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June 16, 2023

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

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

Dear Secretary Chiavetta:

On behalf of Philadelphia Gas Works ("PGW"), enclosed for filing please find its Demand Side Management Program Implementation Plan Fiscal Years 2024-2026 with regard to the above-referenced matter. The Implementation Plan describes program budgets and implementation details that PGW will follow to implement its EnergySense Demand-Side Management Portfolio from September 1, 2023 to August 31, 2026. PGW's 2024-2026 Technical Reference Manual is also included with this filing.

This document is being submitted consistent with the directives of the Commission in its tentative opinion and order entered August 4, 2016 and its final opinion and order entered November 1, 2016 at this docket. Copies to be served in accordance with the attached Certificate of Service.

Sincerely,

/s/ Lauren M. Burge

Lauren M. Burge

Enclosure

cc: Cert. of Service w/enc.
Cornelia Schneck, TUS w/enc. – cschneck@pa.gov

CERTIFICATE OF SERVICE

I hereby certify that this day I served a copy of the PGW's Implementation Plan for Fiscal Years 2024-2026 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 16, 2023

PHILADELPHIA GAS WORKS

ENERGYSENSE DEMAND SIDE MANAGEMENT PORTFOLIO

IMPLEMENTATION PLAN

FISCAL YEARS 2024-2026

JUNE 16, 2023

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I. DSM PORTFOLIO IMPLEMENTATION PLAN

A. Introduction

Philadelphia Gas Works' ("PGW" or the "Company") 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 Pennsylvania Public Utility Commission ("PUC" or "Commission") 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 No. P-2014-2459362 ("Final Order") that approved the continuation of five market rate DSM programs from FY 2017 – FY 2020.

Pursuant to that Final Order, DSM programming beyond FY 2020 was 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. Accordingly, PGW filed a Petition for Approval of its DSM plan for Fiscal Years 2021-2023 ("DSM Phase III") on May 6, 2020. Following the filing of the Petition for Approval, several Notices of Intervention by interested parties were filed with the PUC. These interventions and subsequent administrative proceedings resulted in a Joint Petition for Settlement that was approved by the PUC on May 6, 2021. Pursuant to that approval, the Revised EnergySense DSM Portfolio Implementation Plan was filed on June 4, 2021. 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 PGW will follow to implement its EnergySense Demand-Side Management Portfolio ("DSM Portfolio") in Fiscal Years 2024 through 2026 ("DSM Phase IV"). PGW's Fiscal Year is September through August.

PGW's DSM Portfolio has been and 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, 2023 to August 31, 2026, spanning FY 2024, FY 2025, and FY 2026. 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]

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; and may reallocate funds between programs.

B. New Features and DSM Portfolio Updates

1. Updated Rebates and Expanded Offerings

PGW will adjust some incentive amounts for residential and commercial rebates, and increase efficiency requirements for some equipment. This change is necessitated by challenges encountered in Phase III, including inflationary pressures/the COVID-19-induced supply chain crisis. PGW will institute a grandfathering policy for rebate programs to ensure that customers do not 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.

PGW will also launch new prescriptive offerings for residential and commercial measures. These include incentives for Residential Roof Insulation and Commercial Variable Refrigerant Flow (VRF) Natural Gas Heat Pumps. Additionally, PGW will launch a new EnergySense Kit (ESK) program, a Small Business Assessment (SBA) program and also an incentive for new residential multifamily construction projects as part of the Residential Construction Grants program.

PGW will maintain the tiered incentive caps for commercial and multifamily projects that incorporate measures from different PGW-defined categories. 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. This design assures rebate predictability for the customer.

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

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

2. EnergySense Kits

PGW will implement EnergySense Kits ("ESK"), a program that will help customers save energy and money by providing simple energy-saving measures that can be self-installed. Participation in ESK will be free for all PGW residential customers. The program fills a crucial gap by providing energy savings to the customers that do not qualify for PGW's Home Comfort weatherization program (which is its PUC-required Low Income Usage Reduction Program (LIURP)), but may not be making large purchases that would allow them to take advantage of the Residential Equipment Rebates program.

3. Small Business Assessments

PGW will implement Small Business Assessments, a program to encourage PGW small business customers to take advantage of the prescriptive rebate programs by providing free walkthrough energy assessments that recommend energy efficiency upgrades. Customers will receive a free walk-through energy assessment from a PGW-contracted technician to identify energy savings opportunities. The technician will perform a limited number of free and low-cost energy efficiency improvements, such as updating temperature set-points, installing pipe wrap, low-flow devices, minor air sealing and similar measures. Customers must agree to this set of measures as a condition of receiving the assessment. The technician will provide the customer a list of recommended energy efficiency improvements with estimated savings, which will include measures offered in PGW's EnergySense equipment rebate programs.

C. Portfolio Budgets, Savings, and Cost-Effectiveness

1. Budgets[2]

The following are PGW's budgets for the periods beginning in FY 2024 and running through FY 2026.

Table 1 – Projected Portfolio Budget by Program (Nominal)

Program	2024	2025	2026	TOTAL
Portfolio-wide Costs	$687,000	$687,000	$762,000	$2,136,000
Residential Equipment Rebates	$798,757	$798,757	$798,757	$2,396,271
EnergySense Kits	$181,699	$164,475	$164,475	$510,648
Smart Thermostat Marketplace	$94,014	$94,014	$144,014	$332,042
Low Income Smart Thermostat	$60,000	$110,000	$60,000	$230,000
Residential Construction Grants	$231,814	$231,814	$231,814	$695,441
Commercial Equipment Rebates	$323,955	$323,955	$323,955	$971,864
Small Business Assessment	$100,000	$100,000	$100,000	$300,000
TOTAL PORTFOLIO	**$2,477,238**	**$2,510,014**	**$2,585,014**	**$7,572,267**

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

Category	FY 2024	FY 2025	FY 2026	FY 2024 – FY 2026
Customer Incentives	$1,468,369	$1,492,369	$1,492,369	$4,453,108
Administration	$694,084	$652,154	$652,154	$1,998,392
Marketing	$240,000	$240,000	$240,000	$720,000
Inspections	$74,785	$75,491	$75,491	$225,767
Evaluation	-	$50,000	$125,000	$175,000
Total	**$2,477,238**	**$2,510,014**	**$2,585,014**	**$7,572,267**

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.

2. Savings

a) Gas savings

Table 3 – Projected Annual Natural Gas Savings (MMBtu)

Program	FY 2024	FY 2025	FY 2026	FY 2024 – FY 2026
Residential Equipment Rebates	14,227	14,227	14,227	42,682
EnergySense Kits	6,675	8,312	8,312	23,299
Smart Thermostat Marketplace	3,675	3,675	3,675	11,025
Low Income Smart Thermostat	866	866	866	2,597
Residential Construction Grants	2,572	2,572	2,572	7,715
Commercial Equipment Rebates	16,519	16,519	16,519	49,557
Small Business Assessment	618	618	618	1,853
Total	**45,151**	**46,788**	**46,788**	**138,727**

Table 4 – Projected Lifetime Natural Gas Savings (MMBtu)

Program	FY 2024	FY 2025	FY 2026	FY 2024 – FY 2026
Residential Equipment Rebates	340,425	340,425	340,425	1,021,275
EnergySense Kits	100,558	125,260	125,260	351,078
Smart Thermostat Marketplace	40,425	40,425	40,425	121,275
Low Income Smart Thermostat	9,521	9,521	9,521	28,562
Residential Construction Grants	51,433	51,433	51,433	154,300
Commercial Equipment Rebates	319,699	319,699	319,699	959,096
Small Business Assessment	12,355	12,355	12,355	37,065
Total	**874,416**	**899,117**	**899,117**	**2,672,651**

b) Non-Gas Savings

Table 5 – Projected Incremental Annual Electricity Savings (MWh)

Program	FY 2024	FY 2025	FY 2026	FY 2024 – FY 2026
Residential Equipment Rebates	-	-	-	-
EnergySense Kits	-	-	-	-
Smart Thermostat Marketplace	45	45	45	134
Low Income Smart Thermostat	19	19	19	58
Residential Construction Grants	1	1	1	2
Commercial Equipment Rebates[3]	(5)	(5)	(5)	(16)
Small Business Assessment	4	4	4	13
Total	**64**	**64**	**64**	**191**

[3] Negative electric savings: Natural gas-fired heat pumps consume electricity during their operation and therefore result in increased site electric load for the Commercial Equipment Rebates Program.

Table 6 – Projected Incremental Lifetime Electricity Savings (MWh)

Program	FY 2024	FY 2025	FY 2026	FY 2024 – FY 2026
Residential Equipment Rebates	-	-	-	-
EnergySense Kits	-	-	-	-
Smart Thermostat Marketplace	492	492	492	1475
Low Income Smart Thermostat	212	212	212	636
Residential Construction Grants	13	13	13	38
Commercial Equipment Rebates	(107)	(107)	(107)	(320)
Small Business Assessment	87	87	87	261
Total	**697**	**697**	**697**	**2091**

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

Program	FY 2024	FY 2025	FY 2026	FY 2024 – FY 2026
Residential Equipment Rebates	-	-	-	-
EnergySense Kits	2	2	2	7
Smart Thermostat Marketplace	-	-	-	-
Low Income Smart Thermostat	-	-	-	-
Residential Construction Grants	2	2	2	5
Commercial Equipment Rebates	6	6	6	17
Small Business Assessment	0	0	0	0
Total	**9**	**10**	**10**	**28**

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 2023 dollars, of $15.72 million with a benefit cost ratio ("BCR") of 2.31.

a) Projected Performance

Table 8 – Projected Cost-Effectiveness Results (2023$)

Program	TRC PV Benefits	TRC PV Costs	TRC PV Net Benefits	TRC BCR
Portfolio-wide Costs	-	$1,969,475	($1,969,475)	-
Residential Equipment Rebates	$9,443,754	$4,802,399	$4,641,356	1.97
EnergySense Kits	$3,710,533	$487,622	$3,222,911	7.61
Smart Thermostat Marketplace	$2,059,741	$421,762	$1,637,979	4.88
Low Income Smart Thermostat	$380,058	$215,116	$164,942	1.77
Residential Construction Grants	$2,304,435	$990,741	$1,313,694	2.33
Commercial Equipment Rebates	$9,447,830	$2,865,319	$6,582,510	3.30
Small Business Assessment	$427,182	$291,905	$135,277	1.46
Total	**$27,773,533**	**$12,044,338**	**$15,729,195**	**2.31**

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.
- Small Business Assessment Contractor – in this role, the vendor will perform walk-through energy assessments, install low-cost energy efficiency measures, and recommended energy efficiency improvements to customers.
- Low Income Smart Thermostat Installation Vendor – in this role, the vendor will provide and install ENERGY STAR certified smart thermostats in the homes of eligible low-income PGW customers, at no cost to the customer.
- EnergySense Kits Provider – in this role, the vendor will assemble and ship energy saving kits to PGW customers at no cost to PGW customers.

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.

Program or Organization and Description of Coordination
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 continue to 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

PGW will rely on consumer-focused marketing activities to build awareness about the new rebate offerings. This approach has been successful in past marketing efforts for EnergySense, and will be used to support is the launch of PGW's new EnergySense Kits program, among other new offerings. PGW will need to conduct mass marketing activities to generate awareness about this new offer among its residential customer base.

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 EnergySense Kits 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 pursuing energy efficiency upgrades. PGW will also maintain outreach to non-English speaking communities, and has worked with an outreach vendor in recent years to support translation and event tabling targeting non-English speaking customers.

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 rely on virtual inspections using digital tools that allow for greater customer convenience and cost-savings, while still ensuring quality. For customers who prefer virtual 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 will 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 2024 – FY 2026. 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 below provides the anticipated continuation and reporting process from FY 2024 – FY 2026.

Table 9 – Timeline for Continuation & Reporting Process

Fiscal Year	Continuation or Reporting Activity
2024	• FY 2023 Annual Report (December/January) • FY 2025 Implementation Plan (May, if warranted)
2025	• FY 2024 Annual Report (December/January) • FY 2026 Implementation Plan (May, if warranted)
2026	• FY 2025 Annual Report (December/January) • Objection Deadline to Continued DSM Programming (February) • FY 2027 – 2029 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 2023 based on current commodity costs and charges for pipeline and storage capacity. The February 2023 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.

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 III 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 Phases I through III. 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. VRF Natural Gas Heat Pump
ii. Residential Building Roof Insulation
iii. New measures for EnergySense Kits

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-effectiveness assessments.

II. Program Plans

This section provides an overview of the implementation activities, planned for FY 2024-2026 for the seven DSM programs comprising PGW's EnergySense Portfolio:

- Residential Equipment Rebates
- Commercial Equipment Rebates
- Residential Construction Grants
- Smart Thermostat Marketplace
- Low Income Smart Thermostats
- Small Business Assessments
- EnergySense Kits

A. Residential Equipment Rebates Program

1. Program Description

The Residential Equipment Rebates ("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. Beginning in Phase IV, customers will be able to receive a rebate for increasing their roof insulation.

2. Costs, Savings, and Benefits

Projections

The program aims to issue rebates for 3,792 pieces of equipment from FY 2024 – FY 2026, with associated annualized gas savings of 42,682 MMBtu. The program is projected to cost $2,396,271 from FY 2024 – FY 2026. The following table shows a detailed breakout of participation, costs, and savings.

Table 10 – Projected RER Impacts

Projected Budgets (Nominal)	FY 2024	FY 2025	FY 2026	FY 2024 – FY 2026
Projected Budgets (Nominal)				
Customer Incentives	$711,568	$711,568	$711,568	$2,134,704
Administration	$50,599	$50,599	$50,599	$151,677
Inspections	$36,630	$36,630	$36,630	$109,890
TOTAL:	**$798,757**	**$798,757**	**$798,757**	**$2,396,271**
Natural Gas Savings (MMBtus)				
Incremental Annual	14,227	14,227	14,227	42,682
Incremental Lifetime	340,425	340,425	340,425	1,021,275
Projected Participation				
Rebates Awarded	1,264	1,264	1,264	3,792

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, combination boilers, and tankless water heaters. It will also launch rebate offerings for residential roof and attic insulation. Additionally, PGW will continue offering increased incentives to low-income customers that participate in the RER program. Customers will be considered low-income if they have been enrolled in PGW's Customer Responsibility Program ("CRP") 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. PGW will not perform income verification as part of its RER program. PGW will award this incentive tier for the first 400 pieces of equipment to be approved per fiscal year. PGW will report on low-income rebate participation in its Annual Reports filed in this docket, including the number of each type of equipment rebated, and also the housing agencies with which PGW coordinated and the number of measures coordinated. The following table shows the anticipated rebate schedule.

Table 11 – Residential Equipment Rebate Amounts

Measure	Eligibility	First Rebate Per-Project	First Rebate Per-Project (Low Income)	Additional Rebates Per-Project
Natural Gas Furnace	95% AFUE	$400	$800	$250
Natural Gas Water Boiler	94% AFUE	$1,000	$1,400	$700
Natural Gas Combination Boiler	94% AFUE	$1,400	$2,000	$1,000
Tankless Water Heater	ENERGY STAR®	$400	$700	$400
Residential Roof Insulation (Tier 1)	Finished R-Value ≥ R-49	$0.65/sf (+$100 w/Air Sealing)	$0.95/sf (+$100 w/Air Sealing)	-
Residential Roof Insulation (Tier 2)	Finished R-Value ≥ R-38	$0.35/sf (+$50 w/Air Sealing)	$0.50/sf (+$50 w/Air Sealing)	-

PGW rebates are designed to cover between 35-75% of the incremental cost between standard efficiency and high efficiency models. Given PGW's expanded prescriptive rebate structure, RER incentives per project will continue to be capped at different levels based on the project's installation tier as described in Section I.B.1

PGW is introducing a new prescriptive offering for residential roof and attic insulation. The rebates for this measure will be assessed on a tiered basis, depending on the finished R-Value of insulation installed. All PGW residential customers who use natural gas for space heating and install insulation in existing buildings will be eligible to receive this rebate. The insulation must be installed by a Building Performance Institute (BPI) certified contractor, and applicants will be required to submit documentation evidencing contractors' credentials in order to qualify for a rebate.

Projected Activity

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

Table 12 – Projected Rebates Participation by Equipment Type

Product	FY 2024	FY 2025	FY 2026	FY 2024 – FY 2026
Natural Gas Furnace	616	616	616	1,848
Natural Gas Boiler	208	208	208	624
Combi Boiler	108	108	108	324
Tankless Water Heater	52	52	52	156
Roof/Attic Insulation	280	280	280	840
Total	**1,264**	**1, 264**	**1, 264**	**3,792**

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.

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 and 390 multifamily residential homes from FY 2024 – FY 2026, with associated annualized gas savings of 7,715 MMBtu. The program is projected to cost $695,441.

Table 13 – Projected RCG Impacts

	FY 2024	FY 2025	FY 2026	FY 2024 – FY 2026
Projected Budgets (Nominal)				
Customer Incentives	$221,814	$221,814	$221,814	$665,441
Administration	$6,000	$6,000	$6,000	$18,000
Inspections	$4,000	$4,000	$4,000	$12,000
TOTAL:	**$231,814**	**$231,814**	**$231,814**	**$695,441**
Natural Gas Savings (MMBtus)				
Incremental Annual	2,572	2,572	2,572	7,715
Incremental Lifetime	51,443	51,443	51,443	154,300
Projected Participation				
Single Family	100	100	100	300
Multifamily	130	130	130	390

3. Program Eligibility and Incentives

RCG's target market is a new construction or gut rehabilitation single and multi-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.

Under the Residential Construction Grants program, PGW will pay builders an incentive for achieving natural gas savings beyond energy code requirements. It will consist of two components:

Single family program: The single family new construction program will award incentives to builders who exceed the residential building code (2015 International Energy Conservation Code, or "IECC") by at least 15%. The expected grant award is $1,600. This is a continuation of the RCG program that PGW has implemented from 2021-2023. Builders must use natural gas for both space heat and domestic hot water.

Multifamily Program: PGW proposes to add a multifamily component of the New Construction Program. It will offer grants for builders who exceed the 2018 IECC by more than 15%. Adding this component allows PGW to claim significant cost-effective savings for air sealing and insulation and other measures, at minimal cost to the program. There will be two rebate tiers. Buildings that use natural gas for space heating and domestic hot water will earn $550 per unit, and buildings that use natural gas solely for space heating will earn $375 per unit. The program will be designed in coordination with other EnergySense programs in order to give the builder the most generous incentive. So if a builder submitted a project and would earn $5,500 for a 10 unit building through RCG, but would earn $7,000 if they went through the prescriptive equipment rebate

programs for a commercial boiler and water heaters, PGW would approve the $7,000 incentive.

For both programs, 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 building, and submission of the model is one of the ways that builders can comply with the City of Philadelphia's energy code requirements. HERS is a common tool used for energy code compliance and other DSM new construction programs in the region, including the UGI and PECO programs. 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, may perform additional HERS ratings and on-site visits as needed to validate savings claims.

C. Commercial Equipment Rebates Program

1. Program Description

The Commercial Equipment Rebates ("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

Projections

The program aims to issue rebates for 9,333 pieces of equipment[4] from FY 2024 – FY 2026, with associated annualized gas savings of 49,557 MMBtu. The program is projected to cost $971,864. The following table shows a detailed breakout of participation, costs, and savings.

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

Total PGW spending for the CER Program for the cumulative FY 2024 to FY 2026 period shall not exceed the budget shown in the table below ($971,864) by more than 15 percent.

Table 14 – Projected CER Impacts

	FY 2024	FY 2025	FY 2026	FY 2024 – FY 2026
Projected Budgets (Nominal)				
Customer Incentives	$284,703	$284,703	$284,703	$854,109
Administration	$20,533	$20,533	$20,533	$61,598
Inspections	$18,719	$18,719	$18,719	$56,157
TOTAL:	**$323,955**	**$323,955**	**$323,955**	**$971,864**
Natural Gas Savings (MMBtus)				
Incremental Annual	16,519	16,519	16,519	49,557
Incremental Lifetime	319,699	319,699	319,699	959,096
Projected Participation				
Rebates Awarded	3,111	3,111	3,111	9,333

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 the program. 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, commercial cooking equipment, low-flow faucet aerators and showerheads, boiler reset controls, low-intensity infrared heaters, and roof insulation. A new addition to CER measures will be Variable Refrigerant Flow (VRF) natural gas heat pumps, an emerging technology that allows for different zones within a building to be heated and cooled simultaneously.

Incentives for CER measures range between 17% and 71% of measure incremental costs, with most measures ranging in the 40-50% range. Incentive spending for the Commercial Equipment Rebate Program shall be below 55% of the TRC costs for the 2024 – 2026 period. PGW will report on this statistic in the FY2026 Annual Report.

PGW will continue to endeavor to provide DSM plan benefits in the CER Program to small business customers that is reasonably commensurate to small businesses' share of GS-Commercial class load. PGW will provide separate reporting on actual small business participation in the Commercial Equipment Rebate Program with respect to number of participants, annual savings, incentive payments, customer costs, and TRC costs/benefits. Pursuant to PGW's tariff, a "small business" is "a person, sole proprietorship,

partnership, corporation, association or other business whose annual gas consumption does not exceed 300 Mcf."

.

Table 15 – Commercial Equipment Rebate Amounts

Equipment	Efficiency Requirement	Rebate
Commercial Boiler	92 Et	$2,700 - $9,000
Steam Trap (<15 PSIG)	N/A	$50
Steam Trap (≤ 15PSIG < 75)	N/A	$130
Steam Trap (≥ 75 PSIG)	N/A	$150
Low-flow Faucet Aerator (per unit)	1.5 GPM	$5 (minimum of 10)
Low-flow Showerhead (per unit)	1.75 GPM	$18 (minimum of 10)
Commercial Water Heater (Storage)	96 Et	$4.25 / MBH
Commercial Water Heater (Tankless)	96 Et	$4.25 / MBH
Gas Fryer (Standard)	ENERGY STAR	$425
Gas Fryer (Large)	ENERGY STAR	$625
Steam Cooker (3 pans)	ENERGY STAR	$175
Steam Cooker (4 pans)	ENERGY STAR	$300
Steam Cooker (5 pans)	ENERGY STAR	$400
Steam Cooker (6+ pans)	ENERGY STAR	$510
Boiler Reset Controls	N/A	$400
Low-intensity Infrared Heater	≥ 80% Et	$300
Roof Insulation	R-49	$0.60 / sf
VRF Natural Gas Heat Pump	>100% AFUE	$450/ton

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. EnergySense Kits

1. Program Description

The EnergySense Kits ("ESK") program will offer free energy efficiency kits to all PGW residential customers. The kits will be shipped directly to customers for self-installation and will include installation instructions and contact information if further assistance is needed. ESK will provide two types of kits with a predetermined number of energy efficiency measures – one for customers with natural gas space heating and one for customers with natural gas water heating. Customers with natural gas water heating will receive equipment such as faucet aerators and low-flow showerheads, while customers with gas space heating will receive measures such as caulk and foam sealant. Customers who use natural gas for both purposes will receive a single kit with measures from both the space heating and water heating kits. Customers will complete a simple webform that

will determine which kit they will receive. The program will be available to all residential customers at no cost.

2. Costs, Savings, and Benefits

Projections

The program aims to incentivize 6,050 kits over the next period, with associated annualized gas savings of 23,229 MMBtu. The program is projected to cost $510,648.

Table 16 – Projected EnergySense Kits Impacts

	FY 2024	FY 2025	FY 2026	FY 2024 – FY 2026
Projected Budgets (Nominal)				
Customer Incentives	$83,863	$107,863	$107,863	$299,588
Administration	$94,749	$52,819	$52,819	$200,387
Inspections	$3,087	$3,793	$3,793	$10,673
TOTAL:	**$181,699**	**$164,475**	**$164,475**	**$510,648**
Natural Gas Savings (MMBtus)				
Incremental Annual	6,675	8,312	8,312	23,299
Incremental Lifetime	100,558	125,260	125,260	351,078
Projected Participation				
Kits	1,750	2,150	2,150	6,050

3. Program Eligibility and Incentives

The ESK program is open to all residential customers, but is designed to be particularly beneficial to low-income customers. It is a free program that fills a crucial gap in providing energy savings to the low-income customers that do not qualify for PGW's Home Comfort weatherization program, and lower income customers who may not have extra funds for the ESK components, but are not likely to be making large purchases that would allow them to take advantage of the Residential Equipment Rebates program.

4. Evaluation and Verification Inspections

PGW may perform on-site or virtual verifications as outlined in section I.G. PGW will primarily perform verifications in this program by fielding online surveys to all participants to ensure the measures included in the kits are installed in homes with natural gas heating and/or water heating equipment and that the properties have active PGW service.

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

E. Smart Thermostat Marketplace

1. Program Description

The Marketplace program offers direct sales of rebate-discounted ENERGY STAR certified smart thermostats to eligible PGW customers. PGW has relied on a third-party vendor to design the website and implement the program. The Marketplace website is available via PGW My Account and offers 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 HVAC systems. Thermostats purchased through the Marketplace must be self-installed by the customer or by a hired contractor. PGW does not provide installation services for thermostats purchased through the Marketplace.

2. Costs, Savings, and Benefits

Projections

The program aims to incentivize 2,100 thermostats over the next period, with associated annualized gas savings of 11,025 MMBtu. The program is projected to cost $332,042.

Table 17 – Projected Smart Thermostat Marketplace Impacts

	FY 2024	FY 2025	FY 2026	FY 2024 – FY 2026
Projected Budgets (Nominal)				
Customer Incentives	$48,039	$48,039	$48,039	$144,118
Administration	$33,626	$33,626	$33,626	$100,877
Inspections	$12,349	$12,349	$12,349	$37,047
Evaluation	-	-	$50,000	$50,000
TOTAL:	**$94,014**	**$94,014**	**$144,014**	**$332,042**
Natural Gas Savings (MMBtus)				
Incremental Annual	3,675	3,675	3,675	11,025
Incremental Lifetime	40,425	40,425	40,425	121,275
Projected Participation				
Thermostats	700	700	700	2,100

3. Program Eligibility and Incentives

The program's target market includes PGW firm-rate residential and commercial customers seeking to retrofit an existing natural gas 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 limits the number of thermostats that may be purchased through the Marketplace to three per customer, with the second and third purchases receiving smaller instant rebates. 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 five to 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 is undergoing evaluation at the time of the filing of this Plan. It will be further evaluated when there is additional adequate program activity to review post-usage data.

F. Low Income Smart Thermostats

1. Program Description

The Low-Income Smart Thermostat ("LIST") 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 rely on a vendor 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. PGW will also allow customers to apply for the program via a webform that can be accessed on the EnergySense website. They may also provide customers the thermostat for the customer to self-install when requested and deemed appropriate.

2. Costs, Savings, and Benefits

<u>Projections</u>

The program aims to incentivize 450 thermostats over the next period, with associated annualized gas savings of 2,597 MMBtu. The program is projected to cost $230,000.

Table 18 – Projected Low Income Smart Thermostat Impacts

	FY 2024	FY 2025	FY 2026	FY 2024 – FY 2026
Projected Budgets (Nominal)				
Customer Incentives	$18,382	$18,382	$18,382	$55,147
Administration	$41,618	$41,618	$41,618	$124,853
Evaluation	-	$50,000	-	$50,000
TOTAL:	**$60,000**	**$110,000**	**$60,000**	**$230,000**
Natural Gas Savings (MMBtus)				
Incremental Annual	866	866	866	2,597
Incremental Lifetime	9,521	9,521	9,521	28,562
Projected Participation				
Thermostats	150	150	150	450

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. Customers will also be considered low-income if their reported annual income is below 150% of the Federal Poverty Level for their household size. PGW will not perform income verification as part of the LIST program. Customers will not be required to have WiFi connectivity in their homes in order to participate in the program; however, PGW will advice participants about the benefits of having the device connected to the internet and provide general guidance on how customers can obtain free internet service through the Affordable Connectivity Program (ACP).

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. The program is undergoing evaluation at the time of the filing of this Plan. It will be further evaluated when there is additional adequate program activity to review post-usage data.

In its Annual Reports, PGW will report on the number of self-installed thermostats and vendor-installed thermostats.

G. Small Business Assessments

1. Program Description

The Small Business Assessments ("SBA") program seeks to encourage PGW small business customers to take advantage of the prescriptive rebate programs by providing free walkthrough energy assessments that recommend energy efficiency upgrades. The free energy assessments may also include a limited number of no-cost or low-cost measures (i.e., Faucet aerators, temperature setbacks, etc.)

2. Costs, Savings, and Benefits

Projections

The program aims to perform assessments for 102 small business customers from FY 2024 – FY 2026, with associated annualized gas savings of 1,853 MMBtu. The program is projected to cost $300,000.

Table 19 – Projected SBA Impacts

	FY 2024	FY 2025	FY 2026	FY 2024 – FY 2026
Projected Budgets (Nominal)				
TOTAL:	$100,000	$100,000	$100,000	$300,000
Natural Gas Savings (MMBtus)				
Incremental Annual	618	618	618	1,853
Incremental Lifetime	12,355	12,355	12,355	37,065
Projected Participation				
Assessments	34	34	34	102

3. Program Eligibility and Incentives

SBA's target market includes PGW commercial customers whose annual gas usage is less than 300 MBH and have buildings under 50,000 square feet. Buildings over 50,000 square feet will not be eligible for SBA because they are already mandated to participate in energy benchmarking and "Building Tune-ups" due to the City of Philadelphia's requirements for commercial properties. As such, there is an existing incentive and pathway for these large commercial customers to pursue energy efficiency. SBA will seek to serve commercial customers whose size does not trigger compliance with the City's programs, and who may not have resources available to purchase this type of work.

PGW will establish a list of vendors who are preapproved to perform the energy assessments. The incentive for each customer will be limited to $2,500 for the energy assessment and associated report, with an additional $500 available for direct-installation

measures, for a total maximum incentive of $3,000 per customer. This incentive cap will help to control costs and serve as many customers as possible.

SBA will serve as a lead generator to direct customers towards PGW's prescriptive rebate programs, namely CER, while also achieving energy savings through no-cost and low-cost opportunities. Customers will receive a free walk-through energy assessment from a PGW-contracted technician to identify energy savings opportunities. The technician will perform free and low-cost energy efficiency improvements, such as updating temperature set-points, installing pipe wrap, low-flow devices, minor air sealing and similar measures. Customers must agree to this set of measures as a condition of receiving the free assessment. The technician will provide the customer a list of recommended energy efficiency improvements with estimated savings, which will include measures offered in PGW's EnergySense equipment rebate programs.

4. Evaluation, Monitoring, and Verification

PGW will perform on-site or virtual verifications as outlined in section I.G. PGW has set a target to inspect at least ten percent of claims to ensure that direct-install measures are installed on natural gas heating equipment at businesses with active PGW service.

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

III. Appendices

A. PGW Natural Gas Avoided Costs, including DRIPE (2023$)

Calendar Year	Baseload $ / MMBTu	Space Heating $ / MMBtu	DHW $ / MMBtu
2023	$5.01	$13.52	$7.13
2024	$5.11	$13.63	$7.24
2025	$5.19	$13.74	$7.33
2026	$5.18	$13.76	$7.32
2027	$5.19	$13.79	$7.34
2028	$5.23	$13.86	$7.39
2029	$5.34	$13.99	$7.50
2030	$5.42	$14.11	$7.59
2031	$5.53	$14.22	$7.70
2032	$5.53	$14.22	$7.70
2033	$5.53	$14.22	$7.70
2034	$5.53	$14.22	$7.70
2035	$5.53	$14.22	$7.70
2036	$5.53	$14.22	$7.70
2037	$5.53	$14.22	$7.70
2038	$5.53	$14.22	$7.70
2039	$5.53	$14.22	$7.70
2040	$5.53	$14.22	$7.70
2041	$5.53	$14.22	$7.70
2042	$5.53	$14.22	$7.70
2043	$5.53	$14.22	$7.70
2044	$5.53	$14.22	$7.70
2045	$5.53	$14.22	$7.70
2046	$5.53	$14.22	$7.70
2047	$5.53	$14.22	$7.70
2048	$5.53	$14.22	$7.70
2049	$5.53	$14.22	$7.70
2050	$5.53	$14.22	$7.70

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
ESK	EnergySense Kits Program
FY	Fiscal Year (PGW's fiscal year goes from September 1 to August 31)
LIST	Low Income Smart Thermostat Program
PA	Pennsylvania
PV	Present Value
PGW	Philadelphia Gas Works
RCG	Residential Construction Grant Program
RER	Residential Equipment Rebates Program
SBA	Small Business Assessments
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 technical reference manual has been provided as a separate document.

Technical Reference Manual

Measure Savings Algorithms

(Market Rate Programs)

September 1, 2023

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 FY2021-2023. 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. Illinois TRM
    b. Northeast Energy Efficiency Partnerships (NEEP) Mid-Atlantic 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 2023 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: 5/1/23
Effective date: 9/1/23
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 (761 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 $813.[4]
Incremental cost of a boiler is $1,961.[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 11.0, Volume 3. (2022).
[4] Survey of equipment costs for models carried by major supply houses.
[5] Ibid.

2.1.2 Smart Thermostat

Draft date: 5/1/23
Effective date: 9/1/23
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 82 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 PGW Online Marketplace participants in FYs 2021 & 2022.
[7] Pennsylvania Public Utility Commission [PUC]; *Act 129, 2021 Technical Reference Manual, Residential Measures*. Volume 2. (2019, Revised 2021).

Energy Savings

ΔkWh = ΔkWh_{Aux} + ΔkWh_{Cool}

ΔkWh_{Aux} = Furnace Fan kWh savings

ΔkWh_{Cool} = 0 kWh if house has no air conditioning, or unknown
= $\Delta kWh_{CAC,}$ 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, revised 2021).
[9] Ibid.
[10] Illinois Commerce Commission [ICC]: *Illinois Statewide Technical Reference Manual for Energy Efficiency-Residential Measures,* Version 8.03, Volume 3. (2020).

2.1.3 Residential Roof Insulation

Draft date: 5/1/23
Effective date: 9/1/23
End date: TBD

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

Definition of Baseline Condition
The baseline is amount of insulation in the residential unit in its pre-treatment condition. If existing condition is unknown, pre-treatment condition is assumed to be R-19.

Definition of Efficient Condition
An increase in insulation that will reduce energy consumption compared to the pre-treated condition. Minimum R-38.

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 66 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).[11]
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.

[11] 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	12
$SEER_{CAC}$	Variable	Default values: Early Replacement = 12.1 Replace on Burnout = 13	13
		Nameplate	14
$\overline{EER}_{RAC}$	Variable	Default = 10.6	15
		Nameplate	16
CF_{CAC}	Fixed	0.70	17
CF_{RAC}	Fixed	0.58	18
$F_{Room,AC}$	Fixed	0.38	19

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes[20]

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 $1.62 per square foot of insulation.[21]

[12] PUC; *Act 129, 2021 Technical Reference Manual, Residential Measures*. Volume 2. (2019).
[13] Ibid.
[14] Contractor Gathering Data.
[15] PUC; *Act 129, 2021 Technical Reference Manual, Residential Measures*. Volume 2. (2019).
[16] Contractor Gathering Data.
[17] PUC; *Act 129, 2021 Technical Reference Manual, Residential Measures*. Volume 2. (2019).
[18] Ibid.
[19] 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.
[20] NYSERDA Home Performance with ENERGY STAR®.
[21] PUC; Act 129, SWE Team Incremental Measure Cost Database. Volume 4.0. (2020).

2.2 Domestic Hot Water End Use

2.2.1 Tankless Water Heater

Draft date: 5/1/23
Effective date: 9/1/23
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[22]

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

[22] 10 CFR 430.32. *Energy and Water Conservation Standards*. Based on the federal standard for residential gas-fired storage water heater and assumed typical 40 gallon storage. (Up to date as of 1/30/2023).

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[23]

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 $611.[24]

[23] U.S. Energy Information Administration [EIA]; *Updated Buildings Sector Appliance Equipment Costs and Efficiency.* (2018).
[24] Illinois Commerce Commission [ICC]: *Illinois Statewide Technical Reference Manual for Energy Efficiency-Residential Measures,* Version 11.0, Volume 3. (2022).

2.3 Combined Space Heating and Domestic Hot Water End Use

2.3.1 Combination Boiler - Space Heating and DHW

Draft date: 5/1/23
Effective date: 9/1/23
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[25]

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)

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

[25] 10 CFR 430.32. *Energy and Water Conservation Standards.* Based on the federal standard UEF for medium draw pattern DHW. (Up to date as of 1/30/2023).

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)[26]

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[27]

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 $2,469.[28]

[26] 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.
[28] Illinois Commerce Commission [ICC]: *Illinois Statewide Technical Reference Manual for Energy Efficiency-Residential Measures,* Version 11.0, Volume 3. (2022).

2.4 All End Uses

2.4.1 Custom Measure

Draft date: 5/1/23
Effective date: 9/1/23
End date: TBD

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

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

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

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

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

Where:

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

Electric Savings Algorithms

Energy Savings
ΔkWh = *BaselinekWh - EfficientkWh*

Demand Savings
ΔkW = *BaselinekW - EfficientkW*

Where:

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

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: 5/1/23
Effective date: 9/1/23
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
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
The measure lifetime of Residential New Construction is 20 years.[29] 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 single-family home is $1,969. It includes a cost of $1,417 for gas conservation measures[30] and $552 for HERS rating[31].

The incremental cost for an average Philadelphia multifamily home is $1,113. It includes a cost of $813 for gas conservation measures[32] and $300 for HERS rating[33].

[29] Determined by survey of estimated measure lifetime used in Pennsylvania Act 129 New Construction Programs, and Mid Atlantic TRM, V9.
[30] Cost & Savings Estimates ENERGY STAR Certified Homes, Version 3.1 (Rev. 09).
[31] Survey of costs in Act 129 Programs and local marketplace.
[32] Cost & Savings Estimates ENERGY STAR Certified Homes, Version 3.1 (Rev. 09).
[33] 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: 5/1/23
Effective date: 9/1/23
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[34]:

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.[35]

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

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

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

Where:

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

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 66 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 66 for HDD63.

Energy Savings

ΔkWh = 0 kWh

Demand Savings

ΔkW = 0 kW

Persistence

The persistence factor is assumed to be one.

Measure Lifetimes[36]

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.[37]
The cost of a high efficiency early replacement boiler is $5, 010.[38]

The cost of a baseline efficiency furnace is $2,132.
The cost of a baseline efficiency boiler is $4,134.[39]

[36] Illinois Commerce Commission [ICC]; *Illinois Statewide Technical Reference Manual for Energy Efficiency-Residential Measures,* Version 11.0, Volume 3. (2022).
[37] U.S. Energy Information Administration [EIA]; *Updated Buildings Sector Appliance Equipment Costs and Efficiency.* (2018). Based on an 80kbtuh input.
[38] Illinois Commerce Commission [ICC]; *Illinois Statewide Technical Reference Manual for Energy Efficiency-Residential Measures,* Version 8.0, Volume 3. (2020).
[39] 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: 5/1/23
Effective date: 9/1/23
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. If the pre-treatment condition is unknown, it is assumed to be R-19.

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.[40] See reference table in section 8.1 on page 66 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

ΔkWh	= ΔkWh_{Aux} + ΔkWh_{Cool}
ΔkWh_{Aux}	= $Annual\ Gas\ Savings\ (MMBtu) \times Auxiliary$
ΔkWh_{Cool}	= 0 kWh if house has no air conditioning = ΔkWh_{CAC} if house has central air conditioning = ΔkWh_{RAC} if house has room air conditioning = 83% × ΔkWh_{CAC} if no information about air conditioner

[40] 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).[41]
CDD = Cooling Degree Days. See reference tables in section 8.2 on page **Error! Bookmark not defined.**.
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 8.2 on page **Error! Bookmark not defined.**)
$EFLH_{cool\ RAC}$ = Equivalent Full Load Cooling hours for Room AC (See reference table in section 8.2 on page **Error! Bookmark not defined.**)
$F_{Room\ AC}$ = 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.

[41] 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	42
		Default values: Early Replacement = 12.1 Replace on Burnout = 13	43
$SEER_{CAC}$	Variable	Nameplate	44
		Default = 10.6	45
$\overline{EER}_{RAC}$	Variable	Nameplate	46
CF_{CAC}	Fixed	0.70	47
CF_{RAC}	Fixed	0.58	48
$F_{Room,AC}$	Fixed	0.38	49

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes[50]

Measure	Measure Lifetime
Roof Insulation	40
Cavity Insulation	40

Water Savings
There are no water savings for this measure.

Measure Cost
The incremental cost for this measure is $1.62 per square foot of insulation.[51]

[42] PUC; *Act 129, 2021 Technical Reference Manual, Residential Measures*. Volume 2. (2019).
[43] Ibid.
[44] Contractor Gathering Data.
[45] PUC; *Act 129, 2021 Technical Reference Manual, Residential Measures*. Volume 2. (2019).
[46] Contractor Gathering Data.
[47] PUC; *Act 129, 2021 Technical Reference Manual, Residential Measures*. Volume 2. (2019).
[48] Ibid.
[49] 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.
[50] NYSERDA Home Performance with ENERGY STAR®.
[51] PUC; *Act 129, SWE Team Incremental Measure Cost Database.* Volume 4.0. (2020)

4.1.3 High Efficiency Window

Draft date: 5/1/23
Effective date: 9/1/23
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

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

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 8.1 on page 66 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.[52]

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

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

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

[52] 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 8.2 on page **Error! Bookmark not defined.**.
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 8.2 on page **Error! Bookmark not defined.**)
$EFLH_{cool\ RAC}$ = Equivalent Full Load Cooling hours for Room AC. (See reference table in section 8.2 on page **Error! Bookmark not defined.**)
$F_{Room\ AC}$ = 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	53
$SEER_{CAC}$	Variable	Default values: Early Replacement = 12.1 Replace on Burnout = 13	54
		Nameplate	55
$\overline{EER}_{RAC}$	Variable	Default = 10.6	56
		Nameplate	57
CF_{CAC}	Fixed	0.70	58
CF_{RAC}	Fixed	0.58	59
$F_{Room,AC}$	Fixed	0.38	60

Persistence
The persistence factor is assumed to be one.

Measure Lifetime[61]

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.

[53] "*State of Ohio Energy Efficiency Technical Reference Manual*," prepared for the Public Utilities Commission of Ohio by Vermont Energy Investment Corporation. August 6, 2010.
[54] PUC; *Act 129, 2021 Technical Reference Manual, Residential Measures*. Volume 2. (2019).
[55] Contractor gathering data.
[56] DOE Federal Test Procedure 10 CFR 430, Appendix F (Used in ES Calculator for baseline).
[57] Contractor gathering data.
[58] PUC; *Act 129, 2021 Technical Reference Manual, Residential Measures*. Volume 2. (2019).
[59] Ibid.
[60] 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.
[61] NREL Measure Database.

4.1.4 Infiltration Reduction

Draft date: 5/1/23
Effective date: 9/1/23
End date: TBD

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

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

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

Gas Savings Algorithms

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

Where:

HDD_t	=	Heating degree days at temperature t, where t=63°F if no programmable thermostat has been installed and t=62°F if a programmable thermostat has been installed. See reference tables in section III.A for values.
24	=	hours/day
$CFM50_{pre}$	=	CFM50 of building shell leakage as measured by a blower door test before treatment. If a blower door test cannot be performed due to health and safety reasons or other limitations, the CFM50 pre will be estimated based on a comparison of similar housing stock.
$CFM50_{post}$	=	CFM50 of building shell leakage as measured by a blower door test after treatment. If a blower door cannot be performed due to health and safety reasons or other limitations, the CFM50 post will be calculated based on industry best practices as the estimated CFM50 pre value – (square inches of air sealing performed x 7.495).[62]
21.5	=	factor to convert CFM50 value to Btu/hrF heat loss rate, calculated from hourly infiltration modeling[63]

[62] "Operating Instructions for the DG-700 Pressure and Flow Gauge," The Energy Conservancy. 2007. P. 16. From: http://toollending.com/tll_software/EnergyConservatory/dg700%20manual.pdf
[63] An hourly infiltration was calculated using a modified version of the LBL (a.k.a. Sherman-Grimsrud) infiltration model with a wind effect modification (EPRI RP 2034-40, Palmiter and Bond 1991) using Philadelphia TMY2 hourly weather data. This analysis result was then adjusted to account for an assumed party wall leakage fraction of 12% and an estimated 10% thermal regain from infiltration/exfiltration. The resulting value of 21.5 is consistent with statistical analyses of empirical data using CFM50 values and actual gas use and savings from CWP evaluations.

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

Electric Savings Algorithms

If the type of air conditioning is known, then use the appropriate algorithm below. If the type or existence of air-conditioning is not known, then assume that 52% have air-conditioning and estimate the cooling savings as 52% of a house with central air conditioning.[64]

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

Energy Savings

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

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

$\Delta kWh_{Cool} = \Delta kWh_{CAC}$ if house has central air conditioning

= 0 kWh if house has no air conditioning

= ΔkWh_{RAC} if house has room air conditioning

= $52\% \times \Delta kWh_{CAC}$ if no information about air conditioner

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

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

Demand Savings

ΔkW = 0 kW if house has no air conditioning

= ΔkW_{CAC} if house has central air conditioning

= ΔkW_{RAC} if house has room air conditioning

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

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

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

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 of consumption (5.02)[65]
CDD	=	Cooling Degree Days. See reference tables in section III.A for values
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)*
$\overline{EER}_{RAC}$	=	Average Energy Efficiency Ratio of existing room air conditioner (Btu/W▪hr)*
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 section III.A for values
$EFLH_{cool\ RAC}$	=	Equivalent Full Load Cooling hours for Room AC. See section III.A for values
$F_{Room\ AC}$	=	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, Infiltration Reduction

Term	Type	Value	Source
DUA	Fixed	0.75	PUC TRM[66]
$SEER_{CAC}$	Variable	Default values: Early Replacement = 12.1 Replace on Burnout = 13	PUC TRM
		Nameplate	Contractor Data Gathering
$\overline{EER}_{RAC}$	Variable	Default = 10.6	PUC TRM
		Nameplate	Contractor Data Gathering
CF_{CAC}	Fixed	0.70	PUC TRM
CF_{RAC}	Fixed	0.58	PUC TRM

[65] Efficiency Vermont; *Technical Reference Manual: Measure Savings Algorithms and Cost Assumptions.* (2018).
[66] PUC; Act 129, 2021 Technical Reference Manual, Residential Measures. Volume 2. (2019). New York Standard Approach for Estimating Energy Savings from Energy Efficiency Measures in Commercial and Industrial Programs, September 1, 2009.

Term	Type	Value	Source
$F_{Room,AC}$	Fixed	0.38	Calculated[67]

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes[68]

Measure	Measure Lifetime
Infiltration Reduction	20

Water Savings
There are no water savings for this measure.

Measure Cost
The incremental cost for Air Sealing in the Residential Equipment Rebates program is the actual cost of installing the air sealing, both materials and labor.
The incremental cost for weatherstripping in the EnergySense kits program is $5.
The incremental cost for caulking in the EnergySense kits program is $4.

[67] 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
[68] NYSERDA Home Performance with Energy Star.

4.2 Domestic Hot Water End Use

4.2.1 Low Flow Showerhead

Draft date: 5/1/23
Effective date: 9/1/23
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.[69]

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[70]
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[71]
Gas energy savings result from reducing the amount of incoming cold water required to be heated due to the efficient showerhead.

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

[69] Schuldt, March and Debra Tachibana; Energy-related water fixture measurements: Securing the baseline for Northwest Single Family Homes." (2008).
[70] PUC; *Act 129, 2021 Technical Reference Manual, Residential Measures*. Volume 2. (2019).
[71] 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[72]

Equipment Type	Measure Lifetime
Low-flow showerhead	9

Deemed Measure Cost
Incremental cost of a low-flow showerhead is $35.[73] If provided through the EnergySense Kits program, utilize the actual program delivery cost. If unknown, assume $12.

[72] PUC; *Act 129, 2021 Technical Reference Manual, Residential Measures*. Volume 2. (2019).
[73] 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: 5/1/23
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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.[74]

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[75]
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[76]

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

[74] Schuldt, March and Debra Tachibana; *Energy-related water fixture measurements: Securing the baseline for Northwest Single Family Homes."* (2008).
[75] PUC; *Act 129, 2021 Technical Reference Manual, Residential Measures*. Volume 2. (2019).
[76] 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[77]

Equipment Type	Measure Lifetime
Low-flow faucet aerator	10

Deemed Measure Cost
Incremental cost of a low-flow faucet aerator is $8.[78]

[77] PUC; *Act 129, 2021 Technical Reference Manual, Residential Measures*. Volume 2. (2019).
[78] 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: 5/1/23
Effective date: 9/1/23
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[79]

Equipment Type	Measure Lifetime
Tankless Water Heater	20

[79] *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: 5/1/23
Effective date: 9/1/23
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.[80]

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

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

Where:

Length	=	Number of linear feet of steam pipe insulated.
Th_{base}	=	Thickness of base condition insulation (inches).
Th_{bff}	=	Thickness of efficient condition insulation (inches).
HeatLoss(x)	=	Heat loss through hot water pipe as a function of insulation thickness x (Btu/ft /yr).
RE_{DHW}	=	Recovery efficiency of the hot water heater = 75%[81]

[80] Recommendation based on method pioneered by Gary Klein expert on DHW based in California.
[81] 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[82]

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. If provided through the EnergySense Kits program, utilize the actual program delivery cost. If unknown, assume $18.

[82] 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: 5/1/23
Effective date: 9/1/23
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[83]	Baseline Thermal Efficiency
Gas Boiler ≥300,000 Btu/h and ≤2,500,000 Btu/h	84% Thermal Efficiency
Gas Boiler >2,500,000 Btu/h	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.

[83] 10 CFR 431, Standards for Commercial Packaged Boilers. Reflects current federal standards, and new standards beginning January 10, 2023.

Equivalent Full Load Heating Hours by Building Type

Building Type	EFLH[84]
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[85]
The table below lists incremental costs for commercial boilers based on capacity ranges.

Min Capacity	Max Capacity	Incremental Cost
300	499	$6,518
500	799	$10,602
800	1,199	$16,320
1,200	1,599	$26,122
1,600	n/a	$35,580

[84] From NJ Protocols for Philadelphia, adjusted based on 2015 Commercial Equipment Rebate Program evaluation.
[85] Illinois Commerce Commission [ICC]: *Illinois Statewide Technical Reference Manual for Energy Efficiency-Commercial and Industrial Measures,* Version 11.0, Volume 2. (2022).

5.1.2 Low-Intensity Infrared Heater

Draft date: 5/1/23
Effective date: 9/1/23
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%)[86]. If the efficient heater is not an infrared heater then the UF = 100%.
$EFLH_{Heat}$	= Equivalent Full Load Heating Hours.

[86] 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[87]

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[88]

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 $275.[89]

[87] From NJ Protocols for Philadelphia, adjusted based on EnergySense program independent evaluations.
[88] Mass Save; *Technical Reference Manual for estimating savings from energy efficiency measures.* (2016).
[89] Illinois Commerce Commission [ICC]: *Illinois Statewide Technical Reference Manual for Energy Efficiency-Commercial and Industrial Measures,* Version 11.0, Volume 2. (2022)

5.1.3 Steam Trap

Draft date: 5/1/23
Effective date: 9/1/23
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) [90]	Heat of Vaporization, Hv (Btu/lb) [91]	Default Boiler Efficiency, B [92]	Operating Hours, H [93]	Adjustment Factor, A [94]	Leaking & Blow-thru Factor for Unaudited Traps, L [95]
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[96]

Equipment Type	Measure Lifetime
Steam Traps	6

[90] CLEAResult. *Work Paper Steam Traps Revision #2*. (March 2012).
[91] 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.
[92] Ibid. Reference to California Energy Commission Efficiency Data for Steam Boilers.
[93] 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
[94] 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.
[95] CLEAResult; "*Work PaperSteam Traps Revision #*2(2012). If trap is known to be leaking, then this factor is 100%.
[96] 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[97]
The incremental cost of a <15 PSIG steam trap is $84.
The incremental cost of a <15 PSIG <75 steam trap is $241.
The incremental cost of a >75 PSIG steam trap is $299.

[97] Illinois Commerce Commission [ICC]: *Illinois Statewide Technical Reference Manual for Energy Efficiency-Commercial and Industrial Measures,* Version 11.0, Volume 2. (2022).

5.1.4 Boiler Reset Controls

Draft date: 5/1/23
Effective date: 9/1/23
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[98]

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 $636.72.[99]

[98] Illinois Commerce Commission [ICC]: *Illinois Statewide Technical Reference Manual for Energy Efficiency-Commercial and Industrial Measures*, Version 11.0, Volume 2. (2022).
[99] Ibid.

5.1.5 Commercial Roof Insulation

Draft date: 5/1/23
Effective date: 9/1/23
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 66 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	= ΔkWh_{Aux} + ΔkWh_{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).[100]
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.

[100] 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	101
$SEER_{CAC}$	Variable	Default values: Early Replacement = 12.1 Replace on Burnout = 13	102
		Nameplate	103
$\overline{EER}_{RAC}$	Variable	Default = 10.6	104
		Nameplate	105
CF_{CAC}	Fixed	0.70	106
CF_{RAC}	Fixed	0.58	107
$F_{Room,AC}$	Fixed	0.38	108

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes[109]

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 $1.46 per square foot of insulation.[110]

[101] PUC; *Act 129, 2021 Technical Reference Manual, Residential Measures*. Volume 2. (2019).
[102] Ibid.
[103] Contractor Gathering Data.
[104] PUC; *Act 129, 2021 Technical Reference Manual, Residential Measures*. Volume 2. (2019).
[105] Contractor Gathering Data.
[106] PUC; *Act 129, 2021 Technical Reference Manual, Residential Measures*. Volume 2. (2019).
[107] Ibid.
[108] 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.
[109] NYSERDA Home Performance with ENERGY STAR®.
[110] Illinois Commerce Commission [ICC]: *Illinois Statewide Technical Reference Manual for Energy Efficiency-Commercial and Industrial Measures,* Version 11.0, Volume 2. (2022)

5.1.6 Variable Refrigerant Flow (VRF) Natural Gas Heat Pump

Draft date: 5/1/23
Effective date: 9/1/23
End date: TBD

Measure Description
This measure applies to Variable Refrigerant Flow heat pumps purchased at the time of natural replacement of a heating equipment. A qualifying heat pump must meet minimum efficiency requirements (CoP).

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[111]	Baseline Thermal Efficiency
Gas Boiler <300,000 Btu/h	84% AFUE
Gas Boiler ≥300,000 Btu/h and ≤2,500,000 Btu/h	84% Thermal Efficiency
Gas Boiler >2,500,000 Btu/h	85% Combustion Efficiency

Definition of Efficient Condition
Efficient model minimum Coefficient of Performance (CoP) requirements are detailed in the table below. The installed gas boiler must have a COP greater than that shown.

Equipment Type	Minimum CoP Efficiency
VRF Heat Pump	>140%

Gas Savings Algorithms
MMBtu savings are realized due to the increase in Coefficient of Performance (CoP) of the new equipment. Savings are calculated from the baseline new unit to the installed efficient unit.

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

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.
CoP_{Eff} = Coefficient of Performance of new equipment.
$EFLH_{Heat}$ = Equivalent Full Load Heating Hours.

[111] 10 CFR 431, Standards for Commercial Packaged Boilers. Reflects current federal standards, and new standards beginning January 10, 2023.

Equivalent Full Load Heating Hours by Building Type

Building Type	EFLH[112]
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
VRF heat pumps consume electricity during their operation and therefore result in increased site electric load.

$$\Delta kWh = \frac{-Power \times EFLH}{1{,}000}$$

Where:

Power = Nominal maximum electrical power requirement for the gas fired heat pump in watts. If unknown, assume 0.0052 W per Btu/hr heating input capacity.[113]
$EFLH_{Heat}$ = Equivalent Full Load Heating Hours.

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes

Equipment Type	Measure Lifetime
VRF Heat Pumps	20

Water Savings
There are no water savings for this measure.

Deemed Measure Cost[114]
The incremental cost for this measure is $0.122 per output capacity (kBtu/h) of the efficient equipment.

[112] From NJ Protocols for Philadelphia, adjusted based on 2015 Commercial Equipment Rebate Program evaluation.
[113] Iowa Utilities Board: *Iowa Energy Efficiency Statewide Technical Reference Manual*, Version 6.0, Volume 3. (2022).
[114] Ibid.

5.2 Commercial Kitchen End Uses

5.2.1 Commercial Gas Fryer

Draft date: 5/1/23
Effective date: 9/1/23
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.[115]

Standard Fryer (per fry pot): $Annual\ Gas\ Savings\ (MMBtu) = 51.2\ MMBtu$

Large Vat Fryer (per fry pot): $Annual\ Gas\ Savings\ (MMBtu) = 42.0\ MMBtu$

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.

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

Persistence
The persistence factor is assumed to be one.

Measure Lifetimes[116]

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 $1,040.[117]
The incremental cost of a large vat fryer is $2,080.[118]

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

5.2.2 Commercial Gas Steamers (Cooking)

Unique Measure Code(s): TBD
Draft date: 5/1/23
Effective date: 9/1/23
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[119].

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.[120]

# of Pans	Annual Gas Savings (MMBtu)
3 pans	52.30
4 pans[121]	58.85
5 pans	65.40
6+ pans	71.30

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

Energy Savings
ΔkWh = 0 kWh

Demand Savings
ΔkW = 0 kW
Where:

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

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[122]

Equipment Type	Measure Lifetime
Commercial Steam Cooker	12

Water Savings
According to the ENERGY STAR® calculator the water savings would be 103,563 gallons per year for an ENERGY STAR® steamer compared to a baseline steamer.

Deemed Measure Cost[123]
The incremental cost of a 3-pan commercial steam cooker is $1,040.
The incremental cost of a 4-pan commercial steam cooker is $1,040.
The incremental cost of a 5-pan commercial steam cooker is $1,040.
The incremental cost of a 6-pan+ commercial steam cooker is $1,040.

[122] California Public Utilities Commission [CPUC]; *Database of Energy Efficiency Resources*. 2011.
[123] 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: 5/1/23
Effective date: 9/1/23
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.[124]

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:

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

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

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

[124] 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%)[125].
$CAP_{H,e}$ = 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)[126]**
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)[127]**
Multifamily	22.5

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

[125] ASHRAE 90.1-2007, Table 7.8.
[126] 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).
[127] 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[128]

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 $2,448.[129]
The incremental cost for a storage commercial DHW heater is $1,848.[130]

[128] CA DEER 08, EUL_Summary_10-1-08.xls; MA TRM, October 2015; IL TRM, Volume 2, February 8, 2017.
[129] Illinois Commerce Commission [ICC]; *Illinois Statewide Technical Reference Manual for Energy Efficiency-Commercial and Industrial Measures,* Version 7.0, Volume 2. (2018).
[130] 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: 5/1/23
Effective date: 9/1/23
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: 5/1/23
Effective date: 9/1/23
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[131]

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*

[131] 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[132]

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.

[132] 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[133]	HDD62[134]	CDD65[135]	$EFLH_{cool}$ CAC (Hours)[136]	$EFLH_{cool}$ RAC (Hours)[137]
Philadelphia	3,833	3,629	1,184	781	242

[133] Philadelphia Ten Year Degree Day Average from 2010-2019.
[134] Ibid
[135] PA PUC; *Act 129 TRM* , Appendix A. (2019).
[136] Ibid
[137] Ibid