Energy to do more®

Danielle Jouenne, Esq.

UGI Corporation
460 North Gulph Road
King of Prussia, PA 19406

Post Office Box 858
Valley Forge, PA 19482-0858

(610) 992-3203 (direct)
jouenned@ugicorp.com

January 30, 2020

VIA ELECTRONIC FILING
Rosemary Chiavetta, Secretary
Pennsylvania Public Utility Commission
Commonwealth Keystone Building
400 North Street
Harrisburg, PA 17120

Re: Pennsylvania Public Utility Commission et al. v. UGI Utilities Inc. – Gas Division, Docket Nos. R-2015-2518438 et al.

Dear Secretary Chiavetta:

Enclosed for filing on behalf of UGI Utilities, Inc. – Gas Division ("UGI Gas" or "the Company") is the Annual Report for the period October 1, 2018 through September 30, 2019, which is Program Year 3 of the Energy Efficiency and Conservation Plan ("EE&C") for UGI Gas's former South Rate District. The Annual Report is being submitted to the Pennsylvania Public Utility Commission ("the Commission") as required by Paragraph 41 of the Settlement approved in the Company's 2016 base rate proceeding at the above-referenced docket.

PY3 was the last program year for the EE&C of the former South Rate District. Pursuant to an order approving the Settlement of the Company's 2019 base rate proceeding at Docket No. R-2018-3006814, the Commission approved a new five-year EE&C for UGI Gas available to its entire service territory, inclusive of the former North, South, and Central Rate Districts. Annual reporting for EE&C activities after October 1, 2019, will be provided on a consolidated basis with the first annual report on consolidated PY1 submitted in January 2021.

Very truly yours,

Danielle Jouenne
Counsel for UGI Utilities, Inc.

Enclosure
cc: Certificate of Service
Cornelia R. Schneck, Bureau of Technical Utility Services, *at cschneck@pa.gov*

BEFORE THE
PENNSYLVANIA PUBLIC UTILITY COMMISSION

Pennsylvania Public Utility Commission et al. v. UGI Utilities Inc.	:	**Docket No. R-2015-2518438**

CERTIFICATE OF SERVICE

I hereby certify that I have, this 30th day of January 2020, served a true and correct copy of the foregoing document in the manner and upon the persons listed below in accordance with requirements of 52 Pa. Code § 1.54 (relating to service by a participant):

VIA ELECTRONIC AND FIRST CLASS MAIL:

Darryl Lawrence, Esquire
Lauren Burge, Esquire
Office of Consumer Advocate
555 Walnut Street
Forum Place, 5th Floor
Harrisburg, PA 17101-1923
dlawrence@paoca.org
LBurge@paoca.org

Joseph L. Vullo, Esquire
Burke Vullo Reilly Roberts
1460 Wyoming Avenue
Forty Fort, PA 18704
Commission on Economic Opportunity
JLVullo@aol.com

Scott B. Granger, Esquire
Bureau of Investigation & Enforcement
Commonwealth Keystone Building
PO Box 3265
400 North Street, 2nd Floor West
Harrisburg, PA 17105-3265
sgranger@pa.gov

Steven C. Gray, Esquire
Office of Small Business Advocate
300 North Second Street, Suite 202
Harrisburg, PA 17101
sgray@pa.gov

Elizabeth R. Marx, Esquire
Patrick M. Cicero, Esquire
Joline Price, Esquire
Pennsylvania Utility Law Project
118 Locust Street
Harrisburg, PA 17101
CAUSE-PA
pulp@palegalaid.net

John F. Povilaitis, Esquire
Buchanan Ingersoll & Rooney
409 North Second Street, Suite 500
Harrisburg, PA 17101-1357
Retail Energy Supply Association
john.povilaitis@bipc.com

Pamela C. Polacek, Esquire
Vasiliki Karandrikas, Esquire
Alessandra L. Hylander, Esquire.
McNees Wallace & Nurick LLC
100 Pine Street
PO Box 1166
Harrisburg, PA 17108-1166
UGI Industrial Intervenors
ppolacek@mcneeslaw.com
vkarandrikas@mcneeslaw.com
ahylander@mcneeslaw.com

Todd S. Stewart, Esquire
Hawke McKeon & Sniscak LLP
100 North Tenth Street
Harrisburg, PA 17101
Natural Gas Supplier Parties
tsstewart@hmslegal.com

Danielle Jouenne

Report to the
Pennsylvania Public Utility Commission

UGI Utilities, Inc. – Gas Division
UGI South Rate District
Energy Efficiency and Conservation Plan
Program Year 3 (PY3)
October 1, 2018 - September 30, 2019

Prepared by UGI Utilities, Inc. - Gas Division
Filing Date: January 30, 2020

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1 EXECUTIVE SUMMARY

This Annual Report covers the third and final year of the UGI Utilities, Inc. – Gas Division's (UGI Gas) South Rate District's (UGI South) Energy Efficiency and Conservation (EE&C) Plan, which was approved as part of UGI Utilities, Inc. – Gas Division's 2016 Rate Case (Docket No. R-2015-2518438). Program Year 3 (PY3) covers the period of October 1, 2018, through September 30, 2019. Going forward, UGI Gas's reporting for EE&C activities after October 1, 2019, will be provided on a consolidated basis in accordance with UGI Gas's 2019 Rate Case (Docket No. R-2018-3006814). As highlighted below, the EE&C Plan continued the success of PY2 into and throughout PY3:

- Costs in PY3 for the EE&C Portfolio were $6.6 million, which equaled 115% of projected costs. The former UGI South spent $5.3 million on incentives (142% of projections) and $1.3 million on non-incentive costs (66% of projections).
- PY3 savings for the EE programs were 155,281 MMBtus (104% of projections) while costs were $6.6 million (115% of projections). The EE programs also resulted in electric savings of 3,165 MWh in PY3.
- Marketing and administration of the Combined Heat and Power (CHP) Program in PY3 led to the pre-approval of two projects that UGI Gas anticipates will be completed in Fiscal Year 2020. The former UGI South spent $5,562 on administration for the CHP Program in PY3.
- The total EE&C Portfolio provided $14.8 million in net benefits to customers with a benefit-to-cost ratio (BCR) of 2.78 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 $10.4 million in net benefits to customers with a BCR of 2.25.

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). Pursuant to the order entered September 20, 2018 at Docket Nos. A-2018-3000381, *et al.*, on October 1, 2018, UGI Central Penn Gas, Inc. and UGI Penn Natural Gas, Inc. merged with UGI Utilities, Inc., with UGI Utilities, Inc. as the sole surviving entity. As of the effective date of the merger, the service territory of UGI Gas was known as the UGI South Rate District of UGI Utilities, Inc. On October 4, 2019, the Commission entered an order at Docket No. R-2018-3006814 approving the settlement of UGI Gas's base rate proceeding, unifying the UGI Gas North, South, and Central Rate Districts, and approving a new unified five-year UGI Gas EE&C Plan for UGI Gas's fiscal years 2020-2024.

UGI Gas respectfully submits this report, in accordance with the settlement at Docket No. R-2015-2518438, documenting the PY3 EE&C Plan results for the former UGI Gas South Rate District. 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.

In PY3, the former UGI South had seven natural gas EE programs in its EE&C Portfolio and one program focused on CHP. These programs were:

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

These programs followed the designs and goals established in UGI Gas's 2016 rate case. All the EE&C programs were voluntary and offered UGI Gas customers in the former South Rate District 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

Portfolio spending of $6.6 million was 115% of projected PY3 spending, while annual savings of 155,281 MMBtus were 104% of PY3 projections. The savings were primarily driven by the continued success of the Residential Prescriptive program. There were no CHP projects completed in PY3; however, two pre-approved projects will likely be completed in Fiscal Year 2020. The EE&C Portfolio had present value TRC net benefits of $14.8 million, with a BCR of 2.78 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 $10.4 million, with a BCR of 2.25. The following tables provide a high-level overview of the EE&C Portfolio's spending and savings for PY3 and the current phase.

Table 1. EE&C PORTFOLIO SUMMARY – PY3			
Program	**Actual**	**Projected**	**%**
Portfolio Spending	**$6,627,115**	**$5,759,126**	**115%**
EE Programs	$6,621,553	$5,082,126	130%
CHP Program	$5,562	$677,000	1%
EE Program Natural Gas Savings			
Annual (MMBtus)	155,281	148,703	104%
Lifetime (MMBtus)	2,962,273	1,588,964	186%
CHP Net Primary Energy Savings			
Annual (MMBtus)	0	455,460	0
Lifetime ((MMBtus)	0	6,831,898	0

Table 2. EE&C PORTFOLIO SUMMARY - PHASE I			
Program	**Actual**	**Projected**	**%**
Portfolio Spending	$13,423,227	$27,000,000	**50%**
EE Programs	$13,406,379	$27,204,900	55%
CHP Program	$16,848	$2,795,100	1%
EE Program Natural Gas Savings			
Annual (MMBtus)	299,876	633,049	47%
Lifetime (MMBtus)	5,852,558	7,016,957	83%
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 AND PARTICIPATION BY PROGRAM – PY3				
Program	**Total**	**Incentive**	**Non-Incentive**	**Customers***
Residential Prescriptive (RP)	$4,471,914	$4,227,000	$244,914	9,119
Nonresidential Prescriptive (NP)	$259,917	$167,432	$92,486	30
Residential Retrofit (RR)	$539,838	$188,939	$350,899	254
Residential New Construction (RNC)	$790,020	$581,171	$208,849	518
Nonresidential Retrofit (NR)	$175,403	$143,600	$31,803	13
Nonresidential New Construction (NNC)	$7,150	$0	$7,150	0
Behavior and Education (BE)	$0	$0	$0	0
Portfolio wide Costs	$377,310	$0	$377,310	N/A
Energy Efficiency Total	**$6,621,553**	**$5,308,142**	**$1,313,411**	**9,934**
CHP	$5,562	$0	$5,562	0
Portfolio Total	**$6,627,115**	**$5,308,142**	**$1,318,973**	**9,934**

***Represents unique customers who have received a rebate.**

Table 4. PORTFOLIO COSTS BY PROGRAM – Inception to Date			
Program	**Total**	**Incentive**	**Non-Incentive**
Residential Prescriptive (RP)	$9,206,394	$8,483,900	$722,494
Nonresidential Prescriptive (NP)	$534,188	$303,294	$230,894
Residential Retrofit (RR)	$953,261	$262,451	$690,810
Residential New Construction (RNC)	$1,082,401	$756,336	$326,065
Nonresidential Retrofit (NR)	$462,233	$421,850	$40,383
Nonresidential New Construction (NNC)	$16,550	$0	$16,550
Behavior and Education (BE)	$0	$0	$0
Portfolio wide Costs	$1,151,352	$0	$1,151,352
Energy Efficiency Total	**$13,406,379**	**$10,227,831**	**$3,178,548**
CHP	$16,848	$0	$16,848
Portfolio Total	**$13,423,227**	**$10,227,831**	**$3,195,396**

2.2.2 Summary of Program Savings

Table 5. ENERGY EFFICIENCY PROGRAM SAVINGS – PY3							
Program	Natural Gas (MMBtus)		Electric Energy (MWh)		Capacity	Water Savings (Gal)	
	Annual	Lifetime	Annual	Lifetime	MW-yr.	Annual	Lifetime
Residential Prescriptive (RP)	106,098	1,885,513	1,557	28,591	0.30	0	0
Nonresidential Prescriptive (NP)	17,176	329,405	0	0	0.00	0	0
Residential Retrofit (RR)	1,903	57,832	28	845	0.02	45,770	460,647
Residential New Construction (RNC)	26,094	600,171	1,572	36,162	0.69	246,397	5,667,131
Nonresidential Retrofit (NR)	4,009	89,352	9	257	0.00	0	0
Nonresidential New Construction (NNC)	0	0	0	0	0.00	0	0
Behavior and Education (BE)	0	0	0	0	0.00	0	0
Energy Efficiency Total	**155,281**	**2,962,273**	**3,165**	**65,855**	**1.02**	**292,167**	**6,127,778**

Table 6. ENERGY EFFICIENCY PROGRAM SAVINGS – Inception to Date							
Program	Natural Gas (MMBtus)		Electric Energy (MWh)		Capacity	Water Savings (Gal)	
	Annual	Lifetime	Annual	Lifetime	MW-yr.	Annual	Lifetime
Residential Prescriptive (RP)	224,507	4,241,643	3,259	61,353	0.67	0	0
Nonresidential Prescriptive (NP)	25,689	479,011	0	0	0.00	124,610	623,050
Residential Retrofit (RR)	2,654	78,515	40	1,173	0.03	74,625	736,029
Residential New Construction (RNC)	33,685	774,750	2,065	47,493	0.70	246,397	5,667,131
Nonresidential Retrofit (NR)	13,363	278,640	16	411	0.00	0	0
Nonresidential New Construction (NNC)	0	0	0	0	0.00	0	0
Behavior and Education (BE)	0	0	0	0	0.00	0	0
Energy Efficiency Total	**299,898**	**5,852,558**	**5,379**	**110,429**	**1.40**	**445,632**	**7,026,210**

Table 7. CHP PROGRAM SAVINGS				
Savings	PY3		Inception to Date	
	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 – PY3 (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)	$14,224,459	$5,944,120	$8,280,338	2.39	$11,604,558	$5,944,120	$5,660,438	1.95
Nonresidential Prescriptive (NP)	$1,759,760	$252,475	$1,507,286	6.97	$1,469,989	$252,475	$1,217,515	5.82
Residential Retrofit (RR)	$368,063	$582,809	($214,746)	0.63	$300,392	$582,809	($282,417)	0.52
Residential New Construction (RNC)	$6,084,417	$994,198	$5,090,218	6.12	$4,766,278	$994,198	$3,772,080	4.79
Nonresidential Retrofit (NR)	$724,567	$259,440	$465,127	2.79	$590,338	$259,440	$330,899	2.28
Nonresidential New Construction (NNC)	$0	$5,255	($5,255)	0.00	$0	$5,255	($5,255)	0.00
Behavior and Education (BE)	$0	$0	$0	N/A	$0	$0	$0	N/A
Portfolio wide Costs	$0	$277,334	($277,334)	0.00	$0	$277,334	($277,334)	0.00
Energy Efficiency Total	**$23,161,265**	**$8,315,631**	**$14,845,634**	**2.79**	**$18,731,556**	**$8,315,631**	**$10,415,925**	**2.25**
CHP	$0	$4,088	($4,088)	0.00	$0	$4,088	($4,088)	0.00
Portfolio Total	**$23,161,265**	**$8,319,719**	**$14,841,545**	**2.78**	**$18,731,556**	**$8,319,719**	**$10,411,837**	**2.25**

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)	$32,084,000	$13,500,900	$18,583,099	2.38	$26,289,828	$13,500,900	$12,788,928	1.95
Nonresidential Prescriptive (NP)	$2,714,852	$521,283	$2,193,570	5.21	$2,264,391	$521,283	$1,743,109	4.34
Residential Retrofit (RR)	$539,142	$989,783	($450,641)	0.54	$440,602	$989,783	($549,181)	0.45
Residential New Construction (RNC)	$6,755,707	$1,373,580	$5,382,126	4.92	$5,242,888	$1,373,580	$3,869,308	3.82
Nonresidential Retrofit (NR)	$1,706,350	$892,520	$813,830	1.91	$1,379,816	$892,520	$487,297	1.55
Nonresidential New Construction (NNC)	$0	$12,717	($12,717)	0.00	$0	$12,717	($12,717)	0.00
Behavior and Education (BE)	$0	$0	$0	N/A	$0	$0	$0	N/A
Portfolio wide Costs	$0	$917,306	($917,306)	0.00	$0	$917,306	($917,306)	0.00
Energy Efficiency Total	**$43,800,050**	**$18,208,089**	**$25,591,961**	**2.41**	**$35,617,526**	**$18,208,089**	**$17,409,437**	**1.96**
CHP	$0	$14,998	($14,998)	0.00	$0	$14,998	($14,998)	0.00
Portfolio Total	**$43,800,050**	**$18,223,087**	**$25,576,962**	**2.40**	**$35,617,526**	**$18,223,087**	**$17,394,439**	**1.95**

2.3 Progress Toward Goals

UGI Gas made significant progress toward its savings goals, achieving 104% of its PY3 annual MMBtu projections for the former South Rate District, while administration costs were only 66% of projections. The success of PY3 can be largely attributed to the success of the RP Program, for which customer incentives were 223% higher than projected. Overall, UGI Gas spent $13,423,227 since inception, or approximately 50% of the approved settlement budget of $27 million.

UGI Gas kept the commitments it made in the settlement of its 2016 Base Rate Case. Paragraph 42 of the settlement for UGI Gas's 2016 Rate Case requires the Company 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 55%, which is down from a high of 65% in PY1.

Table 10. NONRESIDENTIAL PROGRAM UTILITY COST PERCENTAGES

Program	Utility Cost	Incremental Participant Cost	Total Cost	% Utility
NP	$534,188	$136,678	$670,866	80%
NR	$462,233	$676,756	$1,138,989	41%
NNC	$16,550	$0	$16,550	100%
Total	**$1,012,971**	**$813,434**	**$1,826,405**	**55%**

In addition, per Paragraph 39 of the settlement for UGI Gas's 2016 Base Rate Case, the Company 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.

UGI Gas's marketing efforts for the multifamily market involved engagement with stakeholders to educate on the benefits of UGI Gas's Energy Efficiency programs. UGI Gas developed specific marketing collateral for multi-family developers that highlighted eligible, smaller sized equipment that would be more applicable for buildings containing more than one unit. UGI Gas also developed individual email marketing campaigns to focus on multi-family stakeholders. The emails were sent in June, August, and September 2018 with one email sent to builders and developers and another sent to customers living in multi-family buildings. UGI Gas continued its coordination efforts with the Housing Alliance of Pennsylvania by facilitating webinars on November 16, 2018, and February 13, 2019, to raise further awareness of UGI Gas's programs. In PY3, UGI Gas identified 370 rebates in the RP and NP program that were tied to buildings with more than one unit, which represented $245,596 in rebates.

Moreover, UGI Gas continued to be compliant with paragraph 40 of the settlement for UGI Gas's 2016 Base Rate Case, which required the Company to: (1) inform customers who contact the former UGI South or its Community Service Providers ("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 PY3, UGI Gas referred 4 former South Rate District customers to the Company's LIURP Team.

2.3.1 Portfolio Costs

Table 11. EE&C PORTFOLIO COSTS BY CATEGORY – PY3			
Component (Nominal $)	**Actual**	**Projected**	**%**
Direct Utility Costs	**$6,627,115**	**$5,759,126**	**115%**
Customer Incentives	$5,308,142	$3,748,422	142%
Administration	$922,974	$1,281,035	72%
Marketing	$156,568	$397,109	39%
Inspections	$87,345	$126,867	69%
Evaluations	$152,085	$205,693	74%
Incremental Participant Costs	**$4,691,772**	**$23,400,168**	**20%**

Table 12. EE&C PORTFOLIO COSTS BY CATEGORY - PHASE I			
Component (Nominal $)	**Actual**	**Projected**	**%**
Direct Utility Costs	**$13,423,227**	**$27,000,000**	**50%**
Customer Incentives	$10,227,831	$16,375,127	62%
Administration	$2,325,033	$7,176,868	32%
Marketing	$544,609	$2,174,572	25%
Inspections	$135,502	$584,206	23%
Evaluations	$190,252	$689,227	28%
Incremental Participant Costs	**$10,072,036**	**$86,610,523**	**12%**

2.3.2 Portfolio Savings

Table 13. EE&C PROGRAM SAVINGS – PY3			
Type	**Actual**	**Projected**	**%**
EE Programs			
Natural Gas (MMBtus)			
Annual	155,281	148,703	104%
Lifetime	2,962,273	1,588,964	186%
Electric Energy (MWh)			
Annual	3,165	1,044	303%
Lifetime	65,855	20,385	323%
Capacity Savings (MW)	1.02	0.23	441%
Water Savings (Gal)			
Annual	292,167	5,662,387	5%
Lifetime	6,127,778	48,733,000	13%
CHP Program			
Net Primary Energy Savings			
Annual (MMBtus)	0	455,460	0%
Lifetime (MMBtus)	0	6,831,898	0%

Table 14. EE&C PROGRAM SAVINGS - PHASE I			
Type	**Actual**	**Projected**	**%**
EE Programs			
Natural Gas (MMBtus)			
Annual	299,876	633,049	47%
Lifetime	5,852,558	7,016,957	83%
Electric Energy (MWh)			
Annual	5,379	4,694	115%
Lifetime	110,429	91,777	120%
Capacity Savings (MW)	1.61	1.03	156%
Water Savings (Gal)			
Annual	445,632	25,448,618	2%
Lifetime	7,026,210	230,688,705	3%
CHP Program			
Net Primary Energy Savings			
Annual (MMBtus)	0	1,706,090	0%
Lifetime (MMBtus)	0	25,591,350	0%

3 PROGRAM RESULTS

3.1 Residential Prescriptive Program

(Rate Classes R/RT, N/NT)

3.1.1 Program Description

The Residential Prescriptive (RP) Program was 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 was 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 aimed 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 $4,471,914 in PY3, of which $4,227,000 were customer incentives. The program provided first year gas savings of 106,098 MMBtus (215% of plan projections) and lifetime gas savings of 1,885,513 MMBtus (204% of plan projections). Under the TRC Test, including DRIPE and CO_2, the RP Program provided $8.3 million in present value of net benefits (2015$) with a BCR of 2.39. Without DRIPE or CO_2, the RP Program provided $5.7 million in present value of net benefits (2015$) with a BCR of 1.95.

The RP Program saw participation remain higher than forecast for PY3. The steady customer participation went hand in hand with contractor participation as program buy-in continued to show growth, and the program exceeded its PY3 participation and savings targets by a significant margin. In total, 9,119 customers participated in the RP Program in PY3 with 2,316 customers receiving multiple rebates. For example, customers installing heating equipment may have also chosen to install a Wi-Fi thermostat. Below is a table that highlights rebates issued by equipment type.

Table 15. RP Participation	
Equipment	**Rebates Issued**
Wi-Fi Thermostat	7,158
ENERGY STAR Furnace	2,857
94+ AFUE Combi-Boiler	839
ENERGY STAR Tankless Water Heater	467
94+ AFUE Boiler	256
Total	**11,577**

3.1.2.1 Marketing Activity

Due to the success of the RP Program in PY2, much of the same marketing strategy was continued into PY3. The strategy continued to include outreach to HVAC contractors, customer bill inserts, digital advertising on multiple social media platforms, email marketing, a successful Black Friday promotion, and energy efficiency content on the UGI website.

HVAC contractor outreach remained a key piece of the RP Program marketing strategy. In PY3, nearly half of participating customers reported hearing about the program from their contractors. In October 2018, contractor sessions were held in Harrisburg, Lancaster, Bethlehem, and Reading and were attended by numerous HVAC companies.

Program marketing also included monthly bill inserts that highlighted the benefits of the program and the rebates available. The announcements were focused on educating customers on the various energy efficiency options available, along with energy saving tips.

During the start of the 2018 Holiday season, a limited time promotion was implemented to encourage the purchase of an Energy Star® Wi-Fi thermostat, via the UGI Marketplace. During this week-long promotion (11/21-11/28), 2,519 thermostats were purchased. During the purchase, customers were given an instant rebate at the point of sale, making it an easy and convenient process. Most of the marketing focus for the RP Program was spent on digital advertising. The UGI website, www.ugi.com/savesmart, was redesigned and optimized to better inform customers of the available rebates and benefits of the Program. Additional digital advertising included various social media channels and google key word searches.

3.1.2.2 Inspection Activity

Energy Federation, Inc. (EFI), the CSP responsible for processing rebates, also was retained to provide inspections on a subset of applications. The purpose of these inspections was to confirm that the equipment on the rebate application matched the equipment that was installed in the customer's home. Payment of the rebate was withheld from applications flagged for inspection until such activity was completed. In PY3, 622 inspections were performed, with only four inspections failing.

3.1.3 Program Updates

There are no program updates for this EE&C Plan.

3.1.4 Residential Prescriptive Program Results

Table 16. PROGRAM COSTS			
Component (Nominal $)	**PY3 - Actual**	**PY3 - Projected**	**%**
Direct Utility Costs	**$4,471,914**	**$2,141,968**	**209%**
Customer Incentives	$4,227,000	$1,894,068	223%
Administration	$51,403	$73,349	70%
Marketing	$77,342	$71,492	108%
Inspections	$54,352	$65,921	82%
Evaluations	$61,818	$37,139	166%
Incremental Participant Costs	**$3,614,996**	**$2,273,825**	**159%**

Table 17. PROGRAM SAVINGS			
Type	**PY3- Actual**	**PY3 - Projected**	**%**
Natural Gas (MMBtus)			
Annual	106,098	49,384	215%
Lifetime	1,885,513	922,911	204%
Electric Energy (MWh)			
Annual	1,556.7	1,002.3	155%
Lifetime	28,591.2	19,454.9	147%
Capacity Savings (MW)	0.300	0.221	136%
Water Savings (Gal)			
Annual	0	0	0%
Lifetime	0	0	0%

Table 18. PROGRAM COST-EFFECTIVENESS (BASE CASE + DRIPE & CO_2)		
Benefits/Cost Component (2015$)	**PY3**	**Inception to Date**
TRC NPV Benefits	$14,224,459	$32,084,000
TRC NPV Costs	$5,944,120	$13,500,900
TRC Net Benefits	$8,280,338	$18,583,099
TRC Benefit/Cost Ratio	2.39	2.38

Table 19. PROGRAM COST-EFFECTIVENESS (BASE CASE)		
Benefits/Cost Component (2015$)	**PY3**	**Inception to Date**
TRC NPV Benefits	$11,604,558	$26,289,828
TRC NPV Costs	$5,944,120	$13,500,900
TRC Net Benefits	$5,660,438	$12,788,928
TRC Benefit/Cost Ratio	1.95	1.95

3.2 Nonresidential Prescriptive Program

(Rate Classes R/RT, N/NT)

3.2.1 Program Description

The Nonresidential Prescriptive (NP) Program was 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 was to encourage business owners to install the most efficient gas heating technologies available to replace older, less efficient equipment. The program also aimed to strengthen UGI Gas's relationships with HVAC contractors, suppliers, and other trade allies.

3.2.2 Program Highlights

The NP Program spent $259,917 in PY3, of which $167,432 were customer incentives. The program provided first year gas savings of 17,176 MMBtus (87% of plan projections) and lifetime gas savings of 329,405 MMBtus (100% of plan projections). Under the TRC Test, including DRIPE and CO_2, the NP Program provided $1.5 million in present value of net benefits (2015$) with a BCR of 6.97. Without factoring in DRIPE or CO_2, the NP Program provided $1.2 million in present value of net benefits (2015$) with a BCR of 5.82.

UGI Gas utilized the services of Energy Federation, Inc. (EFI) to process rebates, provide customer service, and perform quality assurance inspections. Below is a chart that summarizes rebate activity for PY3.

Table 20. NP Participation	
Equipment	**Rebates Issued**
Steam Trap	53
Commercial Boiler (>= 300MBh) 90+ ET	29
Commercial Water Heater	12
Efficient Unit Heater	10
Commercial Fryer	4
Commercial Fryer (Large)	1
Total	**109**

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, bill inserts, and digital advertising.

UGI Gas also continued its membership with the Pennsylvania Restaurant and Lodging Association to continue the Company's outreach to that customer base. In addition, UGI Gas continued its outreach to Multi-Family developers and customers as referenced in section 2.3.

3.2.2.2 Inspection Activity

EFI, the CSP responsible for processing rebates, also was retained to provide inspections on a subset of applications. The purpose of these inspections was to confirm that the equipment on the rebate application matched the equipment that was installed in the customer's business. Payment of the rebate was withheld from applications flagged for inspection until such activity has been completed. In PY3, 63 inspections were performed on NP Program rebates, with zero inspections failing.

3.2.3 Program Updates

There are no program updates for this EE&C Plan.

3.2.4 Nonresidential Prescriptive Program Results

Table 21. PROGRAM COSTS			
Component (Nominal $)	**PY3 - Actual**	**PY3 - Projected**	**%**
Direct Utility Costs	**$259,917**	**$545,009**	**48%**
Customer Incentives	$167,432	$417,809	40%
Administration	$25,911	$46,423	56%
Marketing	$24,249	$29,711	82%
Inspections	$1,098	$23,212	5%
Evaluations	$41,228	$27,854	148%
Incremental Participant Costs	**$83,572**	**$653,698**	**13%**

Table 22. PROGRAM SAVINGS			
Type	**PY3 - Actual**	**PY3 - Projected**	**%**
Natural Gas (MMBtus)			
Annual	17,176	19,819	87%
Lifetime	329,405	329,005	100%
Electric Energy (MWh)			
Annual	0.0	0.0	0%
Lifetime	0.0	0.0	0%
Capacity Savings (MW)	0.000	0.000	0%
Water Savings (Gal)			
Annual	0	4,362,355	0%
Lifetime	0	26,174,130	0%

Table 23. PROGRAM COST-EFFECTIVENESS (BASE CASE + DRIPE & CO_2)		
Benefits/Cost Component (2015$)	**PY3**	**Inception to Date**
TRC NPV Benefits	$1,759,760	$2,714,852
TRC NPV Costs	$252,475	$521,283
TRC Net Benefits	$1,507,286	$2,193,570
TRC Benefit/Cost Ratio	6.97	5.21

Table 24. PROGRAM COST-EFFECTIVENESS (BASE CASE)		
Benefits/Cost Component (2015$)	**PY3**	**Inception to Date**
TRC NPV Benefits	$1,469,989	$2,264,391
TRC NPV Costs	$252,475	$521,283
TRC Net Benefits	$1,217,515	$1,743,109
TRC Benefit/Cost Ratio	5.82	4.34

3.3 Residential New Construction Program

(Rate Classes R/RT)

3.3.1 Program Description

The Residential New Construction (RNC) Program was designed to overcome market barriers to energy efficient space and water heating equipment, as well as high efficiency thermal envelopes, in both the residential new construction sector. This was accomplished through rebates offered to builders and developers. The objective of the program was 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 aimed to strengthen UGI Gas's relationship with builders, HVAC contractors, suppliers, and other trade allies. The RNC Program was launched on January 1, 2018.

For the residential new construction track, the program required builders to work with a Home Energy Rating System (HERS) rater on their home. An incentive of $20 per annual MMBtu saved was paid to a new home, heated with natural gas, that achieved savings of 30% over code or greater. A $30 per annual MMBtu incentive was paid to homes that achieved savings of 30% over code and achieved ENERGY STAR Certification. The increase in incentive was designed to move the market towards more homes being ENERGY STAR Certified and leverage the HERS rating approach taken by the electric distribution companies (EDCs) under their Act 129 new construction programs.

3.3.2 Program Highlights

The RNC Program spent $790,020 in PY3, of which $581,171 were customer incentives. The program provided first year gas savings of 26,094 MMBtus, 1853% of plan projections. Under the TRC Test, including DRIPE and CO_2, the RNC Program provided $5.1 million in present value of net benefits (2015$) with a BCR of 6.12. Without DRIPE or CO_2, the RNC Program provided $3.8 million in present value of net benefits (2015$) with a BCR of 4.79.

UGI Gas utilized the services of Performance Systems Development (PSD) as the program implementer for the Residential New Construction (RNC) and Residential Retrofit (RR) Programs. Below is a chart of participation by rebate type in the RNC program:

Table 25. PROGRAM PARTICIPATION	
Rebate Level	**Rebate Count**
30% Above Code	408
30% Above Code + ENERGY STAR	110
Total	**518**

3.3.2.1 Marketing Activity

In 2019, marketing was conducted through established builders and HERS raters who have been participants in the programs mandated for large EDCs by Act 129 of 2008, P.L. 1592 (Act 129). UGI Gas also included outreach to various Home Builder Associations to educate this audience on the availability of this program. Representatives from Performance Systems Development (“PSD”) also attended the Harrisburg and Lancaster Parade of Homes, along with a variety of home shows throughout the service territory. These events were designed to spotlight participating homes as well as network with builders and raters to increase program participation. Lastly, a newsletter was created each month and sent to all participating builders, raters, and non-participating builders and raters that were identified as active in the former UGI South service territory.

3.3.2.2 Inspection Activity

There were a total of 105 HERS ratings reviewed by PSD, and only three (3) of those ratings failed to qualify for a rebate.

3.3.3 Program Updates

There are no program updates for this EE&C Plan.

3.3.4 Residential New Construction Program Results

Table 26. PROGRAM COSTS			
Component (Nominal $)	**PY3 - Actual**	**PY3 - Projected**	**%**
Direct Utility Costs	**$790,020**	**$178,313**	**443%**
Customer Incentives	$581,171	$78,919	736%
Administration	$170,456	$48,394	352%
Marketing	$3,820	$26,058	15%
Inspections	$28,044	$6,328	443%
Evaluations	$6,530	$18,613	35%
Incremental Participant Costs	**$562,576**	**$29,445**	**1911%**

Table 27. PROGRAM SAVINGS			
Type	**PY3 - Actual**	**PY3 - Projected**	**%**
Natural Gas (MMBtus)			
Annual	26,094	1,408	1853%
Lifetime	600,171	32,381	1853%
Electric Energy (MWh)			
Annual	1,572	24	6584%
Lifetime	36,162	549	6584%
Capacity Savings (MW)	0.694	0.004	17141%
Water Savings (Gal)			
Annual	246,397	0	0%
Lifetime	5,667,131	0	0%

Table 28. PROGRAM COST-EFFECTIVENESS (BASE CASE + DRIPE & CO_2)		
Benefits/Cost Component (2015$)	**PY3**	**Inception to Date**
TRC NPV Benefits	$6,084,417	$6,755,707
TRC NPV Costs	$994,198	$1,373,580
TRC Net Benefits	$5,090,218	$5,382,126
TRC Benefit/Cost Ratio	6.12	4.92

Table 29. PROGRAM COST-EFFECTIVENESS (BASE CASE)		
Benefits/Cost Component (2015$)	**PY3**	**Inception to Date**
TRC NPV Benefits	$4,766,278	$5,242,888
TRC NPV Costs	$994,198	$1,373,580
TRC Net Benefits	$3,772,080	$3,869,308
TRC Benefit/Cost Ratio	4.79	3.82

3.4 Nonresidential New Construction

(Rate Class N/NT)

3.4.1 Program Description

The Nonresidential New Construction (NNC) Program was designed to overcome market barriers to energy efficient space and water heating equipment, as well as high efficiency thermal envelopes, in the nonresidential new construction sector. This was accomplished through rebates offered to builders and developers. The objective of the program was 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 aimed to strengthen UGI Gas's relationship with builders, HVAC contractors, suppliers, and other trade allies. Due to limited activity, the NNC Program was managed internally by UGI Gas EE&C Staff.

3.4.2 Program Highlights

In PY3, $7,150 was spent on administrative activities for this program. There were no NNC projects completed in PY3.

3.4.2.1 Marketing Activity

In order to continue coordination with the Housing Alliance of Pennsylvania, UGI Gas sponsored the 2018 Homes Within Reach Conference. The conference was held in October and was attended by multi-family developers and stakeholders from throughout the former UGI South service territory. As part of the sponsorship, the Company had a booth at the event to further inform customers about the Nonresidential New Construction Program.

3.4.2.2 Inspection Activity

There was no inspection activity in PY3.

3.4.3 Program Updates

There are no program updates for this EE&C Plan. The Nonresidential New Construction program will be merged into the Nonresidential Custom program under the Consolidated UGI Gas EE&C Plan in Fiscal Year 2020.

3.4.4 Nonresidential New Construction Program Results

Table 30. PROGRAM COSTS			
Component (Nominal $)	**PY3 - Actual**	**PY3 - Projected**	**%**
Direct Utility Costs	**$7,150**	**$266,421**	**3%**
Customer Incentives	$0	$117,915	0%
Administration	$6,650	$72,306	9%
Marketing	$500	$38,934	1%
Inspections	$0	$9,455	0%
Evaluations	$0	$27,810	0%
Incremental Participant Costs	**$0**	**$43,994**	**0%**

Table 31. PROGRAM SAVINGS			
Type	**PY3 - Actual**	**PY3 - Projected**	**%**
Natural Gas (MMBtus)			
Annual	0	4,067	0%
Lifetime	0	73,201	0%
Electric Energy (MWh)			
Annual	0.0	0.1	0%
Lifetime	0.0	2.4	0%
Capacity Savings (MW)	0.000	0.000	0%
Water Savings (Gal)			
Annual	0	236,763	0%
Lifetime	0	4,261,741	0%

Table 32. PROGRAM COST-EFFECTIVENESS (BASE CASE + DRIPE & CO_2)		
Benefits/Cost Component (2015$)	**PY3**	**Inception to Date**
TRC NPV Benefits	$0	$0
TRC NPV Costs	$5,255	$12,717
TRC Net Benefits	($5,255)	($12,717)
TRC Benefit/Cost Ratio	0.00	0.00

Table 33. PROGRAM COST-EFFECTIVENESS (BASE CASE)		
Benefits/Cost Component (2015$)	**PY3**	**Inception to Date**
TRC NPV Benefits	$0	$0
TRC NPV Costs	$5,255	$12,717
TRC Net Benefits	($5,255)	($12,717)
TRC Benefit/Cost Ratio	0.00	0.00

3.5 Residential Retrofit Program

(Rate Class R/RT)

3.5.1 <u>Program Description</u>

The Residential Retrofit (RR) Program was 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 encouraged 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 aimed to strengthen UGI Gas's relationship with HVAC contractors, suppliers, and other trade allies.

The RR Program incentivized 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, was $150. In addition to the $150 from the customer, the contractor received a $150 payment from UGI Gas for each audit completed.

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

Table 34. 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

3.5.2 Program Highlights

UGI Gas utilized the services of Performance Systems Development (PSD) as the program implementer for the RR Program. The RR Program spent $539,838 in PY3, of which $188,939 were customer incentives. The program provided first year gas savings of 1,903 MMBtus, 42% of plan projections. The program provided lifetime gas savings of 57,832 MMBtus, 56% of plan projections. Under the TRC Test, including DRIPE and CO_2, the RR Program provided negative $214,746 in present value of net benefits (2015$) with a BCR of 0.63. Without DRIPE or CO_2, the RR Program provided negative $282,417 in present value of net benefits (2015$) with a BCR of 0.52.

Below is a chart of participation by rebate type in the RR program:

Table 35. PROGRAM PARTICIPATION

Rebate Level	Rebate Count
Audit - Home Energy	254
Ceiling Insulation	101
Air Sealing	100
Wi-Fi Thermostat	75
Wall Insulation	40
DHW Pipe Insulation	10
Kitchen/Bath Faucet Aerator	10
Showerhead	10
Duct Sealing	6
Heating Pipe Insulation - Hot Water	6
Duct Insulation	2
Tank Temperature Turn-Down	2
Boiler	1
DHW Replacement - Storage	1
Heating Pipe Insulation - Steam	1

3.5.2.1 Marketing Activity

Marketing for this program in PY3 was designed to drive traffic to the program website www.ugisavesmart.com. The website outlined the customer participation process, the potential rebates, benefits to customer participation, and a list of participating contractors.

UGI Gas continued to market the program through bill inserts throughout the remainder of the program year. In addition to bill inserts, the RR Program marketing strategy also focused on social media advertising, contractor outreach marketing, and a limited time offer promotion. UGI Gas focused on simple messaging that highlighted the benefits of the program that a customer could experience. Most of the marketing focus was put toward contractor outreach. UGI Gas provided contractors with marketing collateral, digital HTML code to place on the contractor's website, and yard signs to place in their customer's yards as they were working on a project.

Following up on the success of the Limited Time Offer (LTO) from PY2, a second iteration was designed, informed by lessons learned from the prior year. Additional Wi-Fi thermostat models were offered, providing the homeowner their choice from three prominent brands, Nest, Ecobee, and Honeywell.

The LTO in PY3 was in effect between April 1, 2019-August 31, 2019 and was marketed to customers via email, the UGI website, and marketing collateral that was distributed during two home shows in March of 2019. The results of PY3 LTO exceeded the result from the prior year, with a slight increase in audits (103 vs. 99), an increase in jobs (57 vs. 33), and an overall conversion rate % increase from 33% to 55%.

3.5.2.2 Inspection Activity

A total of twelve field inspections were conducted in the RR Program with only one inspection failing because the customer did not have a valid UGI Gas account.

3.5.3 Program Updates

There are no program updates for this EE&C Plan. The RR program has been redesigned as part of the Consolidated UGI Gas EE&C Plan starting in Fiscal Year 2020.

3.5.4 Residential Retrofit Program Results

Table 36. PROGRAM COSTS			
Component (Nominal $)	**PY3 - Actual**	**PY3 - Projected**	**%**
Direct Utility Costs	**$539,838**	**$468,586**	**115%**
Customer Incentives	$188,939	$229,055	82%
Administration	$283,230	$158,515	179%
Marketing	$28,418	$74,277	38%
Inspections	$3,852	$6,738	57%
Evaluations	$35,399	$0	0%
Incremental Participant Costs	**$253,067**	**$284,471**	**89%**

Table 37. PROGRAM SAVINGS			
Type	**PY3 - Actual**	**PY3 - Projected**	**%**
Natural Gas (MMBtus)			
Annual	1,903	4,534	42%
Lifetime	57,832	102,420	56%
Electric Energy (MWh)			
Annual	28	8	371%
Lifetime	845	180	469%
Capacity Savings (MW)	0.023	0.005	435%
Water Savings (Gal)			
Annual	45,770	195,762	23%
Lifetime	460,647	4,698,289	10%

Table 38. PROGRAM COST-EFFECTIVENESS (BASE CASE + DRIPE & CO_2)		
Benefits/Cost Component (2015$)	**PY3**	**Inception to Date**
TRC NPV Benefits	$368,063	$539,142
TRC NPV Costs	$582,809	$989,783
TRC Net Benefits	($214,746)	($450,641)
TRC Benefit/Cost Ratio	0.63	0.54

Table 39. PROGRAM COST-EFFECTIVENESS (BASE CASE)		
Benefits/Cost Component (2015$)	**PY3**	**Inception to Date**
TRC NPV Benefits	$300,392	$440,602
TRC NPV Costs	$582,809	$989,783
TRC Net Benefits	($282,417)	($549,181)
TRC Benefit/Cost Ratio	0.52	0.45

3.6 Nonresidential Retrofit Program

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

3.6.1 Program Description

The Nonresidential Retrofit (NR) Program provided incentives for overcoming market barriers for natural gas efficiency retrofits in existing commercial and multi-family buildings. The NR Program launched on January 1, 2018.

3.6.2 Program Highlights

The NR Program spent $175,403 in PY3, of which $143,600 were customer incentives. The program provided first year gas savings of 4,009 MMBtus and lifetime gas savings of 89,352 MMBtus. Under the TRC Test, including DRIPE and CO_2, the NR Program provided $465,127 in present value of net benefits (2015$) with a BCR of 2.79. Without DRIPE or CO_2, the NR Program provided $330,899 in present value of net benefits (2015$) with a BCR of 2.28.

The NR Program provided incentives to 13 projects in PY3. The projects were completed at multi-family buildings, repurposed office space, and a church. These projects provided cost-effective incentives to help overcome the large incremental cost between the installation of low or baseline efficiency measures and high efficiency measures. The rebates were issues for custom space and water heating measures, as well as, shell upgrade measures with insulation and air sealing.

3.6.2.1 Marketing Activity

The NR Program marketing activity was limited in PY3 due to the complex nature of the projects. To ease customer understanding of the program, the Company's website was updated to include a section on the NR Program, referred to as the Commercial Energy Upgrades Program. In addition to updating the website, UGI Gas focused its marketing efforts on developing relationships with trade allies who have experience with commercial energy efficiency projects.

3.6.2.2 Inspection Activity

All 13 NR Program projects that were completed in PY3 passed inspection by UGI Gas Staff prior to releasing payment.

3.6.3 Program Updates

There are no program updates for this EE&C Plan. The Nonresidential Retrofit program will be merged into the Nonresidential Custom program under the Consolidated UGI Gas EE&C in Fiscal Year 2020.

3.6.4 Nonresidential Retrofit Program Results

Table 40. PROGRAM COSTS			
Component (Nominal $)	PY3 - Actual	PY3 - Projected	%
Direct Utility Costs	**$175,403**	**$284,110**	**62%**
Customer Incentives	$143,600	$92,846	155%
Administration	$6,650	$87,276	8%
Marketing	$22,239	$56,636	39%
Inspections	$0	$10,213	0%
Evaluations	$2,914	$37,139	8%
Incremental Participant Costs	**$177,562**	**$115,425**	**154%**

Table 41. PROGRAM SAVINGS			
Type	PY3 - Actual	PY3 - Projected	%
Natural Gas (MMBtus)			
Annual	4,009	4,543	88%
Lifetime	89,352	64,097	139%
Electric Energy (MWh)			
Annual	9	10	87%
Lifetime	257	198	130%
Capacity Savings (MW)	0.0010	0.0008	119%
Water Savings (Gal)			
Annual	0	867,507	0%
Lifetime	0	13,598,841	0%

Table 42. PROGRAM COST-EFFECTIVENESS (BASE CASE + DRIPE & CO_2)		
Benefits/Cost Component (2015$)	PY3	Inception to Date
TRC NPV Benefits	$724,567	$1,706,350
TRC NPV Costs	$259,440	$892,520
TRC Net Benefits	$465,127	$813,830
TRC Benefit/Cost Ratio	2.79	1.91

Table 43. PROGRAM COST-EFFECTIVENESS (BASE CASE)		
Benefits/Cost Component (2015$)	PY3	Inception to Date
TRC NPV Benefits	$590,338	$1,379,816
TRC NPV Costs	$259,440	$892,520
TRC Net Benefits	$330,899	$487,297
TRC Benefit/Cost Ratio	2.28	1.55

3.7 Behavior and Education

(Rate Class R/RT)

3.7.1 Program Description

The objective of the Behavior and Education (BE) Program was to motivate a large group of residential customers to save energy by changing their behavior through education, outreach, and energy monitoring. The premise was 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.

3.7.2 Program Highlights

There are no program highlights at this time.

3.7.2.1 Marketing Activity

There was no marketing activity in PY3.

3.7.2.2 Inspection Activity

There was no inspection activity in PY3.

3.7.3 Program Updates

UGI Gas had tabled the launch of the BE Program. This program was not included in the Consolidated UGI Gas EE&C Plan.

3.7.4 Behavior and Education Program Results

There were no costs or savings for the BE Program in PY3.

3.8 Combined Heat and Power

(Rate Classes DS, LFD)

3.8.1 Program Description

The Combined Heat and Power (CHP) Program sought 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. Efficiencies also stem from avoided transmission and distribution losses from delivering the electricity from the generator to the customer site.

3.8.2 Program Highlights

The CHP Program spent $5,562 on administrative costs in PY3. While no CHP projects were completed in PY3, UGI Gas anticipates that two pre-approved projects will likely be completed in Fiscal Year 2020 under the consolidated EE&C Plan.

3.8.2.1 Marketing Activity

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

3.8.2.2 Inspection Activity

There was no inspection activity in PY3.

3.8.3 Program Updates

There are no program updates for this EE&C Plan.

3.8.4 Combined Heat and Power Program Results

Table 44. PROGRAM COSTS			
Component (Nominal $)	**PY3 - Actual**	**PY3 - Projected**	**%**
Direct Utility Costs	**$5,562**	**$677,000**	**1%**
Customer Incentives	$0	$500,000	0%
Administration	$1,365	$52,000	3%
Marketing	$0	$100,000	0%
Inspections	$0	$5,000	0%
Evaluations	$4,197	$20,000	21%
Incremental Participant Costs	**$0**	**$19,999,310**	**0%**

Table 45. PROGRAM SAVINGS			
Type	**PY3- Actual**	**PY3 - Projected**	**%**
Net Primary Energy Savings (MMBtus)			
Annual	0	455,460	0%
Lifetime	0	6,831,898	0%

Table 46. PROGRAM COST-EFFECTIVENESS (BASE CASE + DRIPE & CO_2)		
Benefits/Cost Component (2015$)	**PY3**	**Inception to Date**
TRC NPV Benefits	$0	$0
TRC NPV Costs	$4,088	$14,998
TRC Net Benefits	($4,088)	($14,998)
TRC Benefit/Cost Ratio	0.00	0.00

Table 47. PROGRAM COST-EFFECTIVENESS (BASE CASE)		
Benefits/Cost Component (2015$)	**PY3**	**Inception to Date**
TRC NPV Benefits	$0	$0
TRC NPV Costs	$4,088	$14,998
TRC Net Benefits	($4,088)	($14,998)
TRC Benefit/Cost Ratio	0.00	0.00

4 Attachments

4.1 Technical Reference Manual

The Technical Reference Manual (TRM) used to calculate savings for the UGI Gas's Consolidated Energy Efficiency and Conservation (EE&C) Plan has been included as an attachment to this report.

The TRM utilized for the former UGI South's EE&C Plan was updated to align more closely with the Act 129 Phase IV TRM that was approved in August of 2019, including adopting savings factors for smart thermostats, climate dependent variables, ancillary electric savings algorithms, and water savings algorithms for low-flow device. In addition, water heating measures were updated to account for new testing methods and ratings, and clarifying language was added regarding establishing baselines, new construction, and custom measures. Lastly, a commercial dishwasher measure was added.

Technical Reference Manual

Measure Savings Algorithms

UGI Gas

December 17, 2019

Table of Contents

Prepared by:

1 Cross-Sector TRM Issues

1.1 Establishing Baselines

The savings methods and assumptions can differ substantially based on the program delivery mechanism for each measure type. Within each of the measure protocols in the TRM, there is a definition for the measure's baseline efficiency, a critical input into the savings calculations. Most measures will fall into one of two categories, each with a baseline that is most commonly used:

- One for market-driven choices – often called "lost opportunity" and either replacing equipment that has failed (replace on burnout) or new installations (new construction)
- One for discretionary installations – either early replacement or retrofit

For all new construction (NC) and replace on burnout (ROB) scenarios, the baseline is typically a jurisdictional code or a national standard; however, there may be cases where a market baseline is appropriate. In these scenarios, the Commission has a preference for codes and standards as it is too expensive and time consuming to conduct annual market baseline and characterization research. Additionally, the TRM provides estimates for gross energy savings only, whereas net savings "…include the effects of free-ridership, spillover, and induced market effects."

For discretionary installation scenarios, the baseline is typically the existing equipment efficiency, but in the case of early replacement (EREP), at some point the savings calculations must incorporate changes to the baseline for new installations (e.g., code or market changes) to account for eventual natural replacement of the equipment. This approach encourages residential and business consumers to replace working inefficient equipment and appliances with new high-efficiency products rather than taking no action to upgrade or only replacing them with new standard-efficiency products.

All baselines are designed to reflect current market practices that are updated periodically to reflect upgrades in federal equipment standards, building code, or information from evaluation results. Specifically for commercial and industrial measures, Pennsylvania has adopted the 2015 International Energy Conservation Code (IECC) per 34 Pa. Code Section 403.21, effective October 1, 2018. Per Section 401.2 of IECC 2015, commercial buildings must comply with either "[t]he requirements of ANSI/ASHRAE/IESNA Standard 90.1[-2013]" or comply with the requirements outlined in IECC 2015 Chapter 4. In accordance with IECC 2015, commercial protocols relying on code standards as the baseline condition may refer to either IECC 2015 or ASHRAE 90.1-2013 per the program design.

The baseline estimates used in the TRM are based on applicable federal standards, or are documented in baseline studies or other market information. This TRM reflects the most up-to-date codes, practices, and market transformation effects. The measures herein include, where appropriate, schedules for the implementation of Federal standards to coincide with the beginning of a program year. These implementation schedules apply to measures where the Federal standard is considered the baseline, as described herein or otherwise required by law. In cases where the ENERGY STAR criterion is considered the eligibility requirement and the existing ENERGY STAR Product Specification Version expires in a given year, the new ENERGY STAR Product Specification Version will become the eligibility requirement at the start of the next consecutive program year.

The combined effect of measure retention and persistence is the ability of installed measures to maintain the initial level of energy savings or generation over the measure life. If the measure is subject to a reduction in savings or generation over time, the reduction in retention or persistence is accounted for using factors in the calculation of resource savings.

2 Residential Time of Replacement Market

2.1 Space Heating End Use

2.1.1 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 (Refer to EFLH table by climate zone in References Section VIII, A, 2)

Electric Savings Algorithms

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

Energy Savings

$\Delta kWh = 446\ kWh$

Demand Savings

$\Delta kW = 0.105\ kW$

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.

Water Savings

There are no water savings for this measure.

2.1.2 WiFi Thermostat – ENERGY STAR®

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

Measure Description
This is an ENERGY STAR 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

$$Annual\ Gas\ Savings\ (MMBtu) = SH_{pre} \times ESF$$

Where:

SH_{pre}	=	Space Heat MMBtu gas usage with manual thermostat = 70.5 – 18.1 = 52.4 MMBtu
ESF	=	Percentage savings from WiFi thermostat compared to non-WiFi connected thermostat. See table below by installation method.
70.5	=	Typical UGI Gas residential heating customer total gas usage in MMBtu.
18.1	=	Non-space-heat gas usage in typical residence.[1]

Heating Energy Savings Factors (ESF)

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

Program Type	Baseline	Air Source Heat Pump	Furnace/Boiler Heating (Electric or Fossil)
Upstream buy-down (Customer Self-Installation)	Unknown Mix Default	6.4%[a]	6.4%[a]
Customer Self-Installation with Education	Unknown Mix Default	7.9%[b]	7.9%[b]
Professional Installation	Manual	11.5%[c]	11.5%[c]
	Conventional programmable	7.9%[d]	7.9%[d]

[a] *Average of heating estimates from two studies. Sources: 9, 11*

[b] *Heating savings are based on average of savings from unknown mix default with customer self-installation and average of professional installation savings from manual and programmable thermostats. In this case, 7.9%=((11.5%×0.42 + 7.9%×0.58) + 6.4%) / 2*

[c] *Average of four heating savings estimates from four studies. Sources: 7, 10, 12*

[d] *The ESF value for a is applied here as an estimate until information becomes available showing different savings incented through a direct install program.*

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.[2]

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} = Furnace Fan kWh savings

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

Deemed Savings ΔkWh

Program Type	Baseline	Fossil Fuel Furnace (Fan Only) ΔkWh_{Aux}	CAC Cooling ΔkWh_{CAC}
Upstream buy-down (Customer Self-Installation)	Unknown Mix Default	48	77
Customer Self-Installation with Education	Unknown Mix Default	60	120

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

Professional Installation	Manual	87	182
	Conventional programmable	60	150

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
WiFi Thermostat	0%	0%

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes

Equipment Type	Measure Lifetime
WiFi Thermostat	11

Source: August 2019 Act 129 TRM, Volume 2, p.47.

Water Savings
There are no water savings for this measure.

2.2 Water Heating End Use

2.2.1 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[3]
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	High	0.64

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 (*V*)
Very Small	$0 \leq GPM < 1.7$	10
Low	$1.7 \leq GPM < 2.8$	38
Medium	$2.8 \leq GPM < 4.0$	55
High	$4.0 \leq GPM$	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	0.87

Gas Savings Algorithms
The following formula for gas savings is based on the DOE test procedure for water heaters[4].

[3] 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
[4] 10 CFR Appendix E to Subpart B of Part 430, Uniform Test Method for Measuring the Energy Consumption of Water Heaters

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

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

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

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.

2.3 Combined Space and Domestic Hot Water Usage

2.3.1 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

Equipment Type	Usage Draw Pattern	Baseline UEF[5]
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	High	0.64

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

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

[5] 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

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

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

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

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

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

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

Where:

$Annual\ Gas\ Savings_{SH}$ = Space heating annual gas savings (MMBtu)
$Annual\ Gas\ Savings_{DHW}$ = Domestic Hot Water annual gas savings (MMBtu)
$Capacity_{Out}$ = Output capacity of equipment to be installed (kBtu/hr)
1,000 = Conversion from kBtu to MMBtu
$AFUE_{Base}$ = Efficiency of new baseline equipment (Annual Fuel Utilization Efficiency)
$AFUE_{Eff}$ = Efficiency of new equipment
$EFLH_{Heat}$ = Equivalent Full Load Heating Hours (990 hours)[6]

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

$$Annual\ Gas\ Savings_{DHW} = \frac{\left(\frac{1}{UEF_{Base}} - \frac{1}{UEF_{Eff}}\right) \times V \times \rho \times c_p \times 67 \times 365}{1{,}000{,}000}$$

Where:

UEF_{Base} = Uniform Energy Factor of baseline water heater. See UEF based on usage draw pattern in Baseline section above. If draw pattern cannot be established assume medium draw pattern.
UEF_{Eff} = Uniform Energy Factor of efficient combi boiler. Since the combi boiler has no or little storage, standby losses are assumed to be negligible and the UEF is assumed to be the same as the AFUE.
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).

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

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

Electric Savings Algorithms

Energy Savings

ΔkWh = 0 kWh

Demand Savings

ΔkW = 0 kW

Where:

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

Freeridership/Spillover

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

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

Persistence

The persistence factor is assumed to be one.

Measure Lifetimes

Equipment Type	Measure Lifetime
Gas Combi Boiler	20

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

Water Savings

There are no water savings for this measure.

2.4 All End Uses

2.4.1 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
ΔkWh = *BaselinekWh* - *EfficientkWh*

Demand Savings
ΔkW = *BaselinekW* - *EfficientkW*

Where:

ΔkWh = Gross customer annual kWh savings for the measure.

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

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

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

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

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

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

Equipment Type	**Free Ridership**	**Spillover**
Custom Measure	0%	0%

Persistence
The persistence factor is assumed to be one.

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

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

3 Residential New Construction

3.1 All End Uses

3.1.1 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

ΔkWh = *BaselinekWh - EfficientkWh*

Demand Savings

ΔkW = *BaselinekW - EfficientkW*

Where:

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

Freeridership/Spillover

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

Equipment Type	Free Ridership	Spillover
Custom Measure	0%	0%

Persistence

The persistence factor is assumed to be one.

Measure Lifetimes

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

4 Residential Early Replacement Market

4.1 Space Heating End Use

4.1.1 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.

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

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

Heating Use weather normalization methods (HeatingUse):

Method 1: Use a linear regression model of use/day as a function of HDD63[7]/day to estimate heating slope (MMbtu/HDD63) and baseload daily use (MMBtu/day) 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 * (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

$\Delta kWh = 446$ kWh

Demand Savings

$\Delta kW = 0.105$ 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.

[7] 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.

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.

Water Savings
There are no water savings for this measure.

4.1.2 WiFi Thermostat – ENERGY STAR®

Unique Measure Code(s): TBD
Draft date: 11/26/19
Effective date: TBD
End date: TBD

Measure Description
This is an ENERGY STAR 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

$$Annual\ Gas\ Savings\ (MMBtu) = SH_{pre} \times ESF$$

Where:

SH_{pre}	=	Space Heat MMBtu gas usage with manual thermostat . Use actual space heating usage where available. If not available, assume = 70.5 – 18.1 = 52.4 MMBtu
ESF	=	Percentage savings from WiFi thermostat compared to non-WiFi connected thermostat. See table below by installation method.
70.5	=	Typical UGI Gas residential heating customer total gas usage in MMBtu.

18.1 = Non-space-heat gas usage in typical residence.[8]

Heating Energy Savings Factors (ESF)[9]

Program Type	Baseline	Air Source Heat Pump	Furnace/Boiler Heating (Electric or Fossil)
Upstream buy-down (Customer Self-Installation)	Unknown Mix Default	6.4%[a]	6.4%[a]
Customer Self-Installation with Education	Unknown Mix Default	7.9%[b]	7.9%[b]
Professional Installation	Manual	11.5%[c]	11.5%[c]
	Conventional programmable	7.9%[d]	7.9%[d]

[a] *Average of heating estimates from two studies. Sources: 9, 11*

[b] *Heating savings are based on average of savings from unknown mix default with customer self-installation and average of professional installation savings from manual and programmable thermostats. In this case, 7.9%=((11.5%×0.42 + 7.9%×0.58) + 6.4%) / 2*

[c] *Average of four heating savings estimates from four studies. Sources: 7, 10, 12*

[d] *The ESF value for a is applied here as an estimate until information becomes available showing different savings incented through a direct install program.*

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.[10]

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

Energy Savings

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

ΔkWh_{Aux} = Furnace Fan kWh savings

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

Deemed Savings ΔkWh

Program Type	Baseline	Fossil Fuel Furnace (Fan Only) ΔkWh_{Aux}	CAC Cooling ΔkWh_{CAC}

[8] Non-space-heat usage assumption from UGI Gas data.
[9] From Act 129 TRM, August 2019, p.51.
[10] Percentage of houses with air-conditioning from UGI data.

Upstream buy-down (Customer Self-Installation)	Unknown Mix Default	48	77
Customer Self-Installation with Education	Unknown Mix Default	60	120
Professional Installation	Manual	87	182
	Conventional programmable	60	150

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
WiFi Thermostat	0%	0%

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes

Equipment Type	Measure Lifetime
WiFi Thermostat	11

Source: August 2019 Act 129 TRM, Volume 2, p.47.

Water Savings
There are no water savings for this measure.

4.1.3 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.
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[11]
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.[12]

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

Energy Savings

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

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

[11] 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.
[12] Percentage of houses with air-conditioning from UGI data.

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

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

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

Demand Savings

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

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

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

Where:

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

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.*

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 (Refer to EFLH table by climate zone in References Section VIII, A, 2)*

$EFLH_{cool\ RAC}$ = *Equivalent Full Load Cooling hours for Room AC (Refer to EFLH table by climate zone in References Section VIII, A, 2)*

$F_{Room\ AC}$ = *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[13]
$SEER_{CAC}$	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[14]

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.

[13] "State of Ohio Energy Efficiency Technical Reference Manual," prepared for the Public Utilities Commission of Ohio by Vermont Energy Investment Corporation. August 6, 2010.
[14] 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). $F_{Room,AC} = (425\ ft^2 * 2.1)/(2323\ ft^2) = 0.38$

4.1.4 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.

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. 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.[15]

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

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

Energy Savings

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

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

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

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

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

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.*

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 (Refer to EFLH table by climate zone in References Section VIII, A, 2)*
$EFLH_{cool\ RAC}$	*= Equivalent Full Load Cooling hours for Room AC (Refer to EFLH table by climate zone in References Section VIII, A, 2)*
$F_{Room\ AC}$	*= 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[16]
$SEER_{CAC}$	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[17]

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.

[16] "State of Ohio Energy Efficiency Technical Reference Manual," prepared for the Public Utilities Commission of Ohio by Vermont Energy Investment Corporation. August 6, 2010.
[17] 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). $F_{Room,AC} = (425\ ft^2 * 2.1)/(2323\ ft^2) = 0.38$

Measure Lifetimes

Measure	Measure Lifetime
Roof Insulation	40
Cavity Insulation	40

Source: NYSERDA Home Performance with Energy Star.

Water Savings
There are no water savings for this measure.

4.1.5 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

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

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.

HDD_{62} = 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}	=	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.

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.[18]

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

Energy Savings

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

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

ΔkWh_{Cool} = 0 kWh if house has no air conditioning
= ΔkWh_{CAC} if house has central air conditioning
= 0 if house has room air conditioning
= 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[19]

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.

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

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

Equipment Type	Free Ridership	Spillover
Programmable Thermostat	0%	0%

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes

Equipment Type	Measure Lifetime
Programmable Thermostat	11

Source: UGI Phase II Electric Filing.

Water Savings
There are no water savings for this measure.

4.1.6 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 Refer to EFLH table by climate zone in References Section VIII, A, 2)
Th_{base}	=	Thickness of base condition insulation (inches)
Th_{bff}	=	Thickness of efficient condition insulation (inches)
HeatLoss(x)	=	Heat loss through duct work as a function of insulation thickness x (Btu/ft /yr)
AFUE	=	Rated AFUE of heating system. If no rating is available then use the method described in the Efficient Space Heating System section for calculating the AFUE. The AFUE of replacement equipment should be used if the heating system replacement precedes the duct work insulation.

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

Insulation Thickness (inches)	**Heat Loss (Btu/ft/yr)**
Bare	1,120,000
0.25	339,500
0.5	205,300
0.75	190,700
1	128,300
1.5	93,970
2	74,370
2.5	61,620
3	52,650
3.5	45,990
4	40,830

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

Item Description	=	bare duct
Calculation Type	=	Heat Loss Per Year Report
Geometry Description	=	Steel Duct - Rectangular Horz.
System Units	=	ASTM C585
Bare Surface Emittance	=	0.8
Process Temperature	=	140 °F
Ave. Ambient Temperature	=	41.8 °F[20]
Ave. Wind Speed	=	0 mph
Relative Humidity	=	N/A
Dew Point	=	N/A
Condensation Control Thickness	=	N/A

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

Hours Per Year	=	2000[21]
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
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.[22]

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

Energy Savings

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

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

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

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

$$\Delta kWh_{RAC} = 0$$

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
= 45% × ΔkW_{CAC} if no information about air conditioner

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

$$\Delta kW_{RAC} = 0$$

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)*

[21] 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
[22] Percentage of houses with air-conditioning from UGI data.

CDD	*= Cooling Degree Days (Degrees F * Days) See the Reference Tables section at the end of this document for projected CDD.*
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)*
$DE_{post(cool)}$	*= Distribution efficiency after duct insulating (See table for values)*
$DE_{pre(cool)}$	*= Distribution efficiency before duct insulating (See table for values. Default assumption is that ducts have no insulation before treatment)*
CF_{CAC}	*= Demand Coincidence Factor for central AC systems (See table below)*
$EFLH_{cool}$	*= Equivalent Full Load Cooling hours for Central AC and ASHP (See table below)*

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

Default values for algorithm terms, Duct Insulation

Term	Type	Value	Source
DUA	Fixed	0.75	OH TRM[23]
$SEER_{CAC}$	Variable	Default values: Early Replacement = 10 Replace on Burnout = 13	PUC Technical Reference Manual
		Nameplate	Contractor Data Gathering
CF_{CAC}	Fixed	0.70	PUC Technical Reference Manual

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

DUCT DISTRIBUTION EFFICIENCY FOR COOLING

INSULATION	*DE*[24]
R-0	64%
R-2	74%
R-4+	77%
R-8+	79%

EFLH

Location	$EFLH_{cool}$ (Hours)[25]
UGI Gas Territory	519

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[26].

4.1.7 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

[24] Distribution Efficiencies (DE) from Act 129 August 2019 TRM, Volume 2, p. 43 for average leakage ducts in attics.
[25] PA 2015 TRM Average of Harrisburg and Allentown for CAC.
[26] NYSERDA Home Performance with Energy Star

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

$$H_{Heat} = \frac{HDD \times 24}{Dt}$$

Where:

Length	=	Number of linear feet of heating pipe insulated
H_{heat}	=	Heating hours for a properly sized boiler. Used as an estimate of the hours in which the space-heating pipe would be hotter than the ambient temperature and would therefore experience heat loss.
Th_{base}	=	Thickness of base condition insulation (inches)
Th_{eff}	=	Thickness of efficient condition insulation (inches)
HeatLoss(x)	=	Heat loss through pipe as a function of insulation thickness x (Btu/ft /hr)
AFUE	=	Rated AFUE of heating system. If no rating is available then use the method described in the Efficient Space Heating System section for calculating the AFUE. The AFUE of replacement equipment should be used if the heating system replacement precedes the pipe insulation.
HDD	=	Base 63° F Heating Degree Days. See the Reference Tables section at the end of this document for projected HDD.
Dt	=	Design temperature difference (assume from 11° F to 70° F for properly sized boiler)[27] = 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

[27] 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	=	212
Ambient Temperature	=	60
Wind Speed	=	0
Nominal Pipe Size	=	2
Bare Metal	=	Copper
Bare Surface Emittance	=	0.6
Insulation Layer 1	=	850F Mineral Fiber PIPE, Type I, C547-11
Outer Jacket Material	=	All Service Jacket
Outer Surface Emittance	=	0.9

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

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

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

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes
The measure life is assumed to be 20 years[28].

[28] NYSERDA Home Performance with Energy Star

4.1.8 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.

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[29]

Repair made when duct run is outside conditioned space	**Pressure Pan Reading Reduction in Pascals (pa)**	**Deemed CFM 25 Net Reduction (CFMpre – CFMpost)[30]**
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	More than 2 pa	325

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

reconnection of disconnection		

Electric Savings Algorithms
Electric savings per 100 CFM-25 reduction:[31]

- 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[32].

4.1.9 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 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

[31] UI/CL&P Program Savigns Documentation, 2011, page 131
[32] California DEER estimate.

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.[33]

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

Energy Savings

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

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

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

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

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

Where:

ΔkWh = gross customer annual kWh savings for the measure.

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

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.*

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[34]
$SEER_{CAC}$	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

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

Term	Type	Value	Source
CF_{RAC}	Fixed	0.58	PUC Technical Reference Manual
$F_{Room,AC}$	Fixed	0.38	Calculated[35]

EFLH

Location	$EFLH_{cool}$ (Hours)[36]	$EFLH_{cool\ RAC}$ (Hours)[37]
UGI Gas Territory	519	161

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.

[35] 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). $F_{Room,AC} = (425\ ft^2 * 2.1)/(2323\ ft^2) = 0.38$
[36] PA 2015 TRM Average of Harrisburg and Allentown for CAC.
[37] PA 2015 TRM Average of Harrisburg and Allentown for RAC

4.2 Domestic Hot Water End Use

4.2.1 Low Flow Showerhead

Unique Measure Code(s): TBD
Draft date: 12/3/19
Effective date: TBD
End date: TBD

Measure Description
This measure relates to the installation of a low flow showerhead in a home. This is an early replacement 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[38].

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

$$\Delta Gallons = \frac{\left(GPM_{base} - GPM_{eff}\right) \times N_{persons} \times T_{person-day} \times N_{showers-day} \times 365 \times ISR}{N_{showerheads-home}}$$

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[39]
GPM_{eff}	=	Maximum gallons per minute of the efficient showerhead
$N_{persons}$	=	Average number of people per household. Actual or defaults: SF=2.5, MF=1.7, Unknown=2.5 [40]
$T_{person-day}$	=	Average minutes per person per day used for showering. 7.8 min/day [41]
$N_{showers-day}$	=	Average number of showers per person per day. 0.6 showers/person/day [42]
365	=	Days per year
ISR	=	In service rate. Kit Default = 35%. Direct install Default = 100%. [43]
$N_{showerheads-home}$	=	Average number of showers per home. Actual or defaults: SF=1.6, MF=1.1, Unknown=1.5 [44]

[38] Pennsylvania Public Utility Commission Act 129 Technical Reference Manual (August 2019)
[39] The Energy Policy Act of 1992 established the maximum flow rate for showerheads at 2.5 gallons per minute (GPM)
[40] Pennsylvania Public Utility Commission Act 129 Technical Reference Manual (August 2019)
[41] Ibid.
[42] Ibid.
[43] Ibid.
[44] Ibid.

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

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

Where:

$\Delta MMBtu$	=	MMBtu of saved natural gas
8.3	=	Constant to convert gallons to pounds (lbs.)
c_p	=	Average specific heat of water at temperature range (1.00 Btu/lb·°F)
T_{out}	=	Assumed temperature of water coming out of showerhead (degrees Fahrenheit) 101 °F
T_{in}	=	Assumed temperature of water entering house (degrees Fahrenheit) 52 °F
RE_{DHW}	=	Recovery efficiency of the domestic hot water heater = 75%[45]

Electric Savings Algorithms
It is assumed that all low flow showerheads 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[46].

4.2.2 Low Flow Faucet Aerators

Unique Measure Code(s): TBD
Draft date: 12/3/19
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.

[45] 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).
[46] 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[47].

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).

$$\Delta Gallons = \frac{(GPM_{base} - GPM_{eff}) \times N_{persons} \times T_{person-day} \times DF \times 365 \times ISR}{N_{faucets-home}}$$

Where:

$\Delta Gallons$	=	Gallons of water saved
GPM_{base}	=	Gallons per minute of baseline aerator = 2.2 GMP[48]
GPM_{eff}	=	Gallons per minute of the efficient aerator
$N_{persons}$	=	Average number of people per household. Actual or Defaults: SF=2.5, MF=1.7, Unknown=2.5[49]
$T_{person-day}$	=	Average minutes per person per day of faucet hot water usage. Kitchen=4.5, Bathroom=1.6, Unknown=6.1[50]
365	=	Days per year
DF	=	Drain rate, the percentage of water flowing down the drain. Kitchen=75%, Bathroom=90%, Unknown=79.5%[51]
ISR	=	In service rate. Kit delivery default = 28%, Direct install default = 100%[52]
$N_{faucets-home}$	=	Average Number of Faucets per home. Actual or for defaults see table below.

Average Number of Faucets per Home[53]

Faucet Type	Single Family	Multifamily	Unknown
Kitchen	1.1	1.0	1.0
Bathroom	2.2	1.2	2.0
Unknown	3.3	2.2	3.0

Natural Gas Savings Algorithms

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

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

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)

[47] Pennsylvania Public Utility Commission Act 129 Technical Reference Manual (August 2019)
[48] Ibid
[49] Ibid
[50] Ibid
[51] Ibid
[52] Ibid
[53] Ibid

T_{out}	=	Average mixed water temperature flowing from the faucet (degrees Fahrenheit) Kitchen=93 °F, Bathroom=86 °F, Unknown=87.8 °F [54]
T_{in}	=	Assumed temperature of water entering house (degrees Fahrenheit) 52 °F [55]
RE_{DHW}	=	Recovery efficiency of the domestic hot water heater = 75%[56]

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

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

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes
The measure life of a faucet aerator is assumed to be 10 years[57].

4.2.3 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 uniform energy factor (UEF) of the existing water heater. If possible, the UEF of the existing water heater should be used. If the UEF of the existing water heater is unknown, 0.575 should be used[58] The EF of the existing water heater may be used in place of the UEF, if the UEF of the existing water heater is unknown.

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 (*V*)
Very Small	$0 \le GPM < 1.7$	10
Low	$1.7 \le GPM < 2.8$	38
Medium	$2.8 \le GPM < 4.0$	55
High	$4.0 \le GPM$	84

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

54 Pennsylvania Public Utility Commission Act 129 Technical Reference Manual (August 2019)
55 Ibid
56 See assumption for low flow shower head.
57 Pennsylvania Public Utility Commission Act 129 Technical Reference Manual (August 2019)
58 From Mass Save "Massachusetts Technical Reference Manual for Estimating Savings from Energy Efficiency Measures: 2011 Program Year – Plan Version." October 2010. Page 242.

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 (UEF) of the new equipment. MMBtu savings vary by equipment type due to differences in model specific baseline UEF and high efficiency UEF 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.

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

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

Electric Savings Algorithms
It is assumed that all installed water heaters 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

Equipment Type	Measure Lifetime
Storage Water Heater	15[59]
Tankless Water Heater	20[60]

[59] DEER values, updated October 10, 2008
http://www.deeresources.com/deer0911planning/downloads/EUL_Summary_10-1-08.xls
[60] Energy Star Residential Water Heaters: Final Criteria Analysis, April 1, 2008, p. 10.

4.2.4 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
R_{DHW}	=	R-value of the hot water heater (h °F ft^2/Btu) = 5.0[61]
8,760	=	Number of hours in a year
RE_{DHW}	=	Recovery efficiency of the domestic hot water heater = 75%[62]
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.

[61] 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
[62] See assumption for low flow showerhead.

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

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

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

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

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes
The measure life of temperature reduction in a natural gas water heater is assumed to be 2 years[63].

4.2.5 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.

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

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

Slow Steady Drip	100 drips	14.4*
Fast Drip	200 drips	28.8*
Small Stream	1 cup (8 fl oz)	89.28

** A drip is assumed to be 0.0001 gallons*[64]

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)[65]
RE_{DHW}	=	Recovery efficiency of the domestic hot water heater = 75%[66]

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.

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

[65] 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

[66] 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

4.2.6 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.[67]

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 UGI or their implementation contractor for judgment.

Water Savings Algorithms

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

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_{bff}	=	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%[68]

“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

[68] See assumption for low flow showerhead.

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[69].

4.2.7 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."[70]

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

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

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

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

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[69] NYSERDA Home Performance with Energy Star
[70] 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[71] 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[72]
8,760	=	Number of hours in a year
RE_{DHW}	=	Recovery efficiency of the domestic hot water heater = 75%[73]
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.

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71 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

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

73 See assumption for low flow showerhead.

Measure Lifetimes
The measure life is assumed to be 5 years[74].

4.3 Combined Space and Domestic Hot Water Usage

4.3.1 Combination Boiler - Space Heating and DHW

Unique Measure Code(s): TBD
Draft date: 12/3/19
Effective date: TBD
End date: TBD

Measure Description
This measure applies to residential-sized combination boilers replacing existing and functioning boilers and water heaters. 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 (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.

The water heater baseline is the uniform energy factor (UEF) of the existing water heater. If possible, the UEF of the existing water heater should be used. If the UEF of the existing water heater is unknown, 0.575 should be used[75] The EF of the existing water heater may be used in place of the UEF, if the UEF of the existing water heater is unknown.

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 (*V*)

[74] Northeast Energy Efficiency Partnerships. *Mid-Atlantic Technical Reference Manual (Version 1.1)*. October 2010
[75] From Mass Save "Massachusetts Technical Reference Manual for Estimating Savings from Energy Efficiency Measures: 2011 Program Year – Plan Version." October 2010. Page 242.

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

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 UEF

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

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

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

Where:

Annual Gas Savings$_{SH}$ = Space heating annual gas savings (MMBtu)
Annual Gas Savings$_{DHW}$ = Domestic Hot Water annual gas savings (MMBtu)

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)

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

Heating Use weather normalization methods (HeatingUse):

Method 1: Use a linear regression model of use/day as a function of HDD63[76]/day to estimate heating slope (MMbtu/HDD63) and baseload daily use (MMBtu/day) 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 * (HDD63projected/HDD63actual).

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

$$Annual\ Gas\ Savings_{DHW} = \frac{\left(\frac{1}{UEF_{Base}} - \frac{1}{UEF_{Eff}}\right) \times V \times \rho \times c_p \times 67 \times 365}{1{,}000{,}000}$$

Where:

UEF_{Base}	=	Uniform Energy Factor of existing baseline water heater
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

Electric Savings Algorithms

Energy Savings

ΔkWh = 0 kWh

Demand Savings

ΔkW = 0 kW

Where:

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

Freeridership/Spillover

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

[76] 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.

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

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes

Equipment Type	Measure Lifetime
Gas Combi Boiler	20

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

Water Savings
There are no water savings for this measure.

4.4 All End Uses

4.4.1 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[77]/day to estimate heating slope (MMbtu/HDD63) and baseload daily use (MMBtu/day) with an annual projected HDD63 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 * (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

[77] 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.

There are no water savings for this measure.

5 Non-Residential Time of Replacement Market

5.1 Space Heating End Use

5.1.1 Efficient Boiler

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[78]
Gas Boiler – ENERGY STAR®	94%

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

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

Where:

$Capacity_{Out}$ = Output capacity of equipment to be installed (kBtu/hr)

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

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[79]
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.

Water Savings

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

There are no water savings for this measure.

5.1.2 Efficient Unit Heater and Infrared Heater

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%)[80]
If the efficient heater is not an infrared heater then the UF = 100%.
$EFLH_{Heat}$ = Equivalent Full Load Heating Hours

Equivalent Full Load Heating Hours by Building Type

Building Type	EFLH[81]
Multifamily	1663

[80] Based on 25% savings assumption for infrared heater compared to conventional unit heater from Massachusetts and Connecticut technical reference manuals as of June 2016.
[81] From NJ Protocols for Philadelphia, adjusted for the PGW evaluation and UGI Gas territory relative HDD.

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.

5.1.3 Steam Trap

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)[82]	Heat of Vaporization Hv (Btu/lb)[83]	Default Boiler Efficiency B[84]	Operating Hours, H[85]	Adjustment Factor, A[86]	Leaking & Blow-thru factor for unaudited traps, L[87]
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.

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

[83] 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.

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

[85] 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.

[86] 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.

[87] 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[88]

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

[88] 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.

5.2 Commercial Kitchen End Uses

5.2.1 Commercial Convection Ovens

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[89].

Definition of Efficient Condition
Cooking energy efficiency greater than or equal to 46%[90] 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.[91]

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

[89] ENERGY STAR calculator default input.
[90] Using ASTM Standard F1496-99 (Reapproved 2005) based on heavy load (potato) cooking test.
[91] 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

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.

5.2.2 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.[92]

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.[93]

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[94]

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.[95]

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

[92] ENERGY STAR calculator default input.
[93] ENERGY STAR Commercial Ovens Key Product Criteria http://www.energystar.gov/index.cfm?c=ovens.pr_crit_comm_ovens
[94] 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
[95] 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} * ($EFOOD_{SteamGas}$ / $GasEFF_{SteamBase}$ – $EFOOD_{SteamGas}$ / $GasEFF_{SteamEE}$) * $\%_{Steam}$

$\Delta IdleEnergy_{ConvGas}$ = [($GasIDLE_{ConvBase}$ * ((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}/$GasPC_{SteamEE}$) * $\%_{Steam}$))]

Where:

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

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

$\Delta IdleEnergy_{ConvGas}$ = 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.

5.2.3 Commercial Gas Fryer

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.[96]

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
$\Delta kWh = 0\ kWh$

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

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 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.

5.2.4 Commercial Gas Steamers (Cooking)

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[97].

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.[98]

# of Pans	Annual Gas Savings (MMBtu)
3 pans	76.6
4 pans	86.4
5 pans	96.2
6 pans	105.4
7 + pans	105.4+ 14.2 per pan > 6 pans

Electric Savings Algorithms

There are no electric savings from this measure.

Energy Savings
ΔkWh = 0 kWh

Demand Savings

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

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

$\Delta kW = 0\ kW$

Where:

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

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

Equipment Type	Free Ridership	Spillover
Commercial Steam Cooker	0%	0%

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes

Equipment Type	Measure Lifetime
Commercial Steam Cooker	12

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

Water Savings
According to the Energy Star calculator the water savings would be 162,060 gallons per year for an Energy Star steamer compared to a baseline steamer.

5.2.5 Commercial Gas Griddle

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[99].

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 and the Mid-Atlantic Technical Reference Manual, Version 8.[100]

$$\Delta MMBtu = MMBTU_{base} - MMBTU_{eff}$$
$$MMBTU_i = (MMMBTU\_Cooking_i + MMBTU\_Idle_i) \times DAYS$$
$$MMBTU\_Cooking_i = \frac{LB \times E_{Food}}{EFF_i}$$
$$MMBTU\_Idle_i = IDLE_i \times SIZE \times [HOURS_{Day} - \frac{LB}{PC_i \times SIZE}]$$

Where:

$\Delta MMBtu$	=	MMBtu of saved gas per year
$MMBTU_{base}$	=	Baseline gas usage (MMBtu)
$MMBTU_{eff}$	=	Efficient gas usage (MMBtu)
$MMBTU\_Cooking_i$	=	Daily cooking energy consumption (MMBTU)
$MMBTU\_Idle_i$	=	Daily idle energy consumption (MMBTU)
$DAYS$	=	Days per year in operation. Default 365 days.
LB	=	Pounds of food cooked per day (lb/day). Default 100 lbs/day.
E_{Food}	=	ASTM Energy to Food. The amount of energy absorbed by the food during cooking per pound of food. (0.000475 MMBTU/lb)
EFF_i	=	Heavy load cooking energy efficiency (%)
$IDLE_i$	=	Idle energy rate (MMBTU/hr/ft^2)
$SIZE$	=	Size of the griddle surface (ft^2)
$HOURS_{Day}$	=	Average daily operating hours. Default 12 hours/day.
PC_i	=	Production Capacity (lb/hr/ ft^2)
SLR_b	=	Baseline water heater standby loss rate (Btu/hr)

[99] From the Energy Star calculator

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

Gas Griddle Performance Metrics: Baseline and Efficient Values

Parameter	Baseline	Efficient
IDLE (MMBTU/hr/ ft^2)	0.00350	0.00265
EFF	32%	38%
PC (lb/hr/ ft^2)	4.17	7.50

Electric Savings Algorithms

There are no electric savings from this measure.

Energy Savings

ΔkWh = 0 kWh

Demand Savings

ΔkW = 0 kW

Where:

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

Freeridership/Spillover

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

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

Persistence

The persistence factor is assumed to be one.

Measure Lifetimes

Equipment Type	Measure Lifetime
Commercial Gas Griddle	12

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

Water Savings

There are no water savings for this measure.

6.1.1 Pre-rinse Spray Valve

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.[101]

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

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%

[101] 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[102]

Water Savings
Expected water savings would be 62,305 gallons per year.[103]

6.1.2 Commercial Dishwashers

Unique Measure Code(s): TBD
Draft date: 9/18/19
Effective date: TBD
End date: TBD

Measure Description
ENERGY STAR commercial dishwashers installed in a commercial kitchen using natural gas to heat both the building's water and booster heater, if applicable for the machine type.

Definition of Baseline Condition
A commercial dishwasher that is not ENERGY STAR certified.

Definition of Efficient Condition
Commercial ENERGY STAR certified dishwashers meeting idle energy rate and water consumption limits by machine type.

Gas Savings Algorithms
The following shows the expected gas savings from a commercial ENERGY STAR dishwasher with the hot water heated by natural gas. These savings come from the Illinois Technical Reference Manual, Version 7, p. 44.

Dishwasher type		MMBtu Baseline	MMBtu ESTAR	MMBtu Savings
Low Temp	Under Counter	34.0	23.4	10.6
	Stationary Single Tank Door	154.3	86.7	67.6
	Single Tank Conveyor	137.5	82.9	54.6
	Multi Tank Conveyor	163.7	85.0	78.7
	Under Counter	33.7	26.6	7.1

[102] Massachusetts 2011 Technical Reference Manual.
[103] Massachusetts 2011 Technical Reference Manual.

High Temp	Stationary Single Tank Door	148.9	102.7	46.2
	Single Tank Conveyor	143.5	115.4	28.0
	Multi Tank Conveyor	239.9	133.6	106.4
	Pot, Pan, and Utensil	80.8	66.9	13.9

Electric Savings Algorithms

The following electric savings account for only idle energy, since the dishwasher is assumed to use natural gas for heating the water.

Dishwasher type		ΔkWh[104]	CF	ΔkW[105]
Low Temp	Under Counter	0	0.9	-
	Stationary Single Tank Door	0	0.9	-
	Single Tank Conveyor	584	0.9	0.08
	Multi Tank Conveyor	0	0.9	-
High Temp	Under Counter	1471	0.9	0.20
	Stationary Single Tank Door	827	0.9	0.11
	Single Tank Conveyor	2511	0.9	0.34
	Multi Tank Conveyor	1986	0.9	0.27
	Pot, Pan, and Utensil	0	0.9	-

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 Dishwasher	0%	0%

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes

Dishwasher type	Equipment Life

104 From the Act 129 TRM for idle energy savings.
105 Based on 18 hours per day and 365 days operation and a coincidence factor of 0.9 from the Act 129 TRM.

Low Temp	Under Counter	10
	Stationary Single Tank Door	15
	Single Tank Conveyor	20
	Multi Tank Conveyor	20
High Temp	Under Counter	10
	Stationary Single Tank Door	15
	Single Tank Conveyor	20
	Multi Tank Conveyor	20
	Pot, Pan, and Utensil	10

Source: Illinois Technical Reference Manual, Version 7 and ENERGY STAR Commercial Kitchen Equipment Savings Calculator.

Water Savings
The following table shows water savings by type of dishwasher.

Dishwasher type		Gallons Baseline	Gallons ESTAR	Gallons Savings
Low Temp	Under Counter	47,391	32,599	14,793
	Stationary Single Tank Door	214,767	120,679	94,088
	Single Tank Conveyor	191,391	115,419	75,972
	Multi Tank Conveyor	227,916	118,341	109,575
High Temp	Under Counter	29,859	23,559	6,301
	Stationary Single Tank Door	131,928	91,020	40,908
	Single Tank Conveyor	127,107	102,270	24,837
	Multi Tank Conveyor	212,576	118,341	94,235
	Pot, Pan, and Utensil	71,589	59,317	12,272

7.1 Commercial Domestic Hot Water End Use

7.1.1 Commercial Domestic Hot Water Heater

Unique Measure Code(s): TBD
Draft date: 12/4/17
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:
The maximum of:

$$BaselineUse = U \times E_b$$

or

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

All building types:

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

$$SLR_b = CAP_{H,b} \times \frac{1000}{800} + 110 \times \sqrt{CAP_{W,b}}$$ [106]

[106] ASHRAE 90.1-2007, Table 7.8.

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

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%)[107]
$CAP_{H,e}$	=	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)[108]
Education	0.00525
Grocery/Convenience Store	0.00319
Restaurant/Cafeteria	0.03996
Inpatient Health Care	0.03935
Outpatient Health Care	0.00350
Lodging	0.02915
Retail (other than in mall)	0.00103
Retail (in mall)	0.00309
Office	0.00165
Police/Fire Station/Jail	0.01514
Other	0.00165

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

	Annual Baseline Gas Usage Rate, E_b (MMBtu/unit/yr)[109]
Multifamily	22.5

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 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 Heater	15

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

Water Savings

There are no water savings for this measure.

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

7.2 All End Uses

7.2.1 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. This includes measures that may be in the TRM but are used in atypical ways and also includes multiple measures that may have interactive effects when combined.

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. Baseline and efficient usages may be determined by either engineering equations or modeling software.

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

Where:

BaselineUse = The gas usage of baseline equipment or building.

EfficientUse = The gas usage of efficient equipment or building.

Electric Savings Algorithms

Energy Savings
ΔkWh = *BaselinekWh* - *EfficientkWh*

Demand Savings
ΔkW = *BaselinekW* - *EfficientkW*

Where:

ΔkWh = Gross customer annual kWh savings for the measure.

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

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

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

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

Equipment Type	Free Ridership	Spillover
Custom Measure	0%	0%

Persistence
The persistence factor is assumed to be one.

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

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

8 Non-Residential New Construction

8.1 All End Uses

8.1.1 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. New construction is defined as the construction of a new "greenfield" building, or the major renovation of an existing building.

Definition of Baseline Condition
The baseline represents the typical building constructed in the absence of a DSM program. The baseline efficiency level is a minimally code compliant structure incorporating current Federal standards, or state and local building codes that are applicable. In most cases this is equivalent to ASHRAE 90.1.

Definition of Efficient Condition
The efficient building is one constructed to a higher standard, which may include higher efficiency equipment, increased insulation, better fenestration, advanced building controls or other measures that reduce overall energy usage in comparison to the baseline minimally code compliant building.

Gas Savings Algorithms
The generalized equation for a custom measure compares the baseline usage to the efficient usage. This will likely be determined using building modeling software.

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

Where:

BaselineUse = The gas usage of baseline equipment or building.

EfficientUse = The gas usage of efficient equipment or building.

Electric Savings Algorithms

Energy Savings
ΔkWh = *BaselinekWh* - *EfficientkWh*

Demand Savings
ΔkW = *BaselinekW* - *EfficientkW*

Where:

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

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

Equipment Type	Free Ridership	Spillover
Custom Measure	0%	0%

Persistence
The persistence factor is assumed to be one.

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

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

9 Non-Residential Early Replacement

9.1 Space Heating End Use

9.1.1 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.[110]

[110] 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.

9.2 All End Uses

9.2.1 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 early replacement or retrofit measures, not otherwise specified in this TRM.

Definition of Baseline Condition
The baseline represents the existing equipment that is currently installed. The efficiency level is based on measurements or nameplate information.

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

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

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

Where:

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

Electric Savings Algorithms

Energy Savings
ΔkWh = *BaselinekWh* - *EfficientkWh*

Demand Savings
ΔkW = *BaselinekW* - *EfficientkW*

Where:

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

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

Equipment Type	Free Ridership	Spillover
Custom Measure	0%	0%

Persistence
The persistence factor is assumed to be one.

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

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

10 Reference Tables

10.1 Residential

10.1.1 HDD & CDD

Heating Degree Days and Cooling Degree Days

Territory	HDD63	HDD62	CDD
Allentown	6,683	6,413	773
Binghamton, NY	5,350	5,110	405
Bradford	4,703	4,481	204
Erie	3,951	3,747	579
Harrisburg	4,512	4,294	1,121
Philadelphia	5,217	4,980	1,184
Pittsburgh	6,686	6,418	726
Scranton	5,054	4,830	608
Williamsport	5,477	5,241	759
Weighted Avg UGI	4,847	4,620	832

Sources: DegreeDays.net 2017-2019 for HDD. Act 129 August 2019 TRM, Appendix A for CDD.

10.1.2 Heating and Cooling EFLH

Heating and Cooling Equivalent Full Load Heating Hours

Reference Location	Zone	Coincidence Factor (CF)	Cooling EFLH Central Air Conditioner	Cooling EFLH Room Air Conditioner or Secondary Zone	Heating EFLH for non-HP (Fossil Fuel Furnace or Boiler)
Allentown	C	0.35	575	178	906
Binghamton, NY	A	0.27	333	103	1,152
Bradford	G	0.22	206	64	1,347
Erie	I	0.27	468	145	1,054
Harrisburg	E	0.45	731	227	997
Philadelphia	D	0.42	781	242	761
Pittsburgh	H	0.37	544	169	942
Scranton	B	0.33	474	147	1,000
Williamsport	F	0.39	559	173	935
Weighted Avg UGI		0.37	593	184	925

Source: Act 129 August 2019 TRM, Appendix A
Notes: ZIP codes associated with each PA climate zone may be found in the Act 129 August 2019 TRM, Appendix A, tab "Zip code lookup table."