degreedays.net data for Reading, PA from December 2012 to December 20165.~~

[34] 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.

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[35].

~~9)~~8) Duct Work Sealing

Unique Measure Code(s): TBD
Draft date: 12/14/15
Effective date: TBD
End date: TBD

Measure Description
This measure provides estimates for stand-alone 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 or a pressure pan measurement to determine a reduction in pascals.

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.

[35] NYSERDA Home Performance with Energy Star

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

CFMpre -CFMpost = Alternative to using a duct blaster is use a pressure pan to measure pascals. The reduction in pascals can be used as an estimate to determine the reduction in CFM 25. See the table below

DSFgas = Duct sealing factor for gas systems. 0.035 MMBtus/CFM-25[36]

Repair made when duct run is outside conditioned space	**Pressure Pan Reading Reduction in Pascals (pa)**	**Deemed CFM 25 Net Reduction (CFMpre – CFMpost)[37]**
Only caulking or mastic required to seal either Supply ***or*** RETURN ducts	1 – 2 pa	75
Patching of significant hole required in SUPPLY ***or*** RETURN, or reconnection of disconnection	More than 2 pa	200
Patching of significant hole required in SUPPLY ***and*** RETURN, or reconnection of disconnection	More than 2 pa	325

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Electric Savings Algorithms
Electric savings per 100 CFM-25 reduction:[38]

- 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[39]

~~10)~~9) High Efficiency Window

Unique Measure Code(s): TBD
Draft date. 12/14/15

[36] Based on 3.5 MMBtus savings per 100 CFM reduction for duct sealing from UI/CL&P Program Savings Documentation – 2011, page 131
[37] CFM 25 leakage range from Residential Energy, 5th edition, John Krigger and Chris Dorsi, p 89
[38] UI/CL&P Program Savigns Documentation, 2011, page 131
[39] California DEER estimate

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 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. See the Reference Tables section at the end of this document for projected HDD.
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 45% have air-conditioning and estimate the cooling savings as 45% of a house with central air conditioning.[49]

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

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

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

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

[49] Percentage of houses with air-conditioning UGI data.

= 45% × 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). See the Reference Tables section at the end of this document for projected CDD.~~HDD~~*

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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[41]
$SEER_{CAC}$	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[42]

EFLH~~, CDD and HDD by City~~

Location	$EFLH_{cool}$ (Hours)[43]	$EFLH_{cool\ RAC}$ (Hours)[44]
UGI Gas Territory	519	161

Formatted Table

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.

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

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

[43] PA 2015 TRM Average of Harrisburg and Allentown for CAC.

[44] PA 2015 TRM Average of Harrisburg and Allentown for RAC

Water Savings
There are no water savings for this measure.

E. Domestic Hot Water End Use

1) Low Flow Showerhead

Unique Measure Code(s): TBD
Draft date: 12/14/15
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[45].

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[46]
GPM_{eff}	=	Maximum gallons per minute of the efficient showerhead
2.48	=	Average number of people per household[47]
11.6	=	Average gallons of water per person per day used for showering[48]
365	=	Days per year
1.6	=	Average number of showers per home[49]

Natural Gas Savings Algorithms

[45] Pennsylvania Public Utility Commission Act 129 Technical Reference Manual (June 2011)
[46] The Energy Policy Act of 1992 established the maximum flow rate for showerheads at 2.5 gallons per minute (GPM)
[47] Pennsylvania, Census of Population, 2000.
[48] 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)
[49] 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

Gas energy savings result from reducing the amount of incoming cold water required to be heated 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)[50]
RE_{DHW}	=	Recovery efficiency of the domestic hot water heater = 75%[51]

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[52].

~~11)~~10) Low Flow Faucet Aerators

Unique Measure Code(s): TBD
Draft date: 12/15/15
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.

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

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[53].

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 aerator = 2.2 GMP[54]
GPM_{eff}	=	Gallons per minute of the efficient aerator
2.48	=	Average number of people per household[55]
10.9	=	Average gallons per day used by faucet[56]
365	=	Days per year
50%	=	Drain rate, the percentage of water flowing down the drain[57]
3 5	=	Average Number of Faucets per home[58]

Natural Gas Savings Algorithms

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

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

Where:

$\Delta MMBtu$	=	MMBtu of saved natural gas
8 3	=	Constant to convert gallons to pounds (lbs)
c_p	=	Average specific heat of water at temperature range (1.00 Btu/lb·°F)
25	=	The difference between the temperature of the water entering the house and the temperature leaving the faucet (degrees Fahrenheit).[59]
RE_{DHW}	=	Recovery efficiency of the domestic hot water heater = 75%[60]

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

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

[54] 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

[55] Pennsylvania, Census of Population, 2000.

[56] 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)

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

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

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

[60] See assumption for low flow shower head.

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[61].

~~12)~~11) Efficient Natural Gas Water Heater

Unique Measure Code(s): TBD
Draft date: 12/14/15
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[62].

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

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

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[63].

~~13)~~12) Hot Water Heater Tank Temperature Turn-down

Unique Measure Code(s): TBD
Draft date: 12/14/15
Effective date: TBD
End date: TBD

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

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

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

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

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

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

Where:

$\Delta MMBtu$	=	MMBtu of saved gas per year
$Area$	=	Surface area of hot water heater (ft^2)
T_{base}	=	Original temperature inside the tank (°F) = Assume 135 °F if no other information provided
T_{eff}	=	New temperature inside the tank (°F) = Assume 120° F if no other information provided

[63] DEER values, updated October 10, 2008 http://www.deeresources.com/deer0911planning/downloads/EUL_Summary_10-1-08.xls

R_{DHW}	=	R-value of the hot water heater (h °F ft^2/Btu) = 5.0[64]
8,760	=	Number of hours in a year
RE_{DHW}	=	Recovery efficiency of the domestic hot water heater = 75%[65]
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 temperature reduction in a natural gas water heater is assumed to be 2 years[66].

~~14)~~13) Repair Hot Water Leaks/Plumbing Repairs

Unique Measure Code(s): TBD
Draft date: 12/14/15
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.

[64] 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
[65] See assumption for low flow showerhead.
[66] Page 410. Vermont Technical Reference Manual and New Jersey Clean Energy Program Protocols

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*[67]

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)[68]
RE_{DHW}	=	Recovery efficiency of the domestic hot water heater = 75%[69]

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.

[67] Figures provided to North Carolina's Dare County Water Department by the North Carolina Rural Water Association: http://www.darenc.com/water/OthstsWtrLoss.htm (accessed June 23, 2011)
[68] 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
[69] See assumption for low flow showerhead

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

~~15)~~14) DHW Pipe Insulation

Unique Measure Code(s): TBD
Draft date: 12/14/15
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 a space heating hot water or steam pipe.

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

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

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

The thickness of the DHW pipe insulation should be equivalent to the diameter of the piping. For example, a 1" diameter pipe should be insulated with 1" thick insulation; a 2-1/2" diameter pipe with 2-1/2" thick insulation.[70]

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.

---

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

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%[71]

"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

[71] See assumption for low flow showerhead.

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[72].

~~16)~~15) Hot Water Storage Tank Wrap

Unique Measure Code(s): TBD
Draft date: 12/14/15
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 installation 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."[73]

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.

[72] NYSERDA Home Performance with Energy Star
[73] 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[74] 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[75]
8,760	=	Number of hours in a year
RE_{DHW}	=	Recovery efficiency of the domestic hot water heater = 75%[76]
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[77].

[74] 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
[75] Assumed to be in unconditioned space, ambient temperature assumption based on: http://lwf.ncdc.noaa.gov/img/documentlibrary/clim81supp3/tempnormal_hires.jpg
[76] See assumption for low flow showerhead

F. All End Uses

1) Energy-Use Report

Unique Measure Code(s): TBD
Draft date: 12/14/15
Effective date: TBD
End date: TBD

Measure Description
Monthly energy-use reports are sent to participating gas customers with the goal of decreasing the customers' energy use.

Definition of Baseline Condition
The baseline is a customer before they have received an energy-use report.

Definition of Efficient Condition
The efficient condition is a customer that has received an energy-use report.

Gas Savings Algorithms
MMBtu savings are realized due to the participating customers changing their behavior after receiving an energy-use report. Savings are calculated by applying a percentage savings to the customer's usage prior to receiving the energy-use report.

$$Annual\ Gas\ Savings\ (MMBtu) = HeatingUse \times (\%Save)$$

Where:

HeatingUse	=	Annual heating use (MMBtu/yr) from weather normalized usage analysis of customer billing data from pre-treatment period. See description below.
%Save	=	Percentage of annual gas savings due to the participating customer receiving an energy-use report. Assume 1.04% savings from evaluation of similar program in Massachusetts. From Massachusetts 2011 TRM.

Heating Use weather normalization methods (HeatingUse):

Method 1: Use a linear regression model of use/day as a function of HDD63[78]/day to estimate heating slope (MMbtu/HDD63) and baseload daily use (MMBtu/day) with an annual projected HDD63~~ of 5062~~[79]~~ ~~to calculate annual heating load. See the Reference Tables section at the end of this document for projected HDD.

[77] Northeast Energy Efficiency Partnerships. *Mid-Atlantic Technical Reference Manual (Version 1.1)*. October 2010
[78] Heating degree days are calculated using base 63°F which was selected based on variable-base degree day regressions of billing data from PGW's Conservation Works Program (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.
[79] ~~This value foref 5062 HDD63 is the average from Reading, PA for the years December 2012 through December 20165.~~

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 * (~~5062~~HDD63projected/HDD63actual).

Electric Savings Algorithms

Energy Savings
ΔkWh = 0 kWh

Demand Savings
ΔkW = 0.0 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
Energy-Use Report	0%	0%

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes

Equipment Type	Measure Lifetime
Energy-Use Report	1

Source: Lifetime estimate used by MassSave

Water Savings
There are no water savings for this measure.

~~IV. Low Income Retrofit Market~~

~~A. Space Heating End Use~~

~~1) Efficient Space Heating System~~

~~Unique Measure Code(s): TBD~~
~~Draft date: 12/14/15~~
~~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.~~

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

~~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[80]/day to estimate heating slope (MMbtu/HDD63) and baseload daily use (MMBtu/day) with an annual HDD63 of 5062[81] 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 * (5062/HDD63actual)~~

~~**Electric Savings Algorithms**~~

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

~~**Energy Savings**~~
~~ΔkWh = 446 kWh~~

~~**Demand Savings**~~
~~ΔkW = 0.105 kW~~

~~Where:~~

~~ΔkWh~~	=	~~Gross customer annual kWh savings for the measure. Based on Act 129 TRM 311 kWh heating season plus 135 kWh cooling season.~~
~~ΔkW~~	=	~~Gross customer summer load kW savings for the measure. Based on Act 129 TRM.~~

~~**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%~~

~~[80] 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.~~

~~[81] This value of 5062 HDD63 is the average from Reading, PA for the years December 2012 through December 2015.~~

~~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 and PGW.~~

~~Water Savings~~
~~There are no water savings for this measure.~~

~~17) Infiltration Reduction~~

~~Unique Measure Code(s): TBD~~
~~Draft date: 12/14/15~~
~~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 Degreedays.net data for Reading, PA from December 2012 – December 2015. HDD63=5062 and HDD62 = 4834.~~
- ~~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/hr°F heat loss rate, calculated from hourly infiltration modeling~~[82]

~~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 45% have air conditioning and estimate the cooling savings as 45% of a house with central air conditioning.~~[83]

~~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~~

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

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

$$\cancel{\Delta kWh_{Cool} = 0\ \text{kWh if house has no air conditioning}}$$
$$\cancel{= \Delta kWh_{CAC}\ \text{if house has central air conditioning}}$$
$$\cancel{= \Delta kWh_{RAC}\ \text{if house has room air conditioning}}$$
$$\cancel{= 45\% \times \Delta kWh_{CAC}\ \text{if no information about air conditioner}}$$

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

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

~~Demand Savings~~

$$\cancel{\Delta kW = 0\ \text{kW if house has no air conditioning}}$$
$$\cancel{= \Delta kW_{CAC}\ \text{if house has central air conditioning}}$$
$$\cancel{= \Delta kW_{RAC}\ \text{if house has room air conditioning}}$$

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

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

~~Where:~~

~~ΔkWh = gross customer annual kWh savings for the measure.~~

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

[82] ~~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/exfiltration. 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.~~

[83] ~~Percentage of houses with air conditioning from UGI data.~~

~~*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~~[84]
~~$SEER_{CAC}$~~	~~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~~[85]

[84] ~~"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~~

~~Location~~	~~$EFLH_{cool}$ (Hours)[85]~~	~~$EFLH_{cool\ RAC}$ (Hours)[87]~~	~~CDD (Base 65)[88]~~
~~UGI Gas Territory~~	~~519~~	~~161~~	~~1196~~

~~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.~~

~~18) Roof and Cavity Insulation~~

~~Unique Measure Code(s): TBD~~
~~Draft date: 12/14/15~~
~~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.~~

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[85] ~~From PECO baseline study, average home size = 2323 ft², average number of room AC units per home = 2.1. Average Room AC capacity = 10,000 BtuH per ENERGY STAR Room AC Calculator, which serves 425 ft² (average between 400 and 450 ft² for 10,000 BtuH unit per ENERGY STAR Room AC sizing chart). $F_{Room\ AC}$ = (425 ft² * 2.1)/(2323 ft²) = 0.38~~
[86] ~~PA 2015 TRM Average of Harrisburg and Allentown for CAC.~~
[87] ~~PA 2015 TRM Average of Harrisburg and Allentown for RAC.~~
[88] ~~From Degreedays.net for Reading, PA, average annual from December 2012 to December 2015.~~

~~**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[89].~~
~~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 45% have air-conditioning and estimate the cooling savings as 45% of a house with central air conditioning.[90]~~

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

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

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

~~ΔkWh_{Cool} = 0 kWh if house has no air conditioning~~
~~= ΔkWh_{CAC} if house has central air conditioning~~
~~= ΔkWh_{RAC} if house has room air conditioning~~
~~= 45% × ΔkWh_{CAC} if no information about air conditioner~~

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

~~[89] From Degreedays.net data for Reading, PA from December 2012 – December 2015, HDD63=5062 and HDD62 = 4834.~~
~~[90] Percentage of houses with air-conditioning from UGI data.~~

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

~~**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~~

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

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

~~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~~

~~Term~~	~~Type~~	~~Value~~	~~Source~~
~~DUA~~	~~Fixed~~	~~0.75~~	~~OH TRM~~[91]
~~$SEER_{CAC}$~~	~~Variable~~	~~Default values:~~ ~~Early Replacement = 10~~ ~~Replace on Burnout = 13~~	~~PUC Technical Reference Manual~~
		~~Nameplate~~	~~Contractor Data Gathering~~
~~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~~[92]

~~EFLH, CDD and HDD by City~~

~~Location~~	~~$EFLH_{cool}$ (Hours)~~[93]	~~$EFLH_{cool\ RAC}$ (Hours)~~[94]	~~CDD (Base 65)~~[95]
~~UGI Gas Territory~~	~~519~~	~~161~~	~~1196~~

~~Freeridership/Spillover~~

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

~~Measure~~	~~Free Ridership~~	~~Spillover~~
~~Insulation~~	~~0%~~	~~0%~~

~~Persistence~~

~~The persistence factor is assumed to be one.~~

~~Measure Lifetimes~~

~~Measure~~	~~Measure Lifetime~~
~~Roof Insulation~~	~~40~~
~~Cavity Insulation~~	~~40~~

~~Source: NYSERDA Home Performance with Energy Star.~~

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

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

[93] ~~PA 2015 TRM Average of Harrisburg and Allentown for CAC.~~

[94] ~~PA 2015 TRM Average of Harrisburg and Allentown for RAC~~

[95] ~~From Degreedays.net for Reading, PA, average annual from December 2012 to December 2015.~~

~~**Water Savings**~~
~~There are no water savings for this measure.~~

~~19) Programmable Thermostat~~

~~Unique Measure Code(s): TBD~~
~~Draft date: 12/14/15~~
~~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**~~

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

~~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}~~	=	~~4834~~[96] ~~The annual heating degree days based on 62°F, representing the estimated balance point temperature of the home with the programmable thermostat.~~
~~HDD_{63}~~	=	~~5062~~[97] ~~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 PGW's Conservation Works Program (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~~

[96] ~~From DegreeDays.net for Reading, PA, December 2012 - December 2015~~
[97] ~~Ibid.~~

~~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 45% have air-conditioning and estimate the cooling savings as 45% of a house with central air conditioning.~~[98]

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

~~Energy Savings~~

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

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

~~ΔkWh_{Cool} = 0 kWh if house has no air conditioning~~
~~= ΔkWh_{CAC} if house has central air conditioning~~
~~= 0 if house has room air conditioning~~
~~= 45% × ΔkWh_{CAC} if no information about air conditioner~~

~~ΔkWh_{CAC} = Single Family Detached = 37.9 kWh~~
~~Single Family Attached = 36.1 kWh~~
~~Multifamily = 34.8 kWh~~[99]

~~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~~
~~Programmable Thermostat~~	~~0%~~	~~0%~~

~~Persistence~~

~~The persistence factor is assumed to be one.~~

~~Measure Lifetimes~~

~~[98] Percentage of houses with air-conditioning from UGI data~~
~~[99] UGI EE&C Plan Phase II, Appendix A, page 100.~~

~~Equipment Type~~	~~Measure Lifetime~~
~~Programmable Thermostat~~	~~11~~

~~Source: UGI Phase II Electric Filing~~

~~Water Savings~~

~~There are no water savings for this measure.~~

~~20) Duct Work Insulation~~

~~Unique Measure Code(s): TBD~~
~~Draft date: 12/14/15~~
~~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 = 846[100] hours~~
~~Th_{base}~~	=	~~Thickness of base condition insulation (inches)~~
~~Th_{eff}~~	=	~~Thickness of efficient condition insulation (inches)~~
~~HeatLoss(x)~~	=	~~Heat loss through duct work as a function of insulation thickness x (Btu/ft-/yr)~~
~~AFUE~~	=	~~Rated AFUE of heating system. If no rating is available then use the method described in the Efficient Space Heating System section for calculating the AFUE. The AFUE of replacement equipment should be used if the heating system replacement precedes the duct work insulation.~~

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

~~[100] From PGW Apprise evaluation for furnaces adjusted to UGI Gas territory based on relative HDD.~~

~~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.cn/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[102].~~

~~21) Heating Pipe Insulation~~

~~Unique Measure Code(s): TBD~~
~~Draft date: 12/14/15~~
~~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**~~

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

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

~~Where:~~

~~Length~~	=	~~Number of linear feet of heating pipe insulated~~
$\cancel{H_{heat}}$	=	~~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.~~

~~[102] NYSERDA Home Performance with Energy Star~~

HDD = ~~Base 63° F Heating Degree Days for Reading, PA = 5,062~~[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.~~

~~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~~

[104] ~~Based on Degreedays.net data from December 2012 to December 2015.~~
[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~~

~~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].~~

~~22) Duct Work Sealing~~

~~Unique Measure Code(s): TBD~~
~~Draft date: 12/14/15~~
~~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~~

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

~~Where~~

[106] ~~NYSERDA Home Performance with Energy Star~~

~~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~~[107]

~~Electric Savings Algorithms~~
~~Electric savings per 100 CFM-25 reduction:~~[108]

- ~~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~~[109]~~.~~

~~23) High Efficiency Window~~

~~Unique Measure Code(s): TBD~~
~~Draft date: 12/14/15~~
~~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:~~

[107] ~~Based on 3.5 MMBtus savings per 100 CFM reduction for duct sealing from UI/CL&P Program Savings Documentation – 2011, page 131~~
[108] ~~UI/CL&P Program Savings Documentation, 2011, page 131~~
[109] ~~California DEER estimate.~~

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[110].~~
~~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 45% have air-conditioning and estimate the cooling savings as 45% of a house with central air conditioning.[111]~~

~~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~~

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

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

$\cancel{\Delta kWh_{Cool}}$ ~~= 0 kWh if house has no air conditioning~~
~~= ΔkWh_{CAC} if house has central air conditioning~~
~~= ΔkWh_{RAC} if house has room air conditioning~~
~~= 45% × ΔkWh_{CAC} if no information about air conditioner~~

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

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

~~Demand Savings~~

$\cancel{\Delta kW}$ ~~= 0 kW if house has no air conditioning~~
~~= ΔkW_{CAC} if house has central air conditioning~~
~~= ΔkW_{RAC} if house has room air conditioning~~

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

~~[110] From NWS data for PHL from 2002-2009, HDD63 = 4033 and HDD62 = 3820~~
~~[111] Percentage of houses with air-conditioning from UGI data.~~

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

~~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~~[112]
~~$SEER_{CAC}$~~	~~Variable~~	~~Default values:~~ ~~Early Replacement = 10~~ ~~Replace on Burnout = 13~~	~~PUC Technical Reference Manual~~
		~~Nameplate~~	~~Contractor Data Gathering~~

[112] ~~"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~~
~~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~~[113]

~~EFLH, CDD and HDD by City~~

~~Location~~	~~$EFLH_{cool}$ (Hours)~~[114]	~~$EFLH_{cool\ RAC}$ (Hours)~~[115]	~~CDD (Base 65)~~[116]
~~UGI Gas Territory~~	~~519~~	~~161~~	~~1196~~

~~Freeridership/Spillover~~

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

~~Measure~~	~~Free-Ridership~~	~~Spillover~~
~~Window~~	~~0%~~	~~0%~~

~~Persistence~~

~~The persistence factor is assumed to be one.~~

~~Measure Lifetime~~

~~Measure~~	~~Measure Lifetime~~
~~Window~~	~~30~~

~~Source: NREL Measure Database.~~

~~Water Savings~~

~~There are no water savings for this measure.~~

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

[114] ~~PA 2015 TRM Average of Harrisburg and Allentown for CAC.~~

[115] ~~PA 2015 TRM Average of Harrisburg and Allentown for RAC~~

[116] ~~From Degreedays.net for Reading, PA, average annual from December 2012 to December 2015.~~

~~G. Domestic Hot Water End Use~~

~~1) Low Flow Showerhead~~

~~Unique Measure Code(s): TBD~~
~~Draft date: 12/14/15~~
~~Effective date: TBD~~
~~End date: TBD~~

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

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

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

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

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

~~Where:~~

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

~~Natural Gas Savings Algorithms~~

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[117] ~~Pennsylvania Public Utility Commission Act 129 Technical Reference Manual (June 2014)~~
[118] ~~The Energy Policy Act of 1992 established the maximum flow rate for showerheads at 2.5 gallons per minute (GPM)~~
[119] ~~Pennsylvania, Census of Population, 2000.~~
[120] ~~Most commonly quoted value of gallons of water used per person per day (including in U.S. Environmental Protection Agency's "water sense" documents, http://www.epa.gov/watersense/docs/home_suppstat508.pdf)~~
[121] ~~Estimate based on review of a number of studies:~~

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

~~Gas energy savings result from reducing the amount of incoming cold water required to be heated due to the efficient showerhead.~~

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

~~Where:~~

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

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

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

~~Persistence~~
~~The persistence factor is assumed to be one.~~

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

~~24) Low Flow Faucet Aerators~~

~~Unique Measure Code(s): TBD~~
~~Draft date: 12/14/15~~
~~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.~~

[122] ~~A good approximation of annual average water main temperature is the average annual ambient air temperature. Average water main temperature = 55° F based on: http://lwf.ncdc.noaa.gov/img/documentlibrary/clim81supp3/tempnormal_hires.jpg~~
[123] ~~Review of AHRI Directory suggests range of recovery efficiency ratings for new Gas DHW units of 70-87%. The average of existing units is estimated at 75% by the Northeast Energy Efficiency Partnerships' Mid-Atlantic Technical Reference Manual Version 1.1 (October 2010)~~
[124] ~~Pennsylvania Public Utility Commission Act 129 Technical Reference Manual (June 2011)~~

~~**Definition of Efficient Condition**~~

~~The efficient condition is a faucet aerator that has a flow rate lower than the baseline condition. If this value is not available than the flow rate is assumed to be 1.5 GPM[125].~~

~~**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 aerator = 2.2 GMP[126]~~
GPM_{eff}	=	~~Gallons per minute of the efficient aerator~~
~~2.48~~	=	~~Average number of people per household[127]~~
~~10.9~~	=	~~Average gallons per day used by faucet[128]~~
~~365~~	=	~~Days per year~~
~~50%~~	=	~~Drain rate, the percentage of water flowing down the drain[129]~~
~~3.5~~	=	~~Average Number of Faucets per home[130]~~

~~**Natural Gas Savings Algorithms**~~

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

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

~~Where:~~

$\Delta MMBtu$	=	~~MMBtu of saved natural gas~~
~~8.3~~	=	~~Constant to convert gallons to pounds (lbs)~~
c_p	=	~~Average specific heat of water at temperature range (1.00 Btu/lb-°F)~~
~~25~~	=	~~The difference between the temperature of the water entering the house and the temperature leaving the faucet (degrees Fahrenheit)[131]~~
RE_{DHW}	=	~~Recovery efficiency of the domestic hot water heater = 75%[132]~~

~~**Electric Savings Algorithms**~~

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

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

[126] ~~Public Service Commission of Wisconsin Focus on Energy Evaluation Default Deemed Savings Review, June 2008. http://www.focusonenergy.com/files/Document_Management_System/Evaluation/acesdeemedsavingsreview_evaluationreport.pdf~~

[127] ~~Pennsylvania, Census of Population, 2000.~~

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

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

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

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

[132] ~~See assumption for low flow shower head~~

~~**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[133].~~

~~25) Efficient Natural Gas Water Heater~~

~~Unique Measure Code(s): TBD~~
~~Draft date: 12/14/15~~
~~Effective date: TBD~~
~~End date: TBD~~

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

~~**Definition of Baseline Condition**~~
~~The baseline is the energy factor (EF) of the existing water heater. If possible, the EF of the existing water heater should be used. If the EF of the existing water heater is unknown, 0.575 should be used[134].~~

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

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

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

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

~~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**~~

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

~~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[125].~~

~~26) Hot Water Heater Tank Temperature Turn-down~~

~~Unique Measure Code(s): TBD~~
~~Draft date: 12/14/15~~
~~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.~~

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

~~Where:~~

$\cancel{\Delta MMBtu}$	=	~~MMBtu of saved gas per year~~
$\cancel{Area}$	=	~~Surface area of hot water heater (ft²)~~
$\cancel{T_{base}}$	=	~~Original temperature inside the tank (°F) = Assume 135 °F if no other information provided~~
$\cancel{T_{eff}}$	=	~~New temperature inside the tank (°F) = Assume 120° F if no other information provided~~

[125] ~~DEER values, updated October 10, 2008~~
~~http://www.deeresources.com/deer0911planning/downloads/EUL_Summary_10-1-08.xls~~

~~R_{DHW}~~	=	~~R-value of the hot water heater (h-°F-ft²/Btu) = 5.0~~[136]
~~8,760~~	=	~~Number of hours in a year~~
~~RE_{DHW}~~	=	~~Recovery efficiency of the domestic hot water heater = 75%~~[137]
~~1,000,000~~	=	~~Btu to MMBtu~~

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

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

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

~~Electric Savings Algorithms~~
~~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 temperature reduction in a natural gas water heater is assumed to be 2 years~~[138].

~~27) Repair Hot Water Leaks/Plumbing Repairs~~

~~Unique Measure Code(s): TBD~~
~~Draft date: 12/14/15~~
~~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.~~

[136] ~~Calculated using the base conductive heat loss co-efficient and surface areas from: *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs* (October 15, 2010), Page 98~~
[137] ~~See assumption for low flow showerhead.~~
[138] ~~Page 410, Vermont Technical Reference Manual and New Jersey Clean Energy Program Protocols~~

~~**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*~~[139]

~~**Natural Gas Savings Algorithms**~~

~~Gas savings result from the avoided energy used to heat the water wasted from the leak.~~

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

~~Where:~~

~~$\Delta MMBtu$~~	=	~~MMBtu of saved natural gas~~
~~8.3~~	=	~~Constant to convert gallons to pounds (lbs)~~
~~c_p~~	=	~~Average specific heat of water at temperature range (1.00 Btu/lb-°F)~~
~~120~~	=	~~Assumed temperature of hot water as it leaves the water heater and travels through the pipes.~~
~~55~~	=	~~Assumed temperature of water entering house (degrees Fahrenheit)~~[140]
~~RE_{DHW}~~	=	~~Recovery efficiency of the domestic hot water heater = 75%~~[141]

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

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

~~**Electric Savings Algorithms**~~

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

~~**Freeridership/Spillover**~~

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

[139] ~~Figures provided to North Carolina's Dare County Water Department by the North Carolina Rural Water Association. http://www.darenc.com/water/Otlists/WtrLoss.htm (accessed June 23, 2011)~~

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

[141] ~~See assumption for low flow showerhead.~~

~~**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~~

~~28) DHW Pipe Insulation~~

~~Unique Measure Code(s): TBD~~
~~Draft date: 12/14/15~~
~~Effective date: TBD~~
~~End date: TBD~~

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

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

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

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

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

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

~~The thickness of the DHW pipe insulation should be equivalent to the diameter of the piping. For example, a 1" diameter pipe should be insulated with 1" thick insulation, a 2-1/2" diameter pipe with 2-1/2" thick insulation.~~[142]

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

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

[142] ~~Recommendation based on method pioneered by Gary Klein, expert on DHW based in California~~

~~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%~~[141]

~~"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~~	~~38,541~~
~~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~~

[141] ~~See assumption for low flow showerhead~~

~~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[144].~~

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

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

~~29) Hot Water Storage Tank Wrap~~

~~Unique Measure Code(s): TBD~~
~~Draft date: 12/14/15~~
~~Effective date: TBD~~
~~End date: TBD~~

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

> ~~"Water heater insulation wraps shall not cover the top of oil or gas systems, and shall not obstruct the pressure relief valve, thermostats, hi-limit switch, plumbing pipes, or access plates. A minimum 2 inch clearance is required from the access door for gas burners.~~
>
> ~~Water heater insulation wraps shall not be installed where forbidden by the manufacturer's instructions found on the nameplate."[145]~~

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

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

---

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

~~**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.~~

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

~~Where:~~

~~$\Delta MMBtu$~~	=	~~MMBtu of saved gas per year~~
~~R_{eff}~~	=	~~R-value of the hot water heater with the insulating blanket (h·°F ft²/Btu)~~
~~R_{base}~~	=	~~Original R-value of the hot water heater (h·°F ft²/Btu) = 5.0[146] unless other information provided~~
~~Area~~	=	~~Surface area of the hot water heater covered by the insulating blanket (ft²)~~
~~T_{tank}~~	=	~~Temperature inside the tank (°F) = Assume 120 °F if no other information provided~~
~~T_{amb}~~	=	~~Temperature outside the tank (°F) = 55 °F[147]~~
~~8,760~~	=	~~Number of hours in a year~~
~~RE_{DHW}~~	=	~~Recovery efficiency of the domestic hot water heater = 75%[148]~~
~~1,000,000~~	=	~~Btu to MMBtu~~

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

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

~~** From New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs (October 15, 2010), Page 98*~~
~~*** Assuming square access area with 4" square and 2" clearance on each side*~~

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

---

[146] ~~Calculated using the base conductive heat loss co-efficient and surface areas from: *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs* (October 15, 2010) Page 98~~
[147] ~~Assumed to be in unconditioned space, ambient temperature assumption based on: http://lwf.ncdc.noaa.gov/img/documentlibrary/clim81supp3/tempnormal_hires.jpg~~
[148] ~~See assumption for low flow showerhead.~~

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

~~**Persistence**~~
~~The persistence factor is assumed to be one.~~

~~**Measure Lifetimes**~~
~~The measure life is assumed to be 5 years~~[149]~~.~~

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

~~V.~~IV. Non-Residential Time of Replacement Market

A. Space Heating End Use

~~2)~~1) Efficient ~~Space Heating System~~Boiler – ENERGY STAR®

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Unique Measure Code(s): TBD
Draft date: 12/14/15
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[150]
Gas Boiler – ENERGY STAR® ~~Tier 1~~	9~~4~~0%
~~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.

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

[150] https://www.energystar.gov/products/heating_cooling/commercial_boilers

Where:

$Capacity_{Out}$	= Output capacity of equipment to be installed (kBtu/hr)
1,000	= Conversion from kBtu to MMBtu
TE_{Base}	= Thermal Efficiency of new baseline equipment
TE_{Eff}	= Thermal Efficiency of new equipment
$EFLH_{Heat}$	= Equivalent Full Load Heating Hours

Equivalent Full Load Heating Hours by Building Type

Building Type	EFLH[151]
Multifamily	1663
Education	1772
Food Sales	2140
Food Service	2342
Health Care	3220
Lodging	901
Retail	1760
Office	1688
Public Assembly	2031
Public Order/Safety	1449
Religious Worship	1748
Service	2872
Warehouse/Storage	1213

Electric Savings Algorithms

Not applicable.

Freeridership/Spillover

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

Equipment Type	Free Ridership	Spillover
Gas Boiler	0%	0%

Persistence

The persistence factor is assumed to be one.

Measure Lifetimes

Equipment Type	Measure Lifetime
Gas Boilers	25

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

[151] From NJ Protocols for Philadelphia, adjusted for the PGW evaluation and UGI Gas territory relative HDD.

Water Savings
There are no water savings for this measure.

2) Efficient Unit Heater and Infrared Heater

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Unique Measure Code(s): TBD
Draft date: 12/4/17
Effective date: TBD
End date: TBD

Measure Description
This measure applies to unit heaters and infrared heaters purchased at the time of natural replacement. A qualifying heater must meet minimum efficiency requirements (Thermal Efficiency).

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

Equipment Type	Baseline Thermal Efficiency
Gas Unit Heater	80%

Definition of Efficient Condition
The installed heaters must have electric ignition and use non-conditioned air for combustion. A unit heater that is not an infrared heater must have a thermal efficiency of 90% or greater. An infrared heater must have a thermal efficiency no less than 80%.

Gas Savings Algorithms
An increase in Thermal Efficiency of the new equipment compared to the baseline heater will provide energy savings for either an efficient unit heater or an infrared heater. For an infrared heater MMBtu savings are also realized due to the lower air temperatures that may be maintained with an infrared heater compared to a more typical unit heater that only heats the air. 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.

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

Where:

$Capacity_{Out}$	= Output capacity of equipment to be installed (kBtu/hr)
1,000	= Conversion from kBtu to MMBtu
TE_{Base}	= Thermal Efficiency of new baseline equipment
TE_{Eff}	= Thermal Efficiency of new equipment
UF	= Usage factor for infrared heater compared to conventional unit heater (75%)[152]
$EFLH_{Heat}$	= Equivalent Full Load Heating Hours

Equivalent Full Load Heating Hours by Building Type

[152] Based on 25% savings assumption for infrared heater compared to conventional unit heater from Massachusetts and Connecticut technical reference manuals as of June 2016.

Building Type	EFLH[153]
Multifamily	1663
Education	1772
Food Sales	2140
Food Service	2342
Health Care	3220
Lodging	901
Retail	1760
Office	1688
Public Assembly	2031
Public Order/Safety	1449
Religious Worship	1748
Service	2872
Warehouse/Storage	1213

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
Efficient Unit Heater	0%	0%
Infrared Heater	0%	0%

Persistence

The persistence factor is assumed to be one.

Measure Lifetimes

Equipment Type	Measure Lifetime
Unit Heater	18
Infrared Heater	17

Source: Massachusetts technical reference manual as of June 2016.

Water Savings

There are no water savings for this measure.

[153] From NJ Protocols for Philadelphia, adjusted for the PGW evaluation and UGI Gas territory relative HDD.

3) Steam Trap

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Unique Measure Code(s): TBD
Draft date: 12/14/15
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)[154]	Heat of Vaporization Hv (Btu/lb)[155]	Default Boiler Efficiency B[156]	Operating Hours, H[157]	Adjustment Factor, A[158]	Leaking & Blow-thru factor for unaudited traps, L[159]
Commercial/Multifamily, low pressure	13.8	951	80%	3,106	50%	27%
Dry Cleaners	38.1	890	80%	2,425	50%	27%
Industrial Low Pressure PSIG<15	13.8	951	80%	7,752	50%	16%
Industrial Medium Pressure 15<PSIG<30	12.7	945	80%	7,752	50%	16%
Industrial Medium Pressure 30<PSIG<75	19	928	80%	7,752	50%	16%
Industrial High Pressure 75<PSIG<125	67.9	894	80%	7,752	50%	16%
Industrial High Pressure 125<PSIG<175	105.8	868	80%	7,752	50%	16%
Industrial High Pressure 175<PSIG<250	143.7	846	80%	7,752	50%	16%
Industrial High Pressure PSIG>250	200.5	820	80%	7,752	50%	16%

Electric Savings Algorithms

Not applicable.

Freeridership/Spillover

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

Equipment Type	Free Ridership	Spillover
Steam Traps	0%	0%

Persistence

The persistence factor is assumed to be one.

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

[155] 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.

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

[157] 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 UGI territory based on the HDD base 55 in Reading, PA relative to Chicago, IL.

[158] 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.

[159] 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%

Measure Lifetime
6 years[160]

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

[160] 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 an 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

~~H.~~G. Commercial Kitchen End Uses

~~4)~~1) Commercial Convection Ovens

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Unique Measure Code(s): TBD
Draft date: 12/14/15
Effective date: TBD
End date: TBD

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

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

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

Definition of Baseline Condition
Cooking energy efficiency of 44% and Idle Energy Rate of 15,100 Btu/h[161].

Definition of Efficient Condition
Cooking energy efficiency greater than or equal to 46%[162] and an Idle Energy Rate less than or equal to 12,000 Btu/h
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.[163]

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

[161] ENERGY STAR calculator default input.
[162] Using ASTM Standard F1496-99 (Reapproved 2005) based on heavy load (potato) cooking test.
[163] http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COO

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

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.

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2) Commercial Combination Ovens

Unique Measure Code(s): TBD
Draft date: 12/4/17
Effective date: TBD
End date: TBD

Measure Description

A device that combines the function of hot air convection (oven mode), saturated and superheated steam heating (steam mode), and combination convection/steam mode for moist heating, to perform steaming, baking, roasting, rethermalizing, and proofing of various food products. In general, the term combination oven is used to describe this type of equipment, which is self-contained. The combination oven is also referred to as a combination oven/steamer, combi or combo.

Definition of Baseline Condition

A baseline combination oven is one that is not Energy STAR certified. Baseline cooking energy efficiency is assumed to be 52% for convection mode and 39% for steam mode. Baseline Idle Energy Rates depend on the number of pans. See the following table.[164]

Pan Capacity	Convection Mode Idle Rate (Btu/hr)	Steam Mode Idle Rate (Btu/hr)
< 15	8,747	18,656
15-30	10,788	24,562
>30	13,000	43,300

Definition of Efficient Condition

To qualify for this measure, the installed equipment must be a new combination oven meeting the ENERGY STAR idle rate and cooking efficiency requirements as specified below.[165]

Combination Oven ENERGY STAR Requirements

Operation	Idle Rate (Btu/hr)	Cooking-Energy Efficiency (%)
Steam Mode	≤ 200P+6,511	≥ 41
Convection Mode	≤ 150P+5,425	≥ 56

P = Pan capacity as defined in Section 1.S. of the Commercial Ovens Program Requirements Version 2.1[166]

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Gas Savings Algorithms

The following shows the expected gas savings from a commercial combination oven meeting the above specifications. These savings come from the Energy Star calculator.[167]

Annual Gas Savings (MMBtu) = ($\Delta CookingEnergy_{ConvGas}$ + $\Delta CookingEnergy_{SteamGas}$ + $\Delta IdleEnergy_{ConvGas}$ + $\Delta IdleEnergy_{SteamGas}$) * Days / 1,000,000

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[164] ENERGY STAR calculator default input
[165] ENERGY STAR Commercial Ovens Key Product Criteria http://www.energystar.gov/index.cfm?c=ovens.pr_crit_comm_ovens
[166] Pan capacity is defined as the number of steam table pans the combination oven is able to accommodate as per the ASTM F-1495-05 standard specification. http://www.energystar.gov/products/specs/system/files/Commercial%20Ovens%20Program%20Requirements%20V2%201.pdf?965d-c5ec&3b06-d2f5
[167] http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COO

$\Delta CookingEnergy_{ConvGas}$ $= LB_{Gas} * (EFOOD_{ConvGas} / GasEFF_{ConvBase} - EFOOD_{ConvGas} / GasEFF_{ConvEE}) * \%_{Conv}$

$\Delta CookingEnergy_{SteamGas}$ $= LB_{Gas} * (EFOOD_{SteamGas} / GasEFF_{SteamBase} - EFOOD_{SteamGas} / GasEFF_{SteamEE}) * \%_{Steam}$

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$\Delta IdleEnergy_{ConvGas}$ $= [(GasIDLE_{ConvBase} * ((HOURS - LB_{Gas}/GasPC_{ConvBase}) * \%_{Conv})) - (GasIDLE_{ConvEE} * ((HOURS - LB_{Gas}/GasPC_{ConvEE}) * \%_{Conv}))]$

$\Delta IdleEnergy_{SteamGas}$ $= [(GasIDLE_{SteamBase} * ((HOURS - LB_{Gas}/GasPC_{SteamBase}) * \%_{Steam})) - (GasIDLE_{SteamEE} * ((HOURS - LB_{Gas}/GasPC_{SteamEE}) * \%_{Steam}))]$

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Where:

$\Delta CookingEnergy_{ConvGas}$ = Change in total daily cooking energy consumed by gas oven in convection mode

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$\Delta CookingEnergy_{SteamGas}$ = Change in total daily cooking energy consumed by gas oven in steam mode

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$\Delta IdleEnergy_{ConvGas}$ = Change in total daily idle energy consumed by gas oven in convection mode

$\Delta IdleEnergy_{SteamGas}$ = Change in total daily idle energy consumed by gas oven in steam mode

LB_{Gas} = Estimated mass of food cooked per day for gas oven (lbs/day)
= Custom, or if unknown, use 200 lbs (If P <15), 250 lbs (If 15 <= P 30), or 400 lbs (If P = >30)

$EFOOD_{ConvGas}$ = Energy absorbed by food product for gas oven in convection mode
= Custom or if unknown, use 250 Btu/lb

GasEFF = Cooking energy efficiency of gas oven
= Custom or if unknown, use values from table below

	Base	EE
$GasEFF_{Conv}$	52%	56%
$GasEFF_{Steam}$	39%	41%

$EFOOD_{SteamGas}$ = Energy absorbed by food product for gas oven in steam mode
= Custom or if unknown, use 105 Btu/lb

$GasIDLE_{Base}$ = Idle energy rate (Btu/hr) of baseline gas oven
= Custom or if unknown, use values from table below

Pan Capacity	Convection Mode ($GasIDLE_{ConvBase}$)	Steam Mode ($GasIDLE_{SteamBase}$)
< 15	8,747	18,656
15-30	10,788	24,562
>30	13,000	43,300

$GasPC_{Base}$ = Production capacity (lbs/hr) of baseline gas oven
= Custom of if unknown, use values from table below

Pan Capacity	Convection Mode ($GasPC_{ConvBase}$)	Steam Mode ($GasPC_{SteamBase}$)
< 15	125	195
15-30	176	211
>30	392	579

$GasIDLE_{ConvEE}$ = Idle energy rate of ENERGY STAR gas oven in convection mode
= 150*P + 5,425

$GasPC_{EE}$ = Production capacity (lbs/hr) of ENERGY STAR gas oven
= Custom of if unknown, use values from table below

Pan Capacity	Convection Mode ($GasPC_{ConvEE}$)	Steam Mode ($GasPC_{SteamEE}$)
< 15	124	172
15-30	210	277
>30	394	640

$GasIDLE_{SteamEE}$ = Idle energy rate of ENERGY STAR gas oven in steam mode

	= 200 * P +6511
Days	= Days of operation per year
	= Custom or if unknown, use 365 days per year
1,000,000	= Conversion factor from Btu to MMBtu

Electric Savings Algorithms

There are no electric savings from this measure.

Energy Savings
ΔkWh = 0 kWh

Demand Savings
ΔkW = 0 kW

Where:

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

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

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

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes

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.

~~30)~~2) Commercial Gas Fryer

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Unique Measure Code(s): TBD
Draft date: 12/14/15
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%.
Idle 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.[168]

Standard Fryer (per frypot):

$$Annual\ Gas\ Savings\ (MMBtu) = 50.80\ MMBtu$$

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

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

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.

~~5~~3) Commercial Gas Steamers (Cooking)

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Unique Measure Code(s): TBD
Draft date: 12/14/15
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[169].

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.[170]

# 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

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

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

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 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.

6)4) Commercial Gas Griddle

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Unique Measure Code(s): TBD
Draft date: 12/14/15
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[171].

Definition of Efficient Condition
Cooking energy efficiency greater than or equal to 38% and a Normalized Idle Energy Rate less than or equal to 2,650 Btu/h per square foot.

All criteria are the same as the ENERGY STAR label.

Gas Savings Algorithms
The following shows the expected gas savings from a commercial gas griddle meeting the above specifications. These savings come from the Energy Star calculator.[172]

$$Annual\ Gas\ Savings\ (MMBtu) = 13.10\ MMBtu$$

Electric Savings Algorithms

There are no electric savings from this measure.

Energy Savings
$\Delta kWh = 0$ kWh

Demand Savings
$\Delta kW = 0$ kW

Where:

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

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

Equipment Type	Free Ridership	Spillover
Commercial Gas Griddle	0%	0%

[171] From the Energy Star calculator

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

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.

7)5) Pre-rinse Spray Valve

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Unique Measure Code(s): TBD
Draft date: 12/14/15
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.[173]

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

Electric Savings Algorithms

There are no electric savings from this measure.

Energy Savings
ΔkWh = 0 kWh

Demand Savings
ΔkW = 0 kW

Where:

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

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

Equipment Type	Free Ridership	Spillover
Pre-rinse Spray Valve	0%	0%

[173] 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[174]

Water Savings
Expected water savings would be 62,305 gallons per year.[175]

~~I.~~H. Commercial Domestic Hot Water End Use

1) Commercial Domestic Hot Water Heater

Unique Measure Code(s): TBD
Draft date: 12/~~14~~/17~~5~~
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 water 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

$$BaselineUse = \frac{SLR_b \times 8760}{10^6}$$

For multifamily buildings:

[174] Massachusetts 2011 Technical Reference Manual.
[175] Massachusetts 2011 Technical Reference Manual.

The maximum of:

$$BaselineUse = U \times E_b$$

or

$$BaselineUse = \frac{SLR_b \times 8760}{10^6}$$

All building types:

$$EfficientUse = \left(BaselineUse - 8760 \times \frac{(SLR_b - SLR_e)}{10^6} \times \eta_b\right) \times \frac{\eta_b}{\eta_e}$$

$$SLR_b = CAP_{H,b} \times \frac{1000}{800} + 110 \times \sqrt{CAP_{W,b}}$$ [176]

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

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.
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%)[177]
$CAP_{H,e}$	=	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

Building Type	Annual Baseline Gas Usage Rate, E_b (MMBtu/ft2/yr)[178]
Education	0.00525
Grocery/Convenience Store	0.00319
Restaurant/Cafeteria	0.03996

[176] ASHRAE 90.1-2007, Table 7.8
[177] ASHRAE 90.1-2007, Table 7.8.
[178] U.S. Energy Information Administration Table E8A. Natural Gas Consumption and Energy Intensities by End Use for All Buildings, 2003.

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)[179]
Multifamily	22.5

Electric Savings Algorithms

There are no electric savings from this measure.

Energy Savings
$\Delta kWh = 0\ kWh$

Demand Savings
$\Delta kW = 0\ kW$

Where:

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

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

Equipment Type	Free Ridership	Spillover
Commercial DHW Heater	0%	0%

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes

Equipment Type	Measure Lifetime
Commercial Tankless Water Heater	20
Commercial Storage DHW	152

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

Heater	

Sources: CA DEER 08, EUL_Summary_10-1-08.xls~~CA DEER~~;, MA ~~2011~~ TRM, October 2015; ~~ENERGY STAR~~IL TRM, Volume 2, February 8, 2017.

Water Savings

There are no water savings for this measure.

~~J~~I. All End Uses

1) Custom Measure

Unique Measure Code(s): TBD
Draft date: 12/14/15
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~~.V. Non-Residential New Construction

A. All End Uses

1) Custom Measures

Unique Measure Code(s): TBD
Draft date: 12/14/15
Effective date: TBD
End date: TBD

Measure Description
This measure applies to all non-residential custom measures applicable to new construction, 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.

~~VII.~~VI. Non-Residential Retrofit

B. Space Heating End Use

1) Efficient Space Heating System

Unique Measure Code(s): TBD
Draft date: 12/14/15
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.[180]

[180] 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 and PGW.

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

C.All End Uses

1) Custom Measures

Unique Measure Code(s): TBD
Draft date: 12/14/15
Effective date: TBD
End date: TBD

Measure Description
This measure applies to all custom non residential 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.

VII. Reference Tables

A.Residential

1) HDD & CDD

Heating Degree Days and Cooling Degree Days

Territory	HDD63	HDD62	CDD
UGI Gas (Reading)	4726	4500	1275
PNG (Scranton)	5434	5192	973

Source: DegreeDay.net 2012-2016

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