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June 4, 2021

Via Electronic Filing
Rosemary Chiavetta, Secretary
PA Public Utility Commission
P.O. Box 3265
Harrisburg, PA 17105-3265

Re: Petition of Philadelphia Gas Works for Approval of Demand-Side Management Plan for FY 2021-2023
Philadelphia Gas Works Universal Service and Energy Conservation Plan for 2014-2016; 52 Pa. Code § 62.4 – Request for Waivers – Docket No. P-2014-2459362

Dear Secretary Chiavetta:

Pursuant to the Joint Petition for Settlement that was approved by the Commission's May 6, 2021 Order, enclosed for electronic filing please find Philadelphia Gas Works' ("PGW") Revised EnergySense Demand Side Management Portfolio Implementation Plan, Fiscal Years 2021-2023, in the above-referenced matter. Copies to be served in accordance with the attached Certificate of Service.

Sincerely,

/s/ *Lauren M. Burge*
Lauren M. Burge, Esq.

cc: Hon. F. Joseph Brady w/enc.
Cert. of Service with enc.

CERTIFICATE OF SERVICE

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

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Dated: June 4, 2021

PHILADELPHIA GAS WORKS

ENERGYSENSE DEMAND SIDE MANAGEMENT PORTFOLIO

REVISED IMPLEMENTATION PLAN

FISCAL YEARS 2021-2023

ORIGINALLY FILED: MAY 6, 2020

REVISED: JUNE 4, 2021

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I. DSM PORTFOLIO IMPLEMENTATION PLAN

A. Introduction

PGW's Demand Side Management ("DSM") portfolio, marketed as EnergySense, is a portfolio of conservation programs that PGW launched in fiscal year 2011 and was initially approved by the PUC for a 5-year term. On December 23, 2014, PGW filed a Petition for Approval of Demand Side Management Plan 2016-2020 ("DSM Phase II") with the PUC. The PUC subsequently approved a DSM Bridge Plan for an interim period effective September 1, 2015, through the earlier of the effective date of the Phase II Plan or August 31, 2016. On November 1, 2016 the PUC entered a final opinion and order at docket P-2014-2459362 ("Final Order") that approved the continuation of five market rate DSM programs from FY 2017 – FY 2020.

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

The following plan ("Implementation Plan") describes program budgets and implementation details that Philadelphia Gas Works ("PGW" or "the Company") will follow to implement its EnergySense Demand-Side Management Portfolio ("DSM Portfolio") in Fiscal Years 2021 through 2023.

PGW's DSM Portfolio will be implemented to achieve three broad goals:

1. Reduce customer bills.
2. Maximize customer value.
3. Help the Commonwealth and the City of Philadelphia reduce greenhouse gas emissions and reduce PGW's overall carbon footprint.

The period of time covered by this Implementation Plan is September 1, 2020 to August 31, 2023, spanning FY 2021, FY 2022, and FY 2023. PGW will continue to file its annual report four months after the close of the fiscal year. PGW will file an amended implementation plan four months prior to the upcoming fiscal year, if necessary, to propose major program changes that would modify the portfolio budget caps from the plans documented herein.[1]

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

B. New Features and DSM Portfolio Updates

1. Program Simplification and Expanded Offerings

PGW has decided to revise its incentive structure and adopt a more simplified approach. PGW will end the Efficient Building Grants ("EBG") and Efficient Construction Grants for commercial/multifamily customers ("CMCG"), with a brief wind-down period in FY 2021 to pay grants for projects approved in Phase II. This change is necessitated by the challenges encountered in Phase II, including low participation and a high level of administrative review and customer effort that resulted in higher program and participant costs. Furthermore, the increase in commercial building code standards, from the 2009 International Energy Conservation Code ("IECC") to the 2015 and 2018 IECC, was also a driver to discontinue the CMCG program since the new building standards will increase building energy efficiency and lead to reduced energy savings options for each building to pursue under the PGW EBG or CMCG programs.

Under its new approach, PGW will launch new prescriptive offerings for the most common cost-effective measures that had been pursued in EBG and CMCG projects. Each efficiency measure is grouped into a measure category. Commercial and multifamily projects that incorporate measures from numerous categories will have higher incentive caps than projects with measures drawn from just one category. This approach will incentivize customers to pursue deep energy-savings projects and address multiple gas end uses in order to achieve higher rebates. The new design also instills rebate predictability for the customer.

Measure Categories	Incentive Cap
1	$25,000
2	$35,000
3	$50,000

Measure Category	Measure
Heating Equipment	Residential Furnace
	Residential Boiler
	Combi Boiler
	Low-Intensity Infrared Heater
	Commercial Boiler
Water Heating	Tankless Residential Water Heater
	Low-flow Faucet Aerator
	Low-flow Showerhead
	Commercial Water Heater (Storage)
	Commercial Water Heater (Tankless)
Building Controls & Distribution	ENERGY STAR® Smart Thermostat
	Steam Trap
	Boiler Reset Controls
Commercial Cooking	Fryer
	Steam Cooker
Commercial Building Envelope	Roof Insulation

As part of the wind-down process mentioned above, PGW will honor its signed grant agreements for EBG and CMCG projects currently underway that will be completed within one year of the agreement date. This policy aims to meet customer expectations, recognizing that customers made equipment purchase decisions for projects with long lead times based on PGW's incentives. PGW has instituted deadlines for this wind-down phase, as indicated in Section II.D.

PGW will also adjust some incentive amounts for residential and commercial rebates, and increase efficiency requirements for some equipment. PGW will institute a grandfathering policy for rebate programs to ensure that customers don't become ineligible between the time they purchase equipment and submit a rebate application. Eligibility and rebate amount will be based on equipment purchase date, following similar approaches used when changing rebate amounts in the past.

2. Incentive Award Caps

Along with the per-project incentive caps outlined in the section above, PGW will limit the amount awarded to an individual customer to $150,000 per year.

3. Smart Thermostat Marketplace

PGW will implement an online Smart Thermostat Marketplace ("Marketplace") program to offer direct-to-consumer sales of smart thermostats, discounted to approximately $30 - $130 by instant rebates. The marketplace will give PGW customers access to a low-cost efficiency measure that can be installed in most homes and is estimated to save 8% on heating usage. This initiative will be implemented through a marketplace vendor, an approach that has successfully been implemented elsewhere in Pennsylvania by electric and natural gas utilities.

4. Targeted Low Income Incentives

Pursuant to PUC approved settlement, in FY 2022 and FY 2023 PGW will offer targeted low-income incentives as part of the EnergySense portfolio. Such incentives include offering higher rebate amounts for a limited number of low-income customers that participate in the Residential Equipment Rebates program, as well as the direct installation of no-cost smart thermostats in eligible customers' homes.

5. Stakeholder Meetings

PGW will convene one stakeholder meeting to allow stakeholders to discuss implementation concerns related to the COVID-19 pandemic.

At least three (3) months in advance of filing an extension of its current DSM plan, a revised DSM plan, or a new DSM or energy efficiency and conservation plan, PGW will host a collaborative meeting with interested parties to review participation rates and discuss changes to the DSM low-income programming set forth in this current plan.

C. Portfolio Budgets, Savings, and Cost-Effectiveness

1. Budgets[2]

The following are PGW's budgets for the periods beginning in FY 2021 and running through FY 2023.

Table 1 – Projected Portfolio Budget by Program (Nominal)

Program	FY 2021	FY 2022	FY 2023	FY 2021 – FY 2023
Residential Equipment Rebates	$659,043	$835,313	$786,579	$2,280,934
Residential Construction Grants	$181,456	$179,305	$229,464	$590,224
Commercial Equipment Rebates	$320,727	$396,425	$342,582	$1,059,734
Efficient Building & Commercial Construction Grant Wind-down	$212,667	-	-	$212,667
Smart Thermostat Marketplace	$215,446	$233,972	$235,639	$685,057
Low-Income Smart Thermostat	-	$60,000	$60,000	$120,000
Porfolio-wide Costs	$715,000	$710,130	$731,414	$2,156,544
Total	**$2,304,338**	**$2,415,144**	**$2,385,677**	**$7,105,159**

2 Portfolio-wide costs only include costs for the EnergySense portfolio described herein. In the FY 2017 – FY 2020 DSM Phase II Compliance Plan, the Portfolio-wide costs budget category were partially attributed to the Home Comfort program, PGW's LIURP. Under that plan, costs were allocated proportionally between the EnergySense portfolio and Home Comfort.

Table 2 – Projected Portfolio Budget by Cost Category (Nominal)

Category	FY 2021	FY 2022	FY 2023	FY 2021 – FY 2023
Customer Incentives	$1,344,550	$1,344,550	$1,344,550	$4,033,650
Market Rate	*$1,344,550*	*$925,540*	*$925,540*	*$3,195,630*
Low Income	-	*$419,010*	*$419,010*	*$838,020*
Administration	$533,381	$537,695	$562,670	$1,633,747
Marketing	$360,000	$360,000	$360,000	$1,080,000
Inspections	$66,406	$67,900	$68,457	$202,763
Evaluation	-	$105,000	$50,000	$155,000
Total	**$2,304,338**	**$2,415,144**	**$2,385,677**	**$7,105,159**

2. Savings

a) Gas savings

Table 3 – Projected Annual Natural Gas Savings (MMBtu)

Program	FY 2021	FY 2022	FY 2023	FY 2021 – FY 2023
Residential Equipment Rebates	14,590	13,099	13,099	40,788
Market Rate	*14,590*	*7,025*	*7,025*	*28,640*
Low Income	-	*6,074*	*6,074*	*12,148*
Residential Construction Grants	1,910	1,910	1,910	5,730
Commercial Equipment Rebates	23,284	24,015	24,015	71,313
Efficient Building & Commercial Construction Grants Wind-down	8,088	-	-	8,088
Smart Thermostat Marketplace	10,692	11,699	11,699	34,089
Low-Income Smart Thermostat	-	1,477	1,477	2,955
Total	**58,563**	**52,200**	**52,200**	**162,963**

Table 4 – Projected Lifetime Natural Gas Savings (MMBtu)

Program	FY 2021	FY 2022	FY 2023	FY 2021 – FY 2023
Residential Equipment Rebates	301,550	271,388	271,388	844,325
Market Rate	*301,550*	*144,402*	*144,402*	*590,353*
Low Income	-	*126,986*	*126,986*	*253,972*
Residential Construction Grants	38,200	38,200	38,200	114,600
Commercial Equipment Rebates	420,521	438,311	438,311	1,297,143
Efficient Building & Commercial Construction Grant Wind-down	168,958	-	-	168,958
Smart Thermostat Marketplace	117,607	128,685	128,685	374,977
Low-Income Smart Thermostat	-	16,252	16,252	32,503
Total	**1,046,836**	**892,835**	**892,835**	**2,832,507**

b) Non-Gas Savings

Table 5 – Projected Incremental Annual Electricity Savings (MWh)

Program	FY 2021	FY 2022	FY 2023	FY 2021 – FY 2023
Residential Equipment Rebates	-	-	-	-
Residential Construction Grants	0	0	0	1
Commercial Equipment Rebates	3	4	4	11
Efficient Building & Commercial Construction Grants Wind-down	9	-	-	9
Smart Thermostat Marketplace	266	293	293	852
Low-Income Smart Thermostat	-	47	47	93
Total	**278**	**344**	**344**	**966**

Table 6 – Projected Incremental Lifetime Electricity Savings (MWh)

Program	FY 2021	FY 2022	FY 2023	FY 2021 – FY 2023
Residential Equipment Rebates	-	-	-	-
Residential Construction Grants	5	5	5	14
Commercial Equipment Rebates	120	160	160	440
Efficient Building & Commercial Construction Grant Wind-down	193	-	-	193
Smart Thermostat Marketplace	2,930	3,220	3,220	9,370
Low-Income Smart Thermostat	-	513	513	1,027
Total	**3,248**	**3,898**	**3,898**	**11,044**

Table 7 – Projected Incremental Annual Water Savings (Millions of Gallons)

Program	FY 2021	FY 2022	FY 2023	FY 2021 – FY 2023
Residential Equipment Rebates	-	-	-	-
Residential Construction Grants	1	1	1	2
Commercial Equipment Rebates	7	7	7	21
Efficient Building & Commercial Construction Grant Wind-down	1	-	-	1
Smart Thermostat Marketplace	-	-	-	-
Low-Income Smart Thermostat	-	-	-	-
Total	**9**	**8**	**8**	**24**

3. Cost-Effectiveness

Table 8 presents PGW's projected cost-effectiveness results. PGW estimates that under the Total Resource Cost ("TRC") test, the programs have a combined present value ("PV") of net benefits, in 2020 dollars, of $11.1 million with a benefit cost ratio ("BCR") of 2.14.

a) Projected Performance

Table 8 – Projected Cost-Effectiveness Results (2020$)

Program	TRC PV Benefits	TRC PV Costs	TRC PV Net Benefits	TRC BCR
Residential Equipment Rebates	$5,377,516	$2,993,084	$2,384,432	1.80
Residential Construction Grants	$1,087,216	$664,817	$422,399	1.64
Commercial Equipment Rebates	$9,401,892	$2,320,698	$7,081,193	4.05
Efficient Building & Commercial Construction Grants Wind-down	$1,237,963	$657,307	$580,656	1.88
Smart Thermostat Marketplace	$3,571,504	$1,083,170	$2,488,333	3.30
Low-Income Smart Thermostat	$324,851	$111,427	$213,423	2.92
Portfolio-wide Costs	-	$1,989,499	$(1,989,499)	-
Total Portfolio	**$21,000,941**	**$9,820,002**	**$11,180,938**	**2.14**

D. Portfolio Implementation and Management

PGW staff will continue their strategic planning and management of the EnergySense portfolio. Day-to-day administration of the programs will continue to be conducted by a portfolio implementation consultant firm or firms. Vendors will fulfill the following roles:

- Market-rate Program Implementer – in this role, the vendor will be responsible for application intake and processing, verification of customer information and eligibility, issuance of rebates, and reporting of program activity to PGW.
- Technical Assistance Provider – in this role, the vendor will be responsible for engineering and project analysis and project inspections.
- Marketing and Outreach Support Provider – in this role, the vendor will work with PGW to develop and implement communications strategies to promote EnergySense programs and drive customer participation.
- Low-Income Smart Thermostat Provider – in this role, the vendor will be responsible for performing outreach to low-income populations, qualifying program participants, and installing smart thermostats in eligible homes.

E. Coordination Activities

PGW continually seeks to coordinate EnergySense efforts as much as possible with other organizations and programs in order to leverage existing resources and avoid lost opportunities and duplication of services. PGW expects to continue the following coordination activities (subject to modification):

Program or Organization and Description of Coordination
ENERGY STAR® PGW is an ENERGY STAR Energy Efficiency Program Sponsor, which has allowed it to be included in its national registries of rebates and incentives and get updates on ENERGY STAR equipment activities. The coordination has been useful to promote the CER commercial food service rebates for ENERGY STAR rated equipment, and is expected to be useful to promote the smart thermostat rebates for ENERGY STAR certified equipment.
Philadelphia Energy Authority ("PEA") PEA is an independent municipal authority focused on issues of energy affordability and sustainability for Philadelphia's government and its citizens. PGW coordinates with PEA to promote EnergySense rebate and grant programs to the commercial building owners, particularly multifamily, and small businesses.
Green Building United ("GBU") GBU is the Philadelphia chapter of the U.S. Green Building Council, and dedicated to environmentally responsible practices in the building industry. PGW has partnered with GBU for events in the past and is exploring future opportunities for EnergySense programs to serve as a resource for building owners to achieve these reductions.
Housing Alliance of Pennsylvania The Housing Alliance of Pennsylvania is an organization that consists of affordable housing property owners, developers, advocates and related stakeholders. PGW has coordinated outreach efforts with Housing Alliance to promote EnergySense programs as a resource.

F. Marketing

PGW will focus its marketing activities on three main activities: consumer-focused market awareness, supply chain and trade ally engagement, and direct to customer marketing. These will be carried out by PGW and its marketing and outreach support vendor.

1. Consumer-Focused Market Awareness

The most significant marketing change will be an increase in consumer-focused marketing activities to build awareness about the new rebate offerings. This increase is warranted to launch PGW's new smart thermostat rebate offering, among other new offerings. The smart thermostat is a relatively low cost measure with limited market penetration but mass market appeal. PGW will need to conduct mass marketing activities to generate awareness about this new offer among its residential customer base. This differs from the strategy used in Phase II that focused on business-to-business marketing targeting the contractors and trade allies that aid consumers in energy equipment decisions.

2. Supply Chain and Trade Ally Engagement

PGW's supply chain engagement encompasses all activities targeting equipment suppliers, project designers, installers, manufacturers, and an assortment of related categories. The goal of outreach project intermediaries and influencers is to educate the individuals that supply and recommend natural gas equipment and project designs.

Supply chain and trade ally marketing has been the greatest source of rebate program referrals since the inception of the EnergySense portfolio. This is due to the fact that replacement of heating equipment is often reactionary, where customers replace equipment because it fails rather than through a planned retirement. In these instances, customer decisions are influenced most by equipment installers. By continuing to build and expand on PGW's relationship with these installers and suppliers, EnergySense will remain top of mind as an effective sales tool.

3. Direct to Customer Marketing

PGW will conduct targeted direct-to-customer marketing, which will focus on encouraging customers to act and make energy efficient purchases and upgrades. The new smart thermostat program will benefit from direct-to-customer marketing, as the measure is discretionary and PGW's marketing can influence customers who may not have otherwise considered making a thermostat purchase.

G. Evaluation and Verification Inspections

PGW will perform on-site verifications on a portion of equipment to ensure the equipment installed qualifies for the program and matches the specifications listed on the rebate application. Inspection quotas are detailed in the individual program sections.

In addition to on-site in-person inspections, PGW may pilot e-inspections using digital tools that allow for greater customer convenience and cost-savings, while still ensuring quality. For customers who prefer e-inspections, they may be given an option to record and upload verification videos to a secure site at their convenience or conduct video-chats via a smartphone or tablet, rather than accept on-site visits. The video would need to show clear images of the rebated equipment with its nameplate model and serial numbers matching the application, and proof of their residence. This approach is used in other utility DSM programs.

PGW will continue to perform third party evaluations on its programs to evaluate the actualized measure savings. PGW uses the results of these independent evaluations to assess program impacts, update savings estimates, and redirect program activities.

H. Continuation and Reporting

This Implementation Plan provides implementation details for the next three years of the DSM program from FY 2021 – FY 2023. During this time, PGW will continue to file its annual implementation plan four months prior to the upcoming fiscal year, but only when proposing major program changes that would increase the portfolio budget caps. PGW will continue to file its annual report four months after the close of the fiscal year.

Table 9 – Timeline for Continuation & Reporting Process below provides the anticipated continuation and reporting process from FY 2021 – FY 2023.

Table 9 – Timeline for Continuation & Reporting Process

Fiscal Year	Continuation or Reporting Activity
2021	• FY 2020 Annual Report (December/January) • FY 2022 Implementation Plan (May, if warranted)
2022	• FY 2021 Annual Report (December/January) • FY 2023 Implementation Plan (May, if warranted)
2023	• FY 2022 Annual Report (December/January) • Objection Deadline to Continued DSM Programming (February) • FY 2024 – 2026 Triennial Implementation Plan (May, if warranted)

I. Key Assumptions

1. Avoided Costs

PGW's avoided costs are used to evaluate project and program cost-effectiveness. PGW will use avoided cost figures updated in February 2020 based on current commodity costs and charges for pipeline and storage capacity. The February 2020 avoided costs are presented in Appendix A.

Pursuant to the PUC's Tentative Order on PGW's Final Phase II Plan, PGW's cost effectiveness calculations include the additional value estimated for Demand Reduction Induced Price Effect ("DRIPE"). DRIPE calculates the impact of reductions in future gas prices caused by DSM reductions in market demand, and reductions in gas supply and price risk as a result of lower PGW system gas demand. PGW began including DRIPE impacts on avoided costs in its cost effectiveness tests in FY 2017.

In its DSM Phase II Plan Final Order, the PUC directed PGW to provide projected TRC results with the internalized market price of carbon dioxide ("CO_2") for informational purposes only in Phase II because Pennsylvania did not have a market for CO_2. Due to the fact that Pennsylvania still does not have a market for CO_2, and due to the costliness and administrative burden to calculate additional cost effectiveness results, PGW will discontinue tracking these additional cost effectiveness results after FY 2020. However, if and when Pennsylvania enters into a system that monetizes carbon, PGW will revisit tracking these metrics .

Avoided costs for electric and water benefits will be based on the Avoided Cost values used in Act 129 at docket M-2019-3006868 (2021 TRC Test Final Order).

2. Benefit-Cost Analysis

PGW will continue to apply the TRC test for determining cost-effectiveness. PGW targets a minimum TRC BCR cost effectiveness threshold of 1.0 for all programs and the portfolio as a whole.

3. Technical Reference Manual

PGW has filed an update to its PUC approved DSM Phase II Technical Reference Manual ("TRM") as Appendix D to this plan. PGW evaluated the TRM calculations based on the results of billing analyses and third-party evaluations conducted during DSM Phase I and DSM Phase II. In instances where an energy efficiency measure's actual savings repeatedly varied from calculated savings, PGW reviewed the savings calculation for potential improvements.

To ensure consistency and follow industry best practices when revising its TRM, PGW developed a methodology for sourcing gas savings formulas and assumptions (ex: operating hours, EFLH, etc...). It established a hierarchy based on the following sources:

- i. Previous PGW program activity with verified savings
- ii. The current Act 129 Phase IV TRM
- iii. Other Pennsylvania Natural Gas Energy Efficiency Programs' TRMs
- iv. Recently updated regional TRMs that have been comprehensively reviewed, including:
    - Northeast Energy Efficiency Partnerships' ("NEEP") Mid-Atlantic TRM
    - Illinois TRM
    - New York TRM
    - Massachusetts TRM
- v. Other reputable TRMs (e.g. California, Wisconsin, Vermont) or Federal agencies (e.g. U.S. Department of Energy, U.S. Environmental Protection Agency)

For each source, the calculations were examined and, where required, climate dependent or location specific variables replaced with appropriate local values. Priority was also placed on recency of data or assumptions.

In addition to updating existing measures, PGW also used the above methodology to add energy saving calculations to the PGW TRM for the following measures:

i. Smart thermostat
ii. Unit heaters
iii. Boiler reset controls
iv. Non-residential Building Roof Insulation

The TRM now includes estimated incremental costs for each measure. The estimates are based on current market information and the available research, and may be updated if new or improved data becomes available.The costs included in PGW's TRM were obtained from a variety of sources determined by the order of importance outlined below, with priority placed on recent sources.

i. Data from Pennsylvania specific studies conducted under Act 129 or using cost-estimating software such as RS-Means.
ii. Data from Federal government studies, such as proceedings for calculating the effects of changing baselines, through ENERGY STAR, or through peer-review journals.
iii. Data from well-regarded TRMs; specifically NEEP's Mid-Atlantic TRM, Illinois TRM, or California's DEER database. In such instances, costs were adjusted for regional differences and inflation.
iv. Contractor quotes and aggregated cost data from previous EnergySense projects, when available.

PGW may add other measures and new technologies to its TRM and add or discontinue rebate offers based on the effects of new cost and savings data on cost-effectivenss assessments.

II. Program Plans

This section provides an overview of the revised implementation activities, planned for FY 2021-2023 for all five DSM programs comprising PGW's EnergySense Portfolio:

- Residential Equipment Rebates Program
- Residential Construction Grants Program
- Commercial Equipment Rebate Program
- Efficient Building Grants Program and Commercial/Multifamily Construction Grants Program Wind-Down
- Smart Thermostat Marketplace
- Low Income Smart Thermostat Program

A. Residential Equipment Rebates Program

1. Program Description

The RER program issues prescriptive rebates on premium efficiency gas appliances and heating equipment to increase the penetration of these measures in the homes and buildings of PGW's customers. Eligible customers use their own contractor to install the premium efficiency equipment and receive rebates to offset most of the incremental cost of the higher efficiency equipment and installation.

2. Costs, Savings, and Benefits

<u>Projections</u>
The program aims to issue rebates for 3,440 pieces of equipment from FY 2021 – FY 2023, with associated annualized gas savings of 40,788 MMBtu. The program is projected to cost $2,280,934 from FY 2021 – FY 2023. The following table shows a detailed breakout of participation, costs, and savings.

Table 10 – Projected RER Impacts

	FY 2021	FY 2022	FY 2023	FY 2021 – FY 2023
Projected Budgets (Nominal)				
Customer Incentives	$603,000	$732,990	$732,990	$2,068,980
Administration	$33,475	$30,200	$31,465	$95,140
Inspections	$22,568	$22,124	$22,124	$66,815
Evaluation	-	$50,000	-	$50,000
TOTAL:	**$659,043**	**$835,313**	**$786,579**	**$2,280,934**
Natural Gas Savings (MMBtus)				
Incremental Annual	14,590	13,099	13,099	40,788
Incremental Lifetime	301,550	271,388	217,388	844,325
Projected Participation				
Rebates Awarded	1,250	1,095	1,095	3,440

3. Program Eligibility and Incentives

RER is designed to persuade customers who are purchasing natural gas furnaces, boilers, combi boilers and tankless water heaters to choose high efficiency models. All PGW firm-rate customers are eligible. Existing and new construction homes and building are eligible to participate, including:

- Single-family homes
- Multifamily buildings
- Commercial facilities using residential-sized equipment

PGW will continue offering residential-sized equipment rebate offerings targeting high efficiency furnaces, boilers and combination boilers. It will also launch rebate offerings for tankless water heaters and ENERGY STAR® certified smart thermostats. The following table shows the anticipated rebate schedule.

Pursuant to settlement, during FY 2022 and FY 2023 PGW will issue up to 400 higher-value prescriptive rebates per year on qualifying equipment for eligible low-income customers. Customers will be considered low income if they have been enrolled in PGW's Customer Responsibility Program within the last year, have received a Utility Emergency Services Fund (UESF) grant within the last year, or have received LIHEAP and assigned it to PGW within the last year.

Table 11 – Residential Equipment Rebate Amounts

Measure	First Rebate Per-Project	First Rebate Per-Project (Low Income)	Additional Rebates Per-Project[3]
Natural Gas Furnace 95% AFUE	$350	$700	$250
Natural Gas Water Boiler, 94% AFUE	$900	$1,225	$700
Natural Gas Combination Boiler, 94% AFUE	$1,300	$1,800	$1,000
ENERGY STAR® Certified Tankless Water Heater	$350	$625	$350
ENERGY STAR® Certified Smart Thermostat	$70	Free through the LI Smart Thermostat Program	$30

PGW rebates are designed to cover between 43-75% of the incremental cost between standard efficiency and high efficiency models. The higher rebate amounts for low-income customers are designed to cover close to 100% of the incremental costs. PGW may perform periodic reviews of the rebates being offered and may change the types of measures covered, the minimum efficiency level required, or the rebate amount based on changing market conditions. Given PGW's introduction of the expanded prescriptive rebate structure, RER incentives per project will be capped at different levels based on the project's installation tier as described in Section I.B.1

Projected Activity

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

Table 12 – Projected Rebates Participation by Equipment Type

Product	FY 2021	FY 2022	FY 2023	FY 2021 – FY 2023
Natural Gas Furnace	800	620	620	2,040
Natural Gas Boiler	150	145	145	440
Combi Boiler	25	80	80	185
Tankless Water Heater	250	170	170	590
Total	**1,225**	**1,015**	**1,015**	**3,255**

4. Evaluation, Monitoring, and Verification

PGW will perform on-site verifications as outlined in section I.G. PGW has set a target to inspect at least ten percent of claims to ensure the equipment installed qualifies for the program and matches the equipment listed on the rebate application.

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

B. Residential Construction Grants Program

1. Program Description

The Residential Construction Grants ("RCG") program seeks to convince homebuilders, building owners, engineers, architects, and contractors to incorporate natural gas energy efficiency into the design of their projects and go beyond standards dictated by the building energy code. The program provides incentives for reaching a certain level of natural gas savings.

2. Costs, Savings, and Benefits

Projections

The program aims to issue grants for 300 single-family residential homes from FY 2021 – FY 2023, with associated annualized gas savings of 5,730 MMBtu. The program is projected to cost $590,224.

Table 13 – Projected RCG Impacts

	FY 2021	FY 2022	FY 2023	FY 2021 – FY 2023
Projected Budgets (Nominal)				
Customer Incentives	$140,000	$140,000	$140,000	$420,000
Administration	$36,456	$35,305	$35,464	$107,224
Inspections	45,000	$4,000	$4,000	$13,000
Evaluation	-	-	$50,000	$50,000
TOTAL:	**$181,456**	**$179,305**	**$229,464**	**$590,224**
Natural Gas Savings (MMBtus)				
Incremental Annual	1,910	1,910	1,910	5,730
Incremental Lifetime	38,200	38,200	38,200	114,600
Projected Participation				
Grants Awarded	100	100	100	300

3. Program Eligibility and Incentives

RCG's target market is a new construction or gut rehabilitation single family homes that will use natural gas provided by PGW for both space heating and water heating. Gut rehabilitation is generally understood to be a project wherein at least two building systems are being replaced and these renovations require energy code compliance.

Projects must exceed the 2015 International Energy Conservation Code (IECC) by at least 15% to qualify for a grant. Applicants must demonstrate the savings by completing an energy model and also submitting a Home Energy Rating System (HERS) rating report. A HERS rating requires a certified third-party inspector to assess and verify the energy performance of the home, and submission of the model is one of the ways that builders can comply with the City of Philadelphia's energy code requirements. PGW seeks to align its process with Philadelphia's regulatory requirements in order to reduce the administrative burden on the customer.

4. Evaluation, Monitoring, and Verification

The program requirement for applicants to complete a HERS rating through a certified third-party rater, which is reviewed by PGW, helps to integrate an aspect of quality control / quality assurance even if PGW is not on-site. In addition to this requirement, PGW, through its program implementer, will perform its own HERS rating on the first project submitted to the program from each new applicant to serve as a project inspection, and may perform additional HERS ratings and on-site visits as needed to validate savings claims.

C. Commercial Equipment Rebates Program

1. Program Description

The CER program issues prescriptive rebates on premium efficiency gas appliances and heating equipment to increase the penetration of these measures in the facilities of PGW's commercial, industrial, and multifamily customers. Eligible customers will use their own contractor to install the premium efficiency equipment and receive rebates to offset most of the incremental cost of the higher efficiency equipment.

2. Costs, Savings, and Benefits

<u>Projections</u>
The program aims to issue rebates for 676 pieces of equipment[4] from FY 2021 – FY 2023, with associated annualized gas savings of 71,313 MMBtu. The program is projected to cost $1,059,734. The following table shows a detailed breakout of participation, costs, and savings. Pursuant to settlement, PGW will limit incentive spending for the CER program to 55% or less of the total Total Resource Cost Present Value (TRC PV) of costs for EnergySense during the 3-year period FY 2021 – FY 2023. Furthermore, total PGW spending for the CER program during this 3-year period will not exceed the budget shown in Table 15 below by more than 15 percent.

Table 14 – Projected CER Impacts

	FY 2021	FY 2022	FY 2023	FY 2021 – FY 2023
Projected Budgets (Nominal)				
Customer Incentives	$283,869	$302,845	$302,845	$889,559
Administration	$19,226	$20,023	$20,624	$59,874
Inspections	$17,632	$18,556	$19,113	$55,302
Evaluation	-	$55,000	-	$55,000
TOTAL:	**$320,727**	**$396,425**	**$342,582**	**$1,059,734**
Natural Gas Savings (MMBtus)				
Incremental Annual	23,284	24,015	24,015	71,313
Incremental Lifetime	420,521	438,311	438,311	1,297,143
Projected Participation				
Rebates Awarded	220	228	228	676

3. Program Eligibility and Incentives

CER's target market includes PGW firm-rate customers seeking to purchase equipment that could be substituted with high-efficiency models incentivized through theprogram.

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[4] Projected totals count rebates for low flow aerators and showerheads at the building-level.

Owners and renters, with the approval of the owner, are both eligible. Equipment must be purchased and installed within the applicable promotion period to be eligible.

PGW will continue offering rebates for commercial boilers and water heaters, steam traps and commercial cooking equipment. New prescriptive rebate offerings include: low-flow faucet aerators and showerheads, boiler reset controls, low-intensity infrared heaters, and roof insulation. Several of the new measures have been proposed and installed by customers as custom projects in the Efficient Building Grants and Commercial / Multifamily Construction Grant programs, though are now incentivized through a prescriptive rebate.

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Table 15 – Commercial Equipment Rebate Amounts

Equipment	Efficiency Requirement	Rebate
Commercial Boiler	92 Et	\$2,500 - \$8,400
Steam Trap (<15 PSIG)	N/A	\$45
Steam Trap (≤ 15PSIG < 75)	N/A	\$120
Steam Trap (≥ 75 PSIG)	N/A	\$140
Low-flow Faucet Aerator (per unit)	1.5 GPM	\$4
Low-flow Showerhead (per unit)	1.75 GPM	\$16
Commercial Water Heater (Storage)	96 Et	\$4 / MBH
Commercial Water Heater (Tankless)	96 Et	\$4 / MBH
Gas Fryer (Standard)	ENERGY STAR	\$400
Gas Fryer (Large)	ENERGY STAR	\$600
Steam Cooker (3 pans)	ENERGY STAR	\$150
Steam Cooker (4 pans)	ENERGY STAR	\$275
Steam Cooker (5 pans)	ENERGY STAR	\$375
Steam Cooker (6+ pans)	ENERGY STAR	\$480
Boiler Reset Controls	N/A	\$350
Low-intensity Infrared Heater	80 Et	\$250
Roof Insulation	R49	\$0.55 / sf

PGW will continue to endeavor to provide EnergySense benefits in the CER Program to small business customers that are reasonably commensurate to small businesses' share of GS-Commercial class load. For this purpose, a small business is defined as a person, sole proprietorship, partnership, corporation, association or other business whose annual gas consumption does not exceed 300 Mcf.

4. Evaluation and Verification

PGW will continue to implement evaluation and verification activities in accordance with the portfolio's current timeline. Moreover, PGW will also continue to schedule and conduct inspections on at least 10 percent of Commercial Equipment Rebates program projects and rebates over \$10,000.

D. Efficient Building Grants Program and Commercial / Multifamily Construction Grants Program Wind-Down

1. Program Description

The EBG program offered grants to customers who performed comprehensive custom energy-savings retrofits to existing commercial, multifamily and industrial buildings. The CMCG Program offered custom grants to customers who built new buildings or gut rehabilitated buildings exceeding energy code requirements.

The EBG and CMCG programs will be discontinued in FY 2021.Grants will be awarded in FY 2021 for projects that were underway in FY 2020 but not completed by the end of the year. No new grants will be offered after FY 2020 and no payments will be issued after FY 2021.

2. Costs, Savings, and Benefits

Projections
During the wind-down of EBG and CMCG, PGW aims to issue grants for up to six projects at a projected cost of $212,667, with associated annualized gas savings of 8,088 MMBtu.

Table 16 – Projected EBG and CMCG Wind Down Impacts

	FY 2021
Projected Budgets (Nominal)	
Customer Incentives	$202,667
Administration	$10,000
TOTAL:	**$212,667**
Natural Gas Savings (MMBtus)	
Incremental Annual	8,088
Incremental Lifetime	168,958
Projected Participation	
Grants Awarded	6

3. Program Eligibility and Incentives

PGW will stop offering the EBG and CMCG program to customers in FY 2020. The company's EBG and CMCG program implementation activities in FY 2021 will consist of ensuring a steady wind-down of activity from previously approved grant awards.

E. Smart Thermostat Marketplace

1. Program Description

The Marketplace program will offer direct sales of rebate-discounted ENERGY STAR certified smart thermostats to eligible PGW customers. PGW will hire a marketplace vendor to design the website and implement the program. The vendor will sell smart thermostats discounted by the amount of PGW's rebate. This creates an "instant rebate" that obviates the need for the customer to take any action after the purchase to receive the rebate. This arrangement provides energy-saving equipment that is affordable and can easily be retrofit on most heating systems. Thermostats can be self-installed by the customer or by a contractor.

2. Costs, Savings, and Benefits

<u>Projections</u>
The program aims to incentivize 6,625 thermostats over the next period, with associated annualized gas savings of 34,089 MMBtu. The program is projected to cost $685,057.

Table 17 – Projected Smart Thermostat Marketplace Impacts

	FY 2021	FY 2022	FY 2023	FY 2021 – FY 2023
Projected Budgets (Nominal)				
Customer Incentives	$115,015	$125,205	$125,205	$365,424
Administration	$79,225	$85,548	$87,214	$251,986
Inspections	$21,206	$23,220	$23,220	$67,646
TOTAL:	**$215,446**	**$233,972**	**$235,639**	**$685,057**
Natural Gas Savings (MMBtus)				
Incremental Annual	10,692	11,699	11,699	34,089
Incremental Lifetime	117,607	128,685	128,685	374,977
Projected Participation				
Thermostats	2,072	2,277	2,277	6,625

3. Program Eligibility and Incentives

The program's target market includes PGW firm-rate residential and commercial customers seeking to retrofit an existing heating system with a smart thermostat. Owners and renters, with the approval of the owner, are both eligible. Equipment must be purchased from PGW's marketplace in order to be eligible. PGW will limit the number of thermostats that may be purchased through the Marketplace to three per customer. Building owners and builders that seek to install greater quantities may apply for rebates through the prescriptive RER program.

4. Evaluation and Verification Inspections

PGW will perform on-site verifications as outlined in section I.G. PGW has set a target to inspect at least ten percent of claims to ensure the equipment purchased from the marketplace are installed on natural gas heating equipment at addresses with active PGW service.

The program will be evaluated when there is adequate program activity to review post-usage data.

F. Low Income Smart Thermostat Program

1. Program Description

The Low-Income Smart Thermostat program will provide ENERGY STAR certified smart thermostats in the homes of eligible low-income PGW customers, at no cost to the customer. PGW will select a vendor or vendors to perform outreach to low-income populations, qualify program participants for income and program eligibility, install smart thermostats, and provide customers with education regarding how to use the thermostat, including how to achieve savings. The vendor will perform installations in customer homes as the primary program delivery vehicle. They may also provide customers the thermostat for the customer to self-install when requested and deemed appropriate, particularly in response to public health and safety concerns.

2. Costs, Savings, and Benefits

Projections

The program aims to install approximately 726 thermostats from FY 2022 - FY2023, with associated annualized gas savings of 2,955 MMBtu. The full program is projected to cost $120,000.

Table 18 – Projected LI Smart Thermostat Impacts

	FY 2021	FY 2022	FY 2023	FY 2021 – FY 2023
Projected Budgets (Nominal)				
Customer Incentives	-	$43,510	$43,510	$87,021
Administration	-	$16,409	$16,409	$32,979
Inspections	-	-	-	-
TOTAL:	**-**	**$60,000**	**$60,000**	**$120,000**
Natural Gas Savings (MMBtus)				
Incremental Annual	-	1,477	1,477	2,955
Incremental Lifetime	-	16,252	16,252	32,503
Projected Participation				
Thermostats	-	363	363	726

3. Program Eligibility and Incentives

The program's target market is low-income PGW customers on a residential firm-rate. Customers will be considered low income if they have been enrolled in CRP within the last year, have received a UESF grant within the last year, or have received LIHEAP and assigned it to PGW within the last year.

4. Evaluation and Verification Inspections

As deemed necessary, PGW will perform verification inspections to ensure that smart thermostats are installed in homes and businesses with active PGW service used for space heat.

III. Appendices

A. PGW Natural Gas Avoided Costs, including DRIPE (2020$)

Calendar Year	Baseload $ / MMBTu	Space Heating $ / MMBtu	DHW $ / MMBtu
2020	$ 3.23	$ 7.88	$ 4.39
2021	$ 3.34	$ 8.15	$ 4.54
2022	$ 3.33	$ 8.13	$ 4.53
2023	$ 3.42	$ 8.15	$ 4.60
2024	$ 3.84	$ 8.86	$ 5.09
2025	$ 4.19	$ 9.26	$ 5.46
2026	$ 4.53	$ 9.60	$ 5.80
2027	$ 4.81	$ 9.76	$ 6.04
2028	$ 4.75	$ 9.59	$ 5.96
2029	$ 4.71	$ 9.55	$ 5.92
2030	$ 4.67	$ 9.52	$ 5.89
2031	$ 4.72	$ 9.57	$ 5.93
2032	$ 4.75	$ 9.60	$ 5.96
2033	$ 4.83	$ 9.68	$ 6.04
2034	$ 4.89	$ 9.74	$ 6.10
2035	$ 4.89	$ 9.74	$ 6.10
2036	$ 4.89	$ 9.74	$ 6.10
2037	$ 4.95	$ 9.80	$ 6.17
2038	$ 4.99	$ 9.84	$ 6.21
2039	$ 5.01	$ 9.86	$ 6.23
2040	$ 5.03	$ 9.88	$ 6.24
2041	$ 5.04	$ 9.89	$ 6.25
2042	$ 5.08	$ 9.92	$ 6.29
2043	$ 5.11	$ 9.95	$ 6.32
2044	$ 5.14	$ 9.98	$ 6.35
2045	$ 5.18	$ 10.02	$ 6.39
2046	$ 5.23	$ 10.08	$ 6.44
2047	$ 5.30	$ 10.15	$ 6.51
2048	$ 5.36	$ 10.20	$ 6.57
2049	$ 5.40	$ 10.25	$ 6.61

B. *List of Acronyms*

Acronym	**Meaning**
BCR	Benefit-cost ratio
CER	Commercial Equipment Rebates Program
CMCG	Commercial/Multifamily Efficient Construction Grant Program
CY	Calendar Year
DRIPE	Demand-Reduction-Induced Price Effect
DSM	Demand-Side Management
EBG	Efficient Building Grants Program
FY	Fiscal Year (PGW's fiscal year goes from September 1 to August 31)
PA	Pennsylvania
PV	Present Value
PGW	Philadelphia Gas Works
RCG	Residential Construction Grant Program
RER	Residential Equipment Rebates Program
TRC	Total Resource Cost
TRM	Technical Reference Manual

C. Units

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

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

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

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

1 MMBtu = 1 Dth
1.03 therm = 1 ccf

D. Technical Reference Manual

The current technical reference manual has been provided as a separate document. This technical reference manual was updated in June 2021 to reference new baseline AFUE levels for residential gas boilers that reflect updated federal equipment efficiency standards for gas boilers and combi boilers manufactured on and after January 15, 2021. These updates will go into effect in FY 2022.

Technical Reference Manual

Measure Savings Algorithms

(Market Rate Programs)

September 1, 2021

Table of Contents

1 Background

1.1 Purpose of the TRM

This Technical Reference Manual (TRM) provides a transparent and consistent basis for calculating the energy savings generated by the market rate energy efficiency programs administered by Philadelphia Gas Works (PGW), collectively referred to as EnergySense. A previous version of PGW's TRM was filed with the Pennsylvania Public Utilities Commission (PUC) as part of its Demand Side Management Plan for FY2016-2020. The current version supersedes the aforementioned TRM, and, unless otherwise noted, serves as the primary source for savings calculations and incremental cost assumptions. Additionally, this TRM does not represent an exclusive set of measures that may be applied in EnergySense. Using the custom measure and assumption update methodology described herein, PGW may offer incentives to include new measures during the implementation period.

1.2 Updating Assumptions

To ensure consistency and follow industry best practices when updating its TRM, PGW uses the following hierarchy for adding new or revising existing gas savings formulas and assumptions (ex: operating hours, EFLH, etc.):

1. Previous PGW program activity with verified savings
2. The current Act 129 Phase IV TRM
3. Other Pennsylvania Natural Gas Energy Efficiency Program TRMs
4. Recently updated regional TRMs that have been comprehensively reviewed, including:
    a. Northeast Energy Efficiency Partnerships (NEEP) Mid-Atlantic TRM
    b. Illinois TRM
    c. New York TRM
    d. Massachusetts TRM
5. Other reputable TRMs (e.g. California, Wisconsin, Vermont) or Federal agencies (e.g. U.S. Department of Energy, U.S. Environmental Protection Agency)

For each source, the calculations are examined and, where required, climate-dependent or location-specific variables are replaced with appropriate local values. Priority is also placed on recent data.

PGW has included a Realization Rate adjustment factor into many measure calculations. This is applied for measures that are reviewed through a post-usage analysis and have a realization rate calculated based on a statistically significant sample size. PGW will update these figures as new analyses become available.

The TRM contains estimated incremental costs (in 2020 dollars, unless otherwise noted) for each measure. The estimates are a point in time snapshot and may be updated during the implementation if new or improved data becomes available. The current costs were obtained from a variety of sources using the hierarchy below, with preference given to recent sources. Costs were adjusted for regional differences and inflation.

i. Data from Pennsylvania specific studies conducted under Act 129 or using cost-estimating software such as RS-Means.
ii. Data from Federal government studies, such as proceedings for calculating the effects of changing baselines, through ENERGY STAR, or through peer-review journals.
iii. Data from well-regarded TRMs; specifically NEEP's Mid-Atlantic TRM, Illinois TRM, or California's DEER database.
iv. Contractor quotes and aggregated cost data from previous EnergySense projects, when available.

2 Residential Time of Replacement Market

2.1 Space Heating End Use

2.1.1 Efficient Space Heating System

Draft date: 5/1/20
Effective date: 9/1/21
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	84%

Definition of Efficient Condition
Efficient model minimum AFUE requirements are detailed in the table below. Installed gas furnaces or boilers must have an AFUE greater than those values shown. For boilers, the installed equipment must also have an input capacity of less than 300,000 Btu/hr.

Equipment Type	Minimum AFUE
Gas Furnace	95%
Gas Boiler	94%

Gas Savings Algorithms
MMBtu savings are realized due to the increase in AFUE of 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.

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

Where:

$Capacity_{Out}$	= Output capacity of equipment to be installed (kBtu/hr)
1,000	= Conversion from kBtu to MMBtu
$AFUE_{Base}$	= Efficiency of new baseline equipment (Annual Fuel Utilization Efficiency)
$AFUE_{Eff}$	= Efficiency of new equipment
$EFLH_{Heat}$	= Equivalent Full Load Heating Hours (730 hours for furnaces, 854 for boilers)[1]
RR_{adj}	= Realization Rate Adjustment (112% for furnaces, 92% for boilers)[2]

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.

Persistence

The persistence factor is assumed to be one.

Measure Lifetimes[3]

Equipment Type	Measure Lifetime
Gas Furnaces	20
Gas Boilers	25

Water Savings

There are no water savings for this measure.

Deemed Measure Cost

Incremental cost of a furnace is $718.[4]
Incremental cost of a boiler is $1,366.[5]

[1] EFLH values filed by PGW in 2014 and in subsequent years, informed by findings of 2013 Residential Equipment Rebate Program Evaluation.
[2] Philadelphia Gas Works 2016 Residential Equipment Rebates Evaluation
[3] Illinois Commerce Commission [ICC]; *Illinois Statewide Technical Reference Manual for Energy Efficiency-Residential Measures,* Version 8.0, Volume 3. (2020).
[4] U.S. Energy Information Administration [EIA]; *Updated Buildings Sector Appliance Equipment Costs and Efficiency.* (2018). Based on an 80 kbtuh input.
[5] Illinois Commerce Commission [ICC]; *Illinois Statewide Technical Reference Manual for Energy Efficiency-Residential Measures,* Version 8.0, Volume 3. (2020).

2.1.2 Smart Thermostat

Draft date:	5/1/20
Effective date:	9/1/20
End date:	TBD

Measure Description
This is an ENERGY STAR®-certified smart thermostat, controlling a residential-sized gas furnace or boiler.

Definition of Baseline Condition
The baseline is either a manual thermostat where each temperature setting change requires human intervention, or a conventional programmable (non-smart) thermostat.

Definition of Efficient Condition
The efficient thermostat is one that automatically adjusts heating and cooling temperature settings for optimal performance, and has been independently certified and earned an ENERGY STAR® label based on actual field data, to deliver energy savings.

Gas Savings Algorithms

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

Where:

SH_{pre}	=	Space Heat MMBtu gas usage with manual thermostat. Enter actual space heat usage if known. If unknown, use 73 MMBtu.[6]
ESF	=	Percentage savings from smart thermostat compared to a manual or conventional programmable thermostat. See table below by installation method.

Heating Energy Savings Factors (ESF)[7]

Program Type	**Baseline**	**Furnace/Boiler Heating (Electric or Fossil)**
Upstream Buy-Down (Customer Self-Installation)	Unknown Mix Default	6.4%
Customer Self-Installation with Education	Unknown Mix Default	7.9%
Professional Installation	Manual	11.5%
	Conventional Programmable	7.9%

Electric Savings Algorithms
If the type of air conditioning is known, then use the appropriate algorithm below.

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.

[6] Average customer space heat usage for participants in PGW's Home Rebates program, 2013 - 2016.
[7] Pennsylvania Public Utility Commission [PUC]; *Act 129, 2021 Technical Reference Manual, Residential Measures*. Volume 2. (2019).

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, or unknown
= ΔkWh_{CAC}, if house has central air conditioning
= 0 if house has room air conditioning

Deemed Savings ΔkWh[8]

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
Professional Installation	Manual	87	182
	Conventional Programmable	60	150

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.

Persistence

The persistence factor is assumed to be one.

Measure Lifetimes[9]

Equipment Type	**Measure Lifetime**
Smart Thermostat	11

Water Savings

There are no water savings for this measure.

Deemed Measure Cost

The incremental cost for an ENERGY STAR® Smart Thermostat is $125.[10]

[8] PUC; *Act 129, 2021 Technical Reference Manual, Residential Measures*. Volume 2. (2019).
[9] Ibid.
[10] Illinois Commerce Commission [ICC]: *Illinois Statewide Technical Reference Manual for Energy Efficiency-Residential Measures,* Version 8.03, Volume 3. (2020).

2.2 Domestic Hot Water End Use

2.2.1 Tankless Water Heater

Draft date: 5/1/20
Effective date: 9/1/20
End date: TBD

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

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

Equipment Type	Baseline UEF
Gas Stand-alone Storage Water Heater	0.58[11]

Definition of Efficient Condition
The installed tankless water heater must have a 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.

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

Where:

UEF_{Base} = Uniform Energy Factor of baseline water heater = 0.58
UEF_{Eff} = Uniform Energy Factor of efficient water heater
V = Daily volume of hot water usage in gallons. If unknown, assume 55 gallons/day.
ρ = Water density at 125º F(8.24 lb/gal)
C_ρ = Specific heat of water (1.00 Btu/lb ºF)
67 = ºF temperature rise between inlet and outlet of water heater
365 = Days per year
1,000,000 = Btu per MMBtu

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

Electric Savings Algorithms
There are no electric savings from this measure.

Energy Savings

$\Delta kWh = 0\ kWh$

Demand Savings

$\Delta kW = 0\ kW$

Where:

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

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes[12]

Equipment Type	Measure Lifetime
Tankless Water Heater	20

Water Savings
There are no water savings for this measure.

Deemed Measure Cost
Incremental cost of a tankless water heater is $627.[13]

[12] U.S. Energy Information Administration [EIA]; *Updated Buildings Sector Appliance Equipment Costs and Efficiency.* (2018).
[13] Northeast Energy Efficiency Partnership [NEEP]: *Mid-Atlantic Technical Reference Manual,* Version 9. (2019).

2.3 Combined Space Heating and Domestic Hot Water End Use

2.3.1 Combination Boiler - Space Heating and DHW

Draft date: 5/1/20
Effective date: 9/1/21
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 with 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	84% AFUE
Gas DHW Tank	0.58 UEF[14]

Definition of Efficient Condition
The installed combi 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 of the new equipment. Savings are calculated from the baseline new unit to the installed efficient unit.

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

Where:

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

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

[14] Based on the federal standard UEF for medium draw pattern DHW.

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 (854 hours)[15]

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}	= Energy Factor of baseline water heater = 0.58
UEF_{Eff}	= Energy Factor of efficient combi boiler. Since the combi boiler has no or little storage, standby losses are assumed to be negligible and the EF is assumed to be the same as the AFUE.
365	= Days per year

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.

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes[16]

Equipment Type	Measure Lifetime
Gas Combi Boiler	20

Water Savings
There are no water savings for this measure.

Deemed Measure Cost
The incremental cost for a combination boiler is $3,014.[17]

[15] EFLH values filed by PGW in 2014 and in subsequent years, informed by findings of 2013 Residential Equipment Rebate Program Evaluation.
[15] Same as lifetime estimate used for tankless water heater.
[17] Navigant Consulting; *Water Heating, Boiler, and Furnace Cost Study. (*2019).

2.4 All End Uses

2.4.1 Custom Measure

Draft date:	5/1/20
Effective date:	9/1/20
End date:	TBD

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

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

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

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

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

Where:

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

Electric Savings Algorithms

Energy Savings
$\Delta kWh = BaselinekWh - EfficientkWh$

Demand Savings
$\Delta kW = BaselinekW - EfficientkW$

Where:

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

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, or be determined based on the hierarchy of sources in section 1.2 Updating Assumptions.

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

Measure Cost
The incremental cost is the cost difference between the efficient equipment and the baseline equipment.

3 Residential New Construction

3.1 All End Uses

3.1.1 Custom Measures

Draft date: 5/1/20
Effective date: 9/1/20
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". The primary residential energy code required in Philadelphia is the 2015 International Energy Conservation Code (IECC).

Definition of Efficient Condition
The efficient condition is any building design that uses less energy than the baseline building design. This lower energy use may be demonstrated by the receipt of a Home Energy Rating System (HERS) index score that is lower than the baseline or reference home score, or other verifiable energy models.

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

The generalized equation for a custom measure(s) compares the baseline usage to the efficient usage.

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

Where:

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

Electric Savings Algorithms

Energy Savings

$\Delta kWh = BaselinekWh - EfficientkWh$

Demand Savings

$\Delta kW = BaselinekW - EfficientkW$

Where:

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

Persistence

The persistence factor is assumed to be one.

Measure Lifetimes
The measure lifetime of Residential New Construction is 20 years.[18] Where deemed appropriate, Residential New Construction lifetimes may be calculated on a custom basis from a weighting of the 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.

Deemed Measure Cost
The incremental cost is the cost difference between the efficient equipment and the baseline equipment. The incremental cost for an average Philadelphia home is $1,783. It includes a cost of $1,283 for gas conservation measures[19] and $500 for HERS rating[20].

[18] Determined by survey of estimated measure lifetime used in Pennsylvania Act 129 New Construction Programs, and Mid Atlantic TRM, V9.
[19] Cost & Savings Estimates ENERGY STAR Certified Homes, Version 3.1 (Rev. 09).
[20] Survey of costs in Act 129 Programs and local marketplace.

4 Residential Early Replacement Market

4.1 Space Heating End Use

4.1.1 Efficient Space Heating System

Draft date: 5/1/20
Effective date: 9/1/20
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. The manufacturer's rated AFUE is used in the savings calculations if it is available. 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[21]:

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

If a heater is inoperable and a baseline AFUE or Steady State Efficiency cannot be determined, the heater installation can be modeled as a natural replacement by applying an 80% AFUE as the baseline condition.[22]

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.

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

[21] Building Performance Institute; *Technical Standards for the Heating Professional* (2007).

Where:

HeatingUse	=	Annual heating use (MMBtu/yr) from weather normalized usage analysis of customer billing data from pre-treatment period. See description below.
$AFUE_{Base}$	=	Efficiency of existing baseline equipment
$AFUE_{Eff}$	=	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/day to estimate heating slope (MMbtu/HDD63) and baseload daily use (MMBtu/day). See reference table in section 8.1 on page 59~~57~~ for HDD63.

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. Then calculate weather adjusted heating use as raw heating use * HDD63. See reference table in section 8.1 on page 59~~57~~ for HDD63.

Energy Savings

ΔkWh = 0 kWh

Demand Savings

ΔkW = 0 kW

Persistence

The persistence factor is assumed to be one.

Measure Lifetimes[23]

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

Water Savings

There are no water savings for this measure.

Deemed Measure Cost

The cost of a high efficiency early replacement furnace is $2,850.[24]
The cost of a high efficiency early replacement boiler is $5, 010.[25]

The cost of a baseline efficiency furnace is $2,132.
The cost of a baseline efficiency boiler is $3,686.[26]

[23] Illinois Commerce Commission [ICC]; *Illinois Statewide Technical Reference Manual for Energy Efficiency-Residential Measures,* Version 8.0, Volume 3. (2020).
[24] U.S. Energy Information Administration [EIA]; *Updated Buildings Sector Appliance Equipment Costs and Efficiency.* (2018). Based on an 80kbtuh input.
[25] Illinois Commerce Commission [ICC]; *Illinois Statewide Technical Reference Manual for Energy Efficiency-Residential Measures,* Version 8.0, Volume 3. (2020).
[26] Baseline equipment costs are included for deferral credit calculations. As the existing equipment nears the end of its useful life, the net cost after subtracting the deferral credit will be closer to the time of replacement incremental cost.

4.1.2 Residential Roof and Cavity Insulation

Draft date: 5/1/20
Effective date: TBD
End date: TBD

Measure Description
This involves increasing the insulation levels in either the attic or walls that 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 that 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.[27] See reference table in section 8.1 on page 5957 for 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.

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

Energy Savings

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

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

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

[27] PUC; *Act 129, 2021 Technical Reference Manual, Residential Measures*. Volume 2. (2019).

Where:

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

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

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

Where:

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

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

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).[28]
CDD = Cooling Degree Days. See reference tables in section **Error! Reference source not found.**~~8.2~~ on page **Error! Bookmark not defined.**~~56~~.
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 reference table in section **Error! Reference source not found.**~~8.2~~ on page **Error! Bookmark not defined.**~~56~~)
$EFLH_{cool\ RAC}$ = Equivalent Full Load Cooling hours for Room AC (See reference table in section **Error! Reference source not found.**~~8.2~~ on page **Error! Bookmark not defined.**~~56~~)
$F_{Room\ AC}$ = Adjustment factor to relate insulated area to area served by Room AC units

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

[28] Efficiency Vermont; *Technical Reference Manual: Measure Savings Algorithms and Cost Assumptions.* (2018).

Default Values for Algorithm Terms, Ceiling/Attic and Wall Insulation

Term	Type	Value	Source
DUA	Fixed	0.75	29
$SEER_{CAC}$	Variable	Default values: Early Replacement = 12.1 Replace on Burnout = 13	30
		Nameplate	31
$\overline{EER}_{RAC}$	Variable	Default = 10.6	32
		Nameplate	33
CF_{CAC}	Fixed	0.70	34
CF_{RAC}	Fixed	0.58	35
$F_{Room,AC}$	Fixed	0.38	36

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes[37]

Measure	Measure Lifetime
Roof Insulation	40
Cavity Insulation	40

Water Savings
There are no water savings for this measure.

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

[29] PUC; *Act 129, 2021 Technical Reference Manual, Residential Measures*. Volume 2. (2019).
[30] Ibid.
[31] Contractor Gathering Data.
[32] PUC; *Act 129, 2021 Technical Reference Manual, Residential Measures*. Volume 2. (2019).
[33] Contractor Gathering Data.
[34] PUC; *Act 129, 2021 Technical Reference Manual, Residential Measures*. Volume 2. (2019).
[35] Ibid.
[36] From PECO baseline study, average home size = 2,323 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)/(2,323 ft^2) = 0.38.
[37] NYSERDA Home Performance with ENERGY STAR®.

4.1.3 High Efficiency Window

Draft date:	5/1/20
Effective date:	9/1/20
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 for retrofits is the U-factor value of the existing window. The baseline for a natural replacement or new construction project is the minimum window required by code. IECC 2015 for Philadelphia requires a U-factor of 0.35 or less.

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

Gas Savings Algorithms

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

Where:

HDD_t	=	Heating degree days at temperature t, where t=63°F if no programmable thermostat has been installed and t=62°F if a programmable thermostat has been installed. See reference table in section 8.1 on page 59~~57~~ for HDD.
24	=	Hours per day
AREA	=	Square feet of window area.
U_{base}	=	U-factor of baseline window.
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 52% have air-conditioning and estimate the cooling savings as 52% of a house with central air conditioning.[38]

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

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

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

[38] Percentage of houses with air conditioning from Act 129 SWE Residential Baseline Survey. (2018).

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

Where:

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

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

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

Where:

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

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

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. See reference tables section in section **Error! Reference source not found.**~~8.2~~ on page **Error! Bookmark not defined.**~~56~~.
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.
CF_{RAC} = Demand Coincidence Factor for Room AC systems.
$EFLH_{cool}$ = Equivalent Full Load Cooling hours for Central AC and ASHP. (See reference table in section **Error! Reference source not found.**~~8.2~~ on page **Error! Bookmark not defined.**~~56~~)
$EFLH_{cool\ RAC}$ = Equivalent Full Load Cooling hours for Room AC. (See reference table in section **Error! Reference source not found.**~~8.2~~ on page **Error! Bookmark not defined.**~~56~~)
$F_{Room\ AC}$ = 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	39
$SEER_{CAC}$	Variable	Default values: Early Replacement = 12.1 Replace on Burnout = 13	40
		Nameplate	41
$\overline{EER}_{RAC}$	Variable	Default = 10.6	42
		Nameplate	43
CF_{CAC}	Fixed	0.70	44
CF_{RAC}	Fixed	0.58	45
$F_{Room,AC}$	Fixed	0.38	46

Persistence
The persistence factor is assumed to be one.

Measure Lifetime[47]

Measure	Measure Lifetime
Window	30

Water Savings
There are no water savings for this measure.

Measure Cost
The incremental cost is the difference between a standard efficiency window and a high efficiency window.

[39] "*State of Ohio Energy Efficiency Technical Reference Manual*," prepared for the Public Utilities Commission of Ohio by Vermont Energy Investment Corporation. August 6, 2010.
[40] PUC; *Act 129, 2021 Technical Reference Manual, Residential Measures*. Volume 2. (2019).
[41] Contractor gathering data.
[42] DOE Federal Test Procedure 10 CFR 430, Appendix F (Used in ES Calculator for baseline).
[43] Contractor gathering data.
[44] PUC; *Act 129, 2021 Technical Reference Manual, Residential Measures*. Volume 2. (2019).
[45] Ibid.
[46] 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). $F_{Room,AC} = (425\ ft^2 * 2.1)/(2323\ ft^2) = 0.38$.
[47] NREL Measure Database.

4.2 Domestic Hot Water End Use

4.2.1 Low Flow Showerhead

Draft date: 5/1/20
Effective date: 9/1/20
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 2.2 GPM will be used.[48]

Definition of Efficient Condition
The flow rate of the efficient showerhead should be lower than the flow rate of the baseline condition. If the exact flow rate is not available it is assumed to be 1.5 GPM.

Water Savings Algorithms[49]
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 = 2.2 GPM if measured rate is not available
GPM_{eff}	= Maximum gallons per minute of the efficient showerhead
$N_{persons}$	= Average number of people per household. Actual or defaults: Single Family = 2.5, Multifamily = 1.7
$T_{person-day}$	= Average minutes per person per day used for showering. 7.8 min/day
$N_{showers-day}$	= Average number of showers per person per day. 0.6 showers/person/day
365	= Days per year
ISR	= In service rate. Self install Default = 35%. Contractor install Default = 100%.
$N_{showerheads-home}$	= Average number of showers per home. Actual or defaults: Single Family = 1.6, Multifamily = 1.1

Gas Savings Algorithms[50]
Gas energy savings result from reducing the amount of incoming cold water required to be heated due to the efficient showerhead.

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

[48] Schuldt, March and Debra Tachibana; Energy-related water fixture measurements: Securing the baseline for Northwest Single Family Homes." (2008).
[49] PUC; *Act 129, 2021 Technical Reference Manual, Residential Measures*. Volume 2. (2019).
[50] Ibid.

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%.

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.

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes[51]

Equipment Type	Measure Lifetime
Low-flow showerhead	9

Deemed Measure Cost
Incremental cost of a low-flow showerhead is $33.[52]

51 PUC; *Act 129, 2021 Technical Reference Manual, Residential Measures*. Volume 2. (2019).
52 Vermont Energy Investment Corporation [VEIC]; *Philadelphia Gas Works' Incremental Cost Review and RX Measure Recommendations for low-flow showerheads & faucet aerators. (*2018).

4.2.2 Low Flow Faucet Aerators

Draft date: 5/1/20
Effective date: 9/1/20
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 2.0 GPM.[53]

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.

Water Savings Algorithms[54]
The water savings for low flow faucet aerators are due to the reduced amount of water being used per minute that flows down the drain (instead of being collected in the sink).

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

Where:

$\Delta Gallons$	=	Gallons of water saved
GPMbase	=	Gallons per minute of baseline aerator = 2.0 GPM
GPMeff	=	Gallons per minute of the efficient aerator
$N_{persons}$	=	Average number of people per household. Actual or Defaults: Single Family=2.5, Multifamily=1.7
$T_{person-day}$	=	Average minutes per person per day of faucet hot water usage. Kitchen=4.5, Bathroom=1.6
365	=	Days per year
DF	=	Drain rate, the percentage of water flowing down the drain. Kitchen=75%, Bathroom=90%, Unknown=79.5%
ISR	=	In service rate. Kit delivery default = 28%, Direct install default = 100%
$N_{faucets-home}$	=	Average Number of Faucets per home. Actual or for defaults see table below.

Average Number of Faucets per Home[55]

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

53 Schuldt, March and Debra Tachibana; *Energy-related water fixture measurements: Securing the baseline for Northwest Single Family Homes.”* (2008).
54 PUC; *Act 129, 2021 Technical Reference Manual, Residential Measures*. Volume 2. (2019).
55 Ibid.

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

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

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

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

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes[56]

Equipment Type	Measure Lifetime
Low-flow faucet aerator	10

Deemed Measure Cost
Incremental cost of a low-flow faucet aerator is $8.[57]

[56] PUC; *Act 129, 2021 Technical Reference Manual, Residential Measures*. Volume 2. (2019).
[57] Vermont Energy Investment Corporation [VEIC]; *Philadelphia Gas Works' Incremental Cost Review and RX Measure Recommendations for low-flow showerheads & faucet aerators. (*2018).

4.2.3 Efficient Natural Gas Water Heater

Draft date: 5/1/20
Effective date: 9/1/20
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, 0.58 should be used. 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.

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
There are no water savings due to this measure.

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

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

Where:

UEF_{Base} = Uniform Energy Factor of baseline water heater = 0.58
UEF_{Eff} = Uniform Energy Factor of efficient water heater
V = Daily volume of hot water usage in gallons. If unknown, assume 55 gallons/day.
ρ = Water density at 125º F (8.24 lb/gal)
C_ρ = Specific heat of water (1.00 Btu/lb ºF)
67 = ºF 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 water heaters are installed in homes that heat water using natural gas. There are no additional electric savings claimed.

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes[58]

Equipment Type	Measure Lifetime
Tankless Water Heater	20

[58] *ENERGY STAR® Residential Water Heaters: Final Criteria Analysis* p. 10, April 1, 2008.

Water Savings
There are no water savings for this measure.

Deemed Measure Cost
The incremental cost is the difference between the full installed cost of a higher efficiency water heater and the full installed cost of a baseline efficiency water heater.

4.2.4 DHW Pipe Insulation

Draft date: 5/1/20
Effective date: 9/1/20
End date: TBD

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

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

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

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

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

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

The thickness of the DHW pipe insulation should be equivalent to the diameter of the piping. For example, a 1" diameter pipe should be insulated with 1" thick insulation; a 2-1/2" diameter pipe with 2-1/2" thick insulation.[59]

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

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

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

Gas Savings Algorithms

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

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%[60]

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

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

Insulation Thickness (inches)	Heat Loss (Btu/ft/yr)
Bare	268,231
0.5	86,461
1.0	65,350
1.5	51,421
2.0	44,851
2.5	38,544
3.0	36,004
3.5	33,989
4.0	32,412
4.5	30,923
5.0	29,872

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

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

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

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes[61]

Equipment Type	Measure Lifetime
DHW Pipe Insulation	20

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

[61] NYSERDA Home Performance with ENERGY STAR®.

5 Non-Residential Time of Replacement Market

5.1 Space Heating End Use

5.1.1 Efficient Boiler

Draft date: 5/1/20
Effective date: 9/1/20
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[62]	Baseline Thermal Efficiency 9/1/20 – 1/10/23	Baseline Thermal Efficiency – After 1/10/23
Gas Boiler ≥300,000 Btu/h and ≤2,500,000 Btu/h	80% Thermal Efficiency	84% Thermal Efficiency
Gas Boiler >2,500,000 Btu/h	82% Combustion Efficiency	85% Combustion Efficiency

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

Equipment Type	Minimum Thermal Efficiency
Gas Boiler	92%

Gas Savings Algorithms
MMBtu savings are realized due to the increase in Thermal Efficiency of the new equipment. Savings are calculated from the baseline new unit to the installed efficient unit.

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

Where:

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

[62] 10 CFR 431, Standards for Commercial Packaged Boilers. Reflects current federal standards, and new standards that will go into effect January 10, 2023.

Equivalent Full Load Heating Hours by Building Type

Building Type	EFLH[63]
Multifamily	1,435
Education	1,529
Food Sales	1,846
Food Service	2,021
Health Care	2,779
Lodging	778
Retail	1,519
Office	1,457
Public Assembly	1,752
Public Order/Safety	1,250
Religious Worship	1,509
Service	2,478
Warehouse/Storage	1,047

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

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes

Equipment Type	Measure Lifetime
Gas Boilers	25

Water Savings
There are no water savings for this measure.

Deemed Measure Cost[64]
The table below lists incremental costs for commercial boilers based on capacity ranges.

Min Capacity	Max Capacity	Incremental Cost
300	499	$6,138
500	799	$10,506
800	1,199	$16,850
1,200	1,599	$28,969
1,600	n/a	$33,141

[63] From NJ Protocols for Philadelphia, adjusted based on 2015 Commercial Equipment Rebate Program evaluation.
[64] Source: US Energy Information Administration, Updated Buildings Sector Appliance Equipment Costs and Efficiencies (2018) p. 98; Survey of equipment costs for models carried by major supply houses.

5.1.2 Low-Intensity Infrared Heater

Draft date: 5/1/20
Effective date: 9/1/20
End date: TBD

Measure Description
This measure applies to infrared heaters purchased at the time of natural replacement. A qualifying heater must meet minimum efficiency requirement.

Definition of Baseline Condition
The baseline equipment is a standard natural gas fired non-infrared heater.

Definition of Efficient Condition
The installed heaters must have electric ignition and use non-conditioned air for combustion.

Gas Savings Algorithms
A low-intensity infrared heater achieves MMBtu savings by providing same level of comfort at lower air temperatures than non-radiant systems, so the thermostat is set lower and conduction heat transfer is lower.

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

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

Equivalent Full Load Heating Hours by Building Type[66]

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

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

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes[67]

Equipment Type	Measure Lifetime
Low-Intensity Infrared Heater	17

Water Savings
There are no water savings for this measure.

Deemed Measure Cost
Incremental cost of a low-intensity infrared heater is $450.[68]

[66] From NJ Protocols for Philadelphia, adjusted based on EnergySense program independent evaluations.
[67] Mass Save; *Technical Reference Manual for estimating savings from energy efficiency measures.* (2016).
[68] Northeast Energy Efficiency Partnerships Incremental Cost Study, Phase Four Final Report, June 15, 2015.

5.1.3 Steam Trap

Draft date: 5/1/20
Effective date: 9/1/20
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 as indicated in the table below. 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)[69]	Heat of Vaporization, Hv (Btu/lb)[70]	Default Boiler Efficiency, B[71]	Operating Hours, H[72]	Adjustment Factor, A[73]	Leaking & Blow-thru Factor for Unaudited Traps, L[74]
Commercial/ Multifamily, Low Pressure	13.8	951	80%	2,720	50%	27%
Dry Cleaners	38.1	890	80%	2,425	50%	27%
Industrial Low Pressure PSIG<15	13.8	951	80%	7,752	50%	16%
Industrial Medium Pressure 15<PSIG<30	12.7	945	80%	7,752	50%	16%
Industrial Medium Pressure 30<PSIG<75	19	915	80%	7,752	50%	16%
Industrial High Pressure 75<PSIG<125	67.9	880	80%	7,752	50%	16%
Industrial High Pressure 125<PSIG<175	105.8	859	80%	7,752	50%	16%
Industrial High Pressure 175<PSIG<250	143.7	837	80%	7,752	50%	16%
Industrial High Pressure PSIG>250	200.5	816	80%	7,752	50%	16%

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

Persistence
The persistence factor is assumed to be one.

Measure Lifetime[75]

Equipment Type	Measure Lifetime
Steam Traps	6

[69] CLEAResult. *Work Paper Steam Traps Revision #2*. (March 2012).
[70] Ibid. 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.
[71] Ibid. Reference to California Energy Commission Efficiency Data for Steam Boilers.
[72] Ibid. Reference to Enbridge service territory data and kW Engineering study. Commercial/Multifamily hours adjusted to Philadelphia based on the HDD base 55 in Philadelphia relative to Chicago
[73] Enbridge adjustment factor used, as referenced in CLEAResult *Work paper Steam Traps Revision* #2. (2012) and DOE Federal Energy Management Program Steam Trap Performance Assessment.
[74] CLEAResult; "*Work PaperSteam Traps Revision* #2(2012). If trap is known to be leaking, then this factor is 100%.
[75] 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.

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

Deemed Measure Cost[76]
The incremental cost of a <15 PSIG steam trap is $77.
The incremental cost of a <15 PSIG <75 steam trap is $229.
The incremental cost of a >75 PSIG steam trap is $282.

[76] Illinois Commerce Commission [ICC]: *Illinois Statewide Technical Reference Manual for Energy Efficiency-Commercial and Industrial Measures,* Version 8.0, Volume 2. (2019).

5.1.4 Boiler Reset Controls

Draft date: 5/1/20
Effective date: 9/1/20
End date: TBD

Measure Description
This measure applies to improving system efficiency by adding controls to commercial heating boilers to vary the boiler entering water temperature relative to heating load as a function of the outdoor air temperature.

Definition of Baseline Condition
The baseline condition is an existing boiler without boiler reset controls.

Definition of Efficient Condition
Installation of boiler reset controls. The system must be set so that the minimum temperature is no greater than 10 degrees above manufacturer's recommended minimum return temperature.

Gas Savings Algorithms

$$\Delta MMBtu = \frac{CAP \times ESF \times EFLH}{1{,}000}$$

Where:

ESF = Estimated percent reduction in heating load due to controls being installed. See Savings Percentage table below.
EFLH = Full Load Heating Hours. If unknown, see table "Equivalent Full Load Heating Hours by Location" in Section 5.1.1.
CAP = Input capacity of boiler (BTU/hr).

Savings Percentage

Boiler Reset	8.0%

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

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes[77]

Equipment Type	Measure Lifetime
Boiler Reset Controls	20

Water Savings
There are no water savings for this measure.

Deemed Measure Cost
Incremental cost of this measure is $676.[78]

[77] Illinois Commerce Commission [ICC]: *Illinois Statewide Technical Reference Manual for Energy Efficiency-Commercial and Industrial Measures*, Version 7.0, Volume 2. (2018).
[78] Ibid.

5.1.5 Commercial Roof Insulation

Draft date:	5/1/20
Effective date:	9/1/20
End date:	TBD

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

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

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

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 reference table in section 8.1on page 59~~57~~ for HDD63 and HDD62.
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.

Energy Savings

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

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

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

Where:

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

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

Demand Savings

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

Where:

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

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

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).[79]
CDD	= Cooling Degree Days. See reference tables section at the end of this document.
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 tables below.

[79] Efficiency Vermont; *Technical Reference Manual: Measure Savings Algorithms and Cost Assumptions.* (2018).

Default Values for Algorithm Terms, Ceiling/Attic and Wall Insulation

Term	Type	Value	Source
DUA	Fixed	0.75	80
$SEER_{CAC}$	Variable	Default values: Early Replacement = 12.1 Replace on Burnout = 13	81
		Nameplate	82
$\overline{EER}_{RAC}$	Variable	Default = 10.6	83
		Nameplate	84
CF_{CAC}	Fixed	0.70	85
CF_{RAC}	Fixed	0.58	86
$F_{Room,AC}$	Fixed	0.38	87

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes[88]

Measure	Measure Lifetime
Insulation	40

Water Savings
There are no water savings for this measure.

Deemed Measure Cost
The incremental cost for this measure is $1.50 per square foot of insulation.[89]

[80] PUC; *Act 129, 2021 Technical Reference Manual, Residential Measures*. Volume 2. (2019).
[81] Ibid.
[82] Contractor Gathering Data.
[83] PUC; *Act 129, 2021 Technical Reference Manual, Residential Measures*. Volume 2. (2019).
[84] Contractor Gathering Data.
[85] PUC; *Act 129, 2021 Technical Reference Manual, Residential Measures*. Volume 2. (2019).
[86] Ibid.
[87] From PECO baseline study, average home size = 2,323 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). $F_{Room,AC} = (425\ ft^2 * 2.1)/(2,323\ ft^2) = 0.38$.
[88] NYSERDA Home Performance with ENERGY STAR®.
[89] 2020 Illinois TRM v.8.0

5.2 Commercial Kitchen End Uses

5.2.1 Commercial Gas Fryer

Draft date: 5/1/20
Effective date: 9/1/20
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® certification requirements.

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.[90]

Standard Fryer (per fry pot): $$Annual\ Gas\ Savings\ (MMBtu) = 50.80\ MMBtu$$

Large Vat Fryer (per fry pot): $$Annual\ Gas\ Savings\ (MMBtu) = 79.50\ MMBtu$$

Electric Savings Algorithms
There are no electric savings from this measure.

Energy Savings
ΔkWh = 0 kWh

Demand Savings
ΔkW = 0 kW

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

[90] USEPA & USDOE; *Savings Calculator for EnergyStar Certified Commercial Kitchen Equipment.* (2015).

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes[91]

Equipment Type	Measure Lifetime
Commercial Fryer	12

Water Savings
There are no water savings for this measure.

Deemed Measure Cost
The incremental cost of a standard fryer is $778.[92]
The incremental cost of a large vat fryer is $1,023.[93]

[91] UGI Gas; *Technical Reference Manual*. (2019).
[92] UGI Utilities Inc. - Gas Division; *Energy Efficiency & Conservation Plan.* Docket No. R-2018-3006814 (2019).
[93] Ibid.

5.2.2 Commercial Gas Steamers (Cooking)

Unique Measure Code(s): TBD
Draft date: 5/1/20
Effective date: 9/1/20
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[94].

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 Energy 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® certification requirements.

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.[95]

# of Pans	Annual Gas Savings (MMBtu)
3 pans	76.6
4 pans[96]	86.4
5 pans	96.2
6 pans	105.4
7 + pans	105.4 + 14.2 per pan > 6 pans

Electric Savings Algorithms
There are no electric savings from this measure.

Energy Savings

$\Delta kWh = 0\ kWh$

Demand Savings

[94] The baseline comes from PG&E's online calculator at http://www.fishnick.com/saveenergy/tools/calculators/gsteamercalc.php
[95] USEPA & USDOE; *Savings Calculator for EnergyStar Certified Commercial Kitchen Equipment.* (2015).
[96] The four pan is interpolated between 3 and 5 pan.

ΔkW = 0 kW

Where:

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

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes[97]

Equipment Type	Measure Lifetime
Commercial Steam Cooker	12

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.

Deemed Measure Cost[98]
The incremental cost of a 3-pan commercial steam cooker is $287.
The incremental cost of a 4-pan commercial steam cooker is $517.
The incremental cost of a 5-pan commercial steam cooker is $745.
The incremental cost of a 6-pan+ commercial steam cooker is $961.

[97] California Public Utilities Commission [CPUC]; *Database of Energy Efficiency Resources*. 2011.
[98] EnergyStar. *Savings Calculator for ENERGY STAR® Certified Commercial Kitchen Equipment*. 2015.

5.3 Commercial Domestic Hot Water End Use

5.3.1 Commercial Domestic Hot Water Heater

Draft date: 5/1/20
Effective date: 9/1/20
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
Baseline water heater is a standard efficiency gas-fired water heater, with a .81 UEF.[99]

Definition of Efficient Condition
The efficient heater is a storage or tankless gas water heater with a Thermal Efficiency equal to or exceeding 94%.

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:

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

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

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

[99] DOE Standard 10 CFR 430, Residential-Duty and Commercial Federal Standard

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%)[100].
$CAP_{H,e}$	= 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	**Annual Baseline Gas Usage Rate, E_b (MMBtu/ft2/yr)[101]**
Education	0.007
Grocery/Convenience Store	0.004
Restaurant/Cafeteria	0.0392
Inpatient Health Care	0.0343
Outpatient Health Care	0.0039
Lodging	0.026
Retail (other than in mall)	0.0025
Retail (in mall)	0.00141
Office	0.0048
Police/Fire Station/Jail	0.0214
Other	0.0023
Building Type	**Annual Baseline Gas Usage Rate, E_b (MMBtu/unit/yr)[102]**
Multifamily	22.5

Electric Savings Algorithms
There are no electric savings from this measure.

[100] ASHRAE 90.1-2007, Table 7.8.
[101] U.S. Energy Information Administration; *2012 Commercial Buildings Energy Consumption Survey: Energy Usage Summary Cooling energy sources, number of buildings and floorspace.* Table E7. (2016).
[102] GDS Associates, Inc. (2009). Natural Gas Energy Efficiency Potential in Massachusetts. Prepared for GasNetworks.

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.

Persistence

The persistence factor is assumed to be one.

Measure Lifetimes[103]

Equipment Type	Measure Lifetime
Commercial Tankless Water Heater	20
Commercial Storage Water Heater	15

Water Savings

There are no water savings for this measure.

Deemed Measure Cost

The incremental cost for a tankless commercial DHW heater is $2,425.[104]
The incremental cost for a storage commercial DHW heater is $1,844.[105]

[103] CA DEER 08, EUL_Summary_10-1-08.xls; MA TRM, October 2015; IL TRM, Volume 2, February 8, 2017.
[104] Illinois Commerce Commission [ICC]; *Illinois Statewide Technical Reference Manual for Energy Efficiency-Commercial and Industrial Measures,* Version 7.0, Volume 2. (2018).
[105] Ibid.

5.4 All End Uses

5.4.1 Custom Measure

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.

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.

Deemed Measure Cost
The incremental cost is the difference between the efficient equipment and the baseline equipment.

6 Non-Residential New Construction

6.1 All End Uses

6.1.1 Custom Measures

Draft date: 5/1/20
Effective date: 9/1/20
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 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 building". The primary residential energy code required in Philadelphia is the 2018 International Energy Conservation Code (IECC).

Definition of Efficient Condition
The efficient condition is any building design that uses less energy than the baseline building design. This lower energy use may be demonstrated by the receipt of an energy model that with savings is lower than the baseline or reference building score, or other verifiable energy models.
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.

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.

Deemed Measure Cost
The incremental cost is the difference between the efficient equipment and the baseline equipment.

7 Non-Residential Early Replacement

7.1 Space Heating End Use

7.1.1 Efficient Space Heating System

Draft date: 5/1/20
Effective date: 9/1/20
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.

$$Annual\ Gas\ Savings\ (MMBtu) = \frac{Capacity_{base}}{1{,}000} \times \left[\frac{1}{AFUE_{base}} - \frac{SR \times (1 + A_{avg})}{AFUE_{eff}}\right] \times EFLH_{Heat,base}$$

Where:

$$SR = \frac{Capacity_{eff}}{Capacity_{base}}$$

$$EFLH_{Heat,base} = \frac{Annual\ Gas\ Use_{base} \times AFUE_{base}}{Capacity_{base}}$$

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.
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.
$AFUE_{eff}$	=	Efficiency of proposed efficient space heating equipment.
$EFLH_{Heat,base}$	=	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).

Runtime Percent Change Adjustment[106]

Sizing Ratio (SR)	**Runtime 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

ΔkW = *BaselinekW - EfficientkW*

[106] Developed by Practical Energy Solutions using simulation modeling.

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.

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes[107]

Equipment Type	Measure Lifetime
Gas Furnaces	20
Gas Boilers	25

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

[107] Lifetime estimates used by Efficiency Vermont and PGW.

7.2 All End Uses

7.2.1 Custom Measures

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.

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 Reference Tables

8.1 Heating Degree Days, Cooling Degree Days, and EFLH

Heating Degree Days and Cooling Degree Days

Territory	**HDD63**[108]	**HDD62**[109]	**CDD65**[110]	**$EFLH_{cool}$ CAC (Hours)**[111]	**$EFLH_{cool}$ RAC (Hours)**[112]
Philadelphia	3,833	3,629	1,184	781	242

[108] Philadelphia Ten Year Degree Day Average from 2010-2019.
[109] Ibid
[110] PA PUC; *Act 129 TRM* , Appendix A. (2019).
[111] Ibid
[112] Ibid