MEMORANDUM

To: TXC56 Working Group Members

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CC: Mimi Goldberg, DNV GL and Rich Hasselman, Tetra Tech

Date: September 20, 2018

Re: Initial Considerations for Attribution/Net-to-Gross Estimation for Energy Optimization (TXC56)

The Massachusetts Program Administrators (PAs) and the Energy Efficiency Advisory Council (EEAC) consultants have contracted with the Massachusetts Cross-Cutting Research Area evaluation team, led by NMR Group, to develop initial considerations for assessing attribution and estimating net-to-gross ratios (NTGR) for energy optimization should the policy change to allow PAs to claim savings from energy optimization. If the policy changes, it will be important to understand when programs should be able to take credit for driving customers' decisions to change fuels with resulting reductions in net MMBTU usage, and how taking credit for energy optimization would affect the framework for understanding and measuring attribution and gross impacts. This research is designed to help the PAs and EEAC prepare for a possible policy change that would allow PAs to claim savings from energy optimization.

Section 1 Background

According to the 2019-2021 plan, energy optimization refers to a fuel-neutral approach to energy efficiency that will allow the PAs to pursue net energy reductions. As the plan states, through energy optimization, the PAs will seek to reduce customers' total energy use and optimize how customers use their energy in a fuel-neutral manner. Energy optimization will focus on space heating. Energy optimization efforts may entail providing customers with information such as the costs of conversion; financial incentives available from the PAs; incentives available from other entities, such as government agencies; estimated payback periods; energy savings; and emissions reductions associated with various heating measures, regardless of fuel type. The PAs expect that the increased education will result in some customers electing to convert from oil or propane to highly efficient heat pumps or gas equipment when those choices are cleaner and less expensive than their current systems. The PAs will include MMBTU savings from the offset oil or propane usage in their claimed savings, and account for any increase in primary fuel usage[1] at the same time. To be considered for attribution to the program, the installation of equipment in association with a fuel conversion must result in an overall reduction in energy usage.

This research has a narrow focus. Our review of studies targeted the residential and non-residential measures we expect would most commonly be installed or replaced when customers change fuels: furnaces, boilers, water heaters, and heat pumps.[2,3] In addition, our review only covered the following energy optimization scenarios:

1. Residential or C&I customers installed high-efficiency *electric* space heating equipment that previously heated space using gas, oil, or propane; the equipment is more efficient than the unit it replaced; and the change was supported by a PA program.
2. Residential or C&I customers installed high-efficiency *gas* space heating equipment that previously heated space using electricity, oil, or propane; the equipment is more efficient than what it replaced; and the change was supported by a PA program.

The goals of our review are as follows:

1. To identify causal interactions between energy optimization induced by programs and early retirement induced by programs, when there is a step-up in equipment efficiency
2. To identify and categorize the range of PA-related attribution scenarios

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[1] It is the evaluation team's understanding, based the 2019-2021 Massachusetts Joint Statewide Electric and Gas Three-Year Energy Efficiency Plan, that "primary fuel" refers to the fuel(s) each PA delivers or for which they administer energy efficiency programs.

[2] Massachusetts EEAC Consultant Team. October 19, 2017. *Advancing/Enhancing Existing Initiatives, Approaches, & Measures: Briefing Document for October 24 EEAC Residential Planning Workshop #2.* http://ma-eeac.org/wordpress/wp-content/uploads/EEAC-Residential-Workshop-2-Final-Briefing-Document-10.22.pdf.

[3] DOER, EEAC Consultant Team (Optimal Energy) and the Massachusetts PAs. October 31, 2017. *Potential Innovative Options to Explore: Briefing Documents for October 31 EEAC Commercial & Industrial Planning Workshop.* http://ma-eeac.org/wordpress/wp-content/uploads/CI-Workshop-2-Briefing-Document-Revised-with-Demand-1030.pdf.

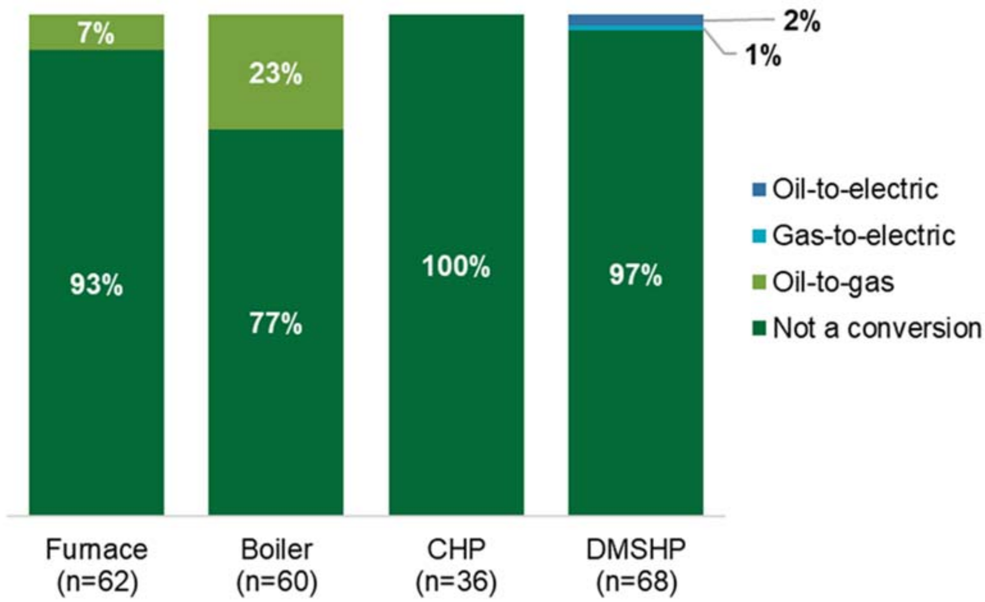
3. To identify other issues or factors that may affect attribution and NTG in a policy environment that supports energy optimization
4. To identify any additional information and next steps that would be needed to develop more comprehensive guidance for assessing attribution and estimating NTG should an energy optimization policy be adopted

To achieve these goals, we identified evaluations and other information for programs outside Massachusetts that offer support for energy optimization, with a focus on documenting reported attribution and NTGRs associated with this support. We have recorded the different approaches to energy optimization and, where possible, have documented the NTG values for energy optimization and related methodology. In addition to reviewing reports and documents from these peer programs, we reviewed other literature that addressed issues related to the design, implementation, and evaluation of energy optimization-related programs.

The Residential HVAC Net-to-Gross and Market Effects Study (TXC34) provides insights about the rates of fuel conversion in Massachusetts. As Figure 1**Error! Reference source not found.** and Table 1**Error! Reference source not found.**, both from this report, show, when the data were collected in the Winter of 2018,

- Participants reported that oil-to-gas conversions for furnaces and boilers represented 7% and 23% of all furnace and boiler installations, respectively. While there were too few conversions to gas for furnaces and boilers to generalize from, anecdotal evidence suggests that participants installed gas furnaces primarily to replace failing oil furnaces, and participants installed gas boilers both to replace failing oil boilers and to replace existing oil boilers early.
- Participants did not report any fuel conversions associated with installing central heat pumps.
- The rate of conversion from oil or gas heating to electric ductless mini-split heat pumps was very low (3% of all ductless mini-split heat pump installations).

Figure 1: Participant Self-Reported Fuel Conversions, Winter 2018



Source: Residential HVAC Net-to-Gross and Market Effects Study (TXC34).

Table 1: Fuel Conversions by Installation Type, Winter 2018

Installation Type	Fuel Conversion	Furnace (n=62)	Boiler (n=60)	DMSHP (n=68)
Early Replacement	**Yes**	**-**	**13%**	**2%**
	No	28%	23%	6%
Replace on Failure	**Yes**	**6%**	**10%**	**1%**
	No	46%	41%	5%
In-Between	**Yes**	**1%**	**-**	**-**
	No	12%	6%	1%
New Installation	(No)	7%	7%	85%
Total	**All**	**100%**	**100%**	**100%**

Source: Residential HVAC Net-to-Gross and Market Effects Study (TXC34).

Section 2 Methodology

The evaluation team conducted a literature review to identify relevant programs in other jurisdictions. Our review of programs relied on publicly available reports, evaluations, and other resources, described in more detail in Appendix A. We tried to cite evidence supported by evaluation results, but some programs either did not have publicly available evaluation reports or the reports did not cover the topics of interest for this study. We documented the information available in the reports and clarified and added to it through follow-up interviews with program administrator or evaluation author contacts for Avista Utilities (evaluator), Efficiency Vermont (program staff), Puget Sound Energy (evaluator), and SMUD (implementer).

The research covered a range of topics, including the energy optimization approaches, eligible equipment, reported NTG values and methodology, and other related evaluation findings. The team employed a systematic approach in this review, documenting whether information relevant to this study was present in each document.

Overall, the documents we reviewed for the programs in other jurisdictions offered some background information, but we found that detailed information on topics related to program attribution and NTG assessment were generally missing from the literature. In addition to reviewing reports and documents from peer programs, we reviewed other literature that addressed the general issues related to the design, implementation, and evaluation of energy optimization-related programs. The additional contextual literature covered many of the topics of interest, but in varying levels of detail. Drawing upon the available information, we developed possible conceptual approaches and scenarios that may serve as a starting point for further discussions with the PAs. See Appendix A for a full listing of programs and related documents.

Section 3 Findings from the Literature Review

3.1 Key Findings

Of the nine programs NMR examined that claimed savings related to fuel conversion, five supported conversions from electricity to natural gas or delivered fuels, and four supported conversions from delivered fuels or natural gas to electricity. Emera Maine's Heat Pump Program, Efficiency Vermont's Heating and Cooling Programs, and ComEd's Heating, Cooling, and Weatherization Rebates Program may be of particular interest to the Massachusetts PAs since these two entities support delivered fuel to electric heat pump conversion.

- None of the programs that claimed savings required that the replaced equipment be in working order or of a certain age, although PPL Electric kept track of this information on their rebate forms. Of the material that we reviewed, only the IL TRM directly addressed early replacement within the context of fuel conversion.
- Of the active programs offering fuel conversion incentives, most required high-efficiency equipment to be installed. In general, the only rebates that didn't require high-efficiency equipment to be installed covered equipment without federal efficiency or ENERGY STAR standards, like electric ovens.
- The programs that we reviewed were not consistent in how they accounted for fuel conversions. For example, the Pennsylvania programs (PPL, PECO, and UGI), which support electric to natural gas conversions, only considered the electricity savings from the replaced equipment, and not the additional fuel consumption of the new equipment (with the exception of clothes dryers for UGI and PECO). Avista Utilities also supports electric to natural gas conversions, but the evaluation accounted for the added gas load. Other PAs that use a conversion factor or penalty to account for added gas or electric load include Puget Sound Energy and ComEd Illinois.[4]
- Most of the programs did not distinguish between fuel savings and efficiency savings. SMUD's program theory took both into account, however. SMUD included the deemed efficiency levels of both the old and new equipment and used a conversion factor between therms and kWh to account for the loss in efficiency when converting fuels. Avista's evaluation adjusted for the increased gas load associated with residential electric-to-gas fuel conversions. The Avista study analyzed the increased gas consumption of homes with and without prior natural gas service and calculated the overall negative savings resulting from the furnace conversions. Puget Sound Energy looked at the difference in electricity and gas consumption between a program group and a control group.
- Programs that support heat pump technologies face specific challenges with regard to secondary fuel sources after the installation of high-efficiency equipment (e.g., partial

[4] Note that the Puget Sound program has been discontinued.

conversions). Three of the programs reported that customers relied on the initial less-efficient fuel source (e.g., oil or propane), which has implications for accurately projecting savings.

- Only three of the program administrators – Emera Maine, Avista, and Efficiency Vermont – measured or claimed net savings for their programs. These organizations either measured NTG at the measure or program level, but not specifically for fuel conversions, and then applied the NTG without regard to whether a fuel conversion occurred (Emera Maine and Avista), or used a deemed NTGR for fuel conversion (Efficiency Vermont). The two programs with evaluated NTGRs accounted for program influences such as marketing and outreach, rebate amount, and the contractor, but did not assess the impact of support from other organizations for fuel conversions or related equipment on customers' decision-making. The deemed values for Efficiency Vermont are negotiated values that were developed with input from the distribution companies, Public Utilities Commission, and Public Service Department. It is important to note that with the exception of heat pumps, the NTG values typically reflect the program-level estimates.
- Just one program administrator, SMUD, considers source fuel, taking into account not only load increases from fuel conversions and savings from replacing less-efficient equipment with high-efficiency equipment, but also losses from power production, transmission, and distribution associated with each fuel source. A key feature of SMUD's approach is to value conversion to electric heating based on the mitigated source BTU from conventional electricity production. While the PAs may want to consider this approach, the Massachusetts policy environment currently prohibits PAs from claiming savings from the replacement of fossil-fuel-generated electricity with electricity generated via renewable sources. However, we assume the PAs could use approved avoided costs associated with changes in generation, transmission, and distribution.

3.2 Review of Programs in Other Jurisdictions

Our literature review identified several PAs implementing programs that support fuel conversions. Among the nine PAs and programs that we determined were relevant to this study, three studies measured NTGRs: Emera Maine Heat Pump Pilot Program, Avista Utilities' (Washington Natural Gas) Fuel Efficiency Program, and Efficiency Vermont (various programs). The remaining studies did not include NTG results and most did not focus on delivered fuel to electric or gas conversions. As a result, insights about their design and implementation have limited relevance for the Massachusetts PAs.

The PAs and programs that we included in this review are as follows:

- Emera Maine Heat Pump Pilot Program
- Washington's Avista Utilities Residential Fuel Efficiency Program
- Efficiency Vermont Heating and Cooling Programs
- Pennsylvania's United Gas Investment, Co. (UGI) Residential and Small Commercial Fuel Switching Program

- Pennsylvania's PPL Electric (Energy Efficient Home Program & Fuel Switching Pilot)
- Pennsylvania's PECO Energy (HVAC rebates [residential] & Gas Conversion rebates [commercial])
- California's Sacramento Municipal Utility District (SMUD) Single-Family Existing, Single-Family New Construction, and Multifamily New Construction Programs
- Washington's Puget Sound Energy Natural Gas Energy Conversion rebate
- Illinois' Commonwealth Edison (ComEd) Heating, Cooling, and Weatherization Rebates Program

We also researched the following programs that addressed fuel conversion in some way, but did not find enough information to include them in this review:

- Energize Connecticut Home Energy Solutions Program
- NYSERDA's Heat Pump Program
- Wisconsin's Focus on Energy Electric Water Heater Conversion Pilot

3.2.1 Approaches to Energy Optimization

Through our review of documents, we identified two main types of programs based on available resources. We categorized these programs based on whether the PA has the following:

1. A standalone program that supports fuel conversions
2. A program that supports fuel conversions in conjunction with the installation of high-efficiency equipment.

Table 2 provides a comparison of key program attributes. As noted above, the level of information about each program varied considerably, so we have summarized this as best we could based on publicly available resources.

Emera Maine Heat Pump Pilot: Emera Maine's Heat Pump Program was implemented after a successful pilot in 2013. Although the program is designed to induce conversion among residential and small business commercial customers who rely on delivered fuels to offset the heating load from the other fuel sources, it is not implemented as a separate fuel conversion program. Currently, the program is coordinated with Efficiency Maine and offers up to $750 for residential customers and up to $5,000 for commercial customers for equipment rebates. On-bill financing is also available.[5] Non-monetary supports documented in the evaluation of the pilot include marketing and outreach to customers, marketing and outreach to installers, an online registry of installers, and referral credits to participants who referred other customers to the program. (The evaluation report does not include specific details regarding the amount of the credit and whether the referral had to led to an installation, and the website currently does not include information on this offering.)

[5] Emera Maine Heat Pump Rebates.

Avista Utilities: Avista offers incentives for fuel conversions through two standalone residential programs: the Fuel Efficiency Program and the Low-Income Fuel Conversion Program. These programs provide rebates for the conversion of homes with electric resistance heat to natural gas heating and for the conversion of electric water heaters to natural gas models. The rebate amounts vary by equipment type and program. The low-income program covers 100% of the costs for electric-to-gas furnace conversions and electric-to-gas water heater conversions. The savings for these programs were calculated and claimed separately from the high-efficiency equipment that was installed through the Gas HVAC and Gas Water Heating programs – that is, the difference in consumption between the code-minimum appliance that was not installed and the high-efficiency appliance that was installed was attributed to the relevant prescriptive program.

Efficiency Vermont: Residential and commercial customers can receive incentives for eligible equipment to convert or supplement existing heating and hot water systems. Efficiency Vermont does not offer one program focused solely on fuel conversions. Fuel conversions occur primarily under the auspices of the Heating and Cooling programs, which offer rebates for high-efficiency equipment. Although Efficiency Vermont has supported fuel-neutral conversions in the past, in recent years, due to costs and market demand, programs have focused more on fuel conversions from systems using fossil fuels (e.g., oil and propane) to electric heat pumps.

Funding for fuel conversions is split between the distribution companies and Efficiency Vermont.[6]

For cold climate heat pumps, the distribution utilities have their own initiatives to promote fuel conversions to a baseline heat pump and claim the related fuel savings. Efficiency Vermont claims the incremental electric savings of a more efficient cold-climate heat pump compared to a baseline heat pump.

Efficiency Vermont also supports centrally ducted air-source and air-to-water heat pumps to promote fuel conversions. The centrally ducted air-source heat pumps are high-efficiency systems and Efficiency Vermont claims the incremental savings from standard efficiency to high-efficiency equipment. Because there is not enough variation in the electric efficiency for air-to-water heat pump systems, they do not claim related incremental savings.

Efficiency Vermont also promotes heat pump water heaters to replace fuel-fired water heaters and electric water heaters and biomass systems (pellet boilers and furnaces, and wood- and pellet-fired stoves) to displace fossil fuel use.

UGI Residential and Small Commercial Fuel Switching Program: UGI offers residential and small commercial rebates for converting space heating, water heating, and clothes drying from electricity to natural gas or solar thermal. New equipment must be labeled ENERGY STAR and the customer must verify that the new gas or solar thermal equipment replaces electric equipment. The rebate for converting to a natural gas furnaces or boiler ($1,500) is significantly larger than the residential appliance program rebate for air source heat pumps ($325 for SEER 15 or $400 for SEER 16). There are no residential electric appliance rebates for water heating or clothes drying.

[6] Efficiency Vermont's funding comes from two different sources with two different goals. The funding from the electric efficiency service charge is tied to electric savings goals while funding from Regional Greenhouse Gas Initiative (RGGI) and Forward Capacity Market (FCM) is focused on fossil fuel savings.

PPL Electric (Energy Efficient Home Program & Fuel Switching Pilot): PPL offers residential rebates for conversions from electric to non-electric (oil, natural gas, or propane) furnaces and boilers. The fuel conversion rebates value ($200) is in between the value of the two residential electric space heating rebates ($100 for ASHP with 16 SEER or $300 for ASHP with 17 SEER).

Previously, PPL ran a pilot program that offered rebates for customers to convert in the other direction (i.e., from non-electric to electric ASHP, DMSHP, and HPWH).

PECO Energy (HVAC rebates [residential] & Gas Conversion rebates [commercial]): PECO offers residential and commercial rebates for converting from electric equipment to gas furnaces, boilers, clothes dryers, stovetops, and storage water heaters. The residential rebate for converting from electric space heating to a gas furnace ($1,000) is much larger than the rebate for electric space heating (ASHP 16+ SEER: $60/ton, ASHP 18+ SEER: $110/ton). Similarly, the residential rebate for converting from an electric clothes dryer to a gas clothes dryer ($150) is significantly larger than the rebate for an electric dryer ($15) or electric heat hump dryer ($75).

PECO Energy is unique in that it offers a $200 rebate simply for converting to natural gas. This rebate requires either the conversion of equipment or the installation of a new gas service line.

SMUD Single-Family Existing, Single-Family New Construction, and Multifamily New Construction Programs: SMUD offers rebates for converting from gas water heating to electric HPWH in existing homes. The rebates for converting from gas to electric ($3,000) are significantly higher than the rebates for replacing existing electric water heating equipment ($1,000).

Additionally, SMUD has several rebates to promote whole home electrification in residential single- and multifamily new construction. Because fewer than 5% of new homes in SMUD's service area are currently being built as all-electric homes, SMUD considers this program a fuel conversion program as well. SMUD offers up to $1,500 for multifamily and $5,000 for single-family new construction if heat pumps are installed for space and water heating, along with electric induction stovetops.

Puget Sound Energy Natural Gas Energy Conversion rebate: PSE offered residential rebates to convert from electric to natural gas water heaters, clothes dryers, furnaces, ranges, and combined space and water heating. This program was discontinued on 1/1/2018.

ComEd Heating, Cooling, and Weatherization Rebates Program: ComEd offers residential rebates for ground source heat pumps and includes fuel conversion and early replacement as components of their gross savings calculations. NTG is a deemed value at the program level.

Table 2. Comparison of Program Attributes
(B=Both Sectors; R=Residential; C=Commercial; LI = Low-Income)

Type of Market Intervention	Emera Maine	UGI (PA)	PECO (PA)	PPL (PA)	SMUD (CA)	Avista Utilities (WA, ID)	Puget Sound Energy*	Efficiency Vermont	ComEd
Program Structure									
Fuel conversion program w/ standard efficiency allowed			B			R, LI			
Combined fuel conversion & EE equipment program	B[1]	B	B	R	R	R, LI	R	B	R
Full fuel conversions		B	B	R	R	R	R		R
Partial fuel conversions	B		R			R		B	R
Type of Fuel Conversion Support									
Monetary incentive for conversion without regard to equipment EE			R			R			
Monetary incentive for conversion if it involves high-efficiency equipment	B	B	B	R	R	R, LI	R	B	R
Non-monetary support through education, marketing, and outreach	B					R, LI		Unknown	
Energy Optimization Options									
Delivered fuels to electricity	B							B	R
Delivered fuels to natural gas			B						
Natural gas to electricity					R				R
Electricity to natural gas		B	B	R		R, LI	R		
Electricity to delivered fuels				R					
Electricity to solar thermal		B							
Equipment									
Furnaces		B	B	R		RI, LI	R	B	
Boilers		B	C	R			R	B	
Water heaters		B	B			RI, LI	R	B	
Heat pumps	B				R			B	R

[1] Commercial includes Small Business.
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3.2.2 Approaches to Calculating Savings

3.2.2.1 Gross Savings Methodology

Below are notable gross savings aspects of the programs included in our review. Table 3 shows the aspects of energy optimization for which each of the programs claim savings, what penalties are included in gross savings, and what methodology was used to estimate gross savings. For more details about the gross savings methodology of all programs, see Appendix A.

Emera Maine Heat Pump Pilot Program: This evaluation used a metering study to isolate the changes in electricity and fuel use due to the heat pump program for delivered fuel to electric conversions. The results do not aggregate gross impacts, but the team estimated average annual use and customers' cost impacts.

Avista Utilities: The Avista evaluation team estimated gross verified savings for the program by conducting a billing analysis. Because the program involves fuel conversions from electric to natural gas equipment, the electricity savings is offset to some extent by increased natural gas consumption. The Avista evaluation factored in the increased gas load as a savings penalty.

Efficiency Vermont: In Vermont, incentives and rebates for fuel conversion are separate from those for installation efficient equipment. For example, for cold climate ductless mini-split heat pumps (ccHPs), the distribution utilities in the state promote the conversion to a baseline heat pump and claim the fuel savings after accounting for a penalty for increased electric load. Efficiency Vermont claims the incremental electric savings of a more efficient cold climate heat pump compared to a baseline heat pump.

Pennsylvania Programs: The PA PUC's Technical Reference Manual includes gross savings algorithms for several fuel conversion measures. For all measures, except residential clothes dryers, gross savings is the full energy consumption of the electric equipment that was removed. Increased gas consumption from fuel conversion does not count against PA Act 129 energy savings, though it is included in the program Total Resource Cost (TRC) test. Note that compliance savings in Pennsylvania are based solely on gross savings. While the utilities may assess NTG, it is used largely for program planning and TRC calculations. None of the Pennsylvania programs that we reviewed assess NTG for fuel conversion efforts.

SMUD: SMUD is the only organization among the ones examined here that takes into account not only load increases from fuel conversions and savings from replacing less-efficient equipment with high-efficiency equipment, but also losses from power production, transmission, and distribution associated with each fuel source. SMUD applies a penalty to the natural gas that is diverted from the customer to the utility due to the inefficiency of electricity generation from natural gas and the transmission and distribution losses from the power plant to the customer. This approach allows SMUD to account for the increasing share of renewable energy in SMUD's portfolio that is expected over the lifetime of the equipment.

After applying these penalties, SMUD adds in the expected kWh of electricity generated from renewables as a sort of free energy based on Smart Energy Consumer Collaborative (SECC) methodology. These additional kWh offset the kWh lost in the conversion of natural gas to electricity and help to increase SMUD's claimed savings from a fuel conversion. In the future, SMUD is likely to calculate fuel conversions in terms of greenhouse gas emissions, which would make this savings calculation more straightforward (Scott Blunk, SMUD, personal communication July 18, 2018). The new equipment must be significantly more efficient than the old equipment to result in positive savings after the conversion penalty has been applied via the conversion factor. Heat pumps, when used for either space heating or water heating, are likely to meet this threshold, while electric ovens and electric induction ranges are not.

Puget Sound Energy: PSE used a billing analysis and simple difference-in-difference approach to generate program-level gross savings estimates. The billing analysis consisted of billing regressions that were applied to both gas and electric consumption for pre- and post-conversion periods.

ComEd: In their PY8 (2015-2016) report, ComEd used an equation from the Illinois TRM v4.0 Section 5.3.8 to calculate energy savings. This equation accounted for savings from the difference in efficiencies between the units, the potential early replacement of the unit, and the potential fuel conversion that may occur when the unit is installed. The most recent version of the Illinois TRM (v7.0) continues to include these scenarios for ground source heat pumps and ductless heat pumps.

Table 3: Gross Savings Methodology

(B=Both Sectors; R=Residential; C=Commercial; LI = Low-Income)

	Emera Maine	Avista Utilities (WA, ID)	Efficiency Vermont	UGI (PA)	PPL (PA)	PECO (PA)	SMUD (CA)	Puget Sound Energy*	ComEd
Savings Claimed									
EE equipment upgrade			B	B	R	B	R		R
Penalties for losses from generation, T&D offset by credits for renewable fuels							R		
Conversion penalty or factor to account for added gas or electric load		R					R	R**	R
Avoided fuel from replaced equipment only	B			B	R	B			
Conversion factor for added gas or electric load **and** avoided fuel from replaced equipment		R						R**	
Avoided fuel from ER									R
Gross Savings Methodology									
Billing analysis	B	R						R	
Metering	B								
TRM				B	R	B			R
Deemed values			B				R		

* Discontinued
** Incorporated credits and penalties into analysis by measuring difference of differences between electric and gas use of treatment and control groups.

3.2.2.2 NTG Methodology

Only three of the program administrators – Emera Maine, Avista, and Efficiency Vermont – measured or claimed net savings for their programs. These organizations either measured NTG at the measure or program level, but specifically not for fuel conversions, and then applied the NTG without regard to whether a fuel conversion occurred, or used a deemed NTGR for fuel conversion. The two organizations that measured NTG used self-reports (Table 4). For more details about the NTG measurement approaches of the three programs, see Appendix A.

Table 4: NTG Calculations

(B=Both Sectors; R=Residential; C=Commercial; LI = Low-Income)

	Emera Maine	Avista Utilities (WA, ID)	Efficiency Vermont	UGI (PA)	PPL (PA)	PECO (PA)	SMUD (CA)	Puget Sound Energy*	ComEd
Program Attribution & NTG									
Calculated NTGR for equipment or program, but not for fuel conversion	B	R							
Deemed NTGR for equipment or program, but not for fuel conversion[1]									R
Deemed NTGR for fuel conversion			B						
NTG Methodology									
Self-report participant surveys	B	R							

[1] Consensus values were derived from self-reported surveys with participants and end-users.
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Table 5 shows the reported NTG values for Emera Maine and Avista Utilities. Efficiency Vermont uses deemed NTGR by each individual combination of equipment type and fuel conversion type. Note that Efficiency Vermont uses program-level NTGRs for most fuel conversion measures. For all programs, they use slightly higher NTGRs for heat pumps.

Table 5: NTG Comparison

Program	Equipment	Free-ridership	Spillover	NTGR
Emera Maine Heat Pump Pilot	DMSHPs	19%	7%	88%
Avista Utilities Fuel Efficiency Program	Furnace, Water Heaters	27%	0%	73%
Efficiency Vermont	Boilers, Furnaces, Space Heater	--	--	79%-100% For non-LI programs
	Heat Pumps	--	--	89%-100% For non-LI programs

3.3 Additional Factors for Consideration

3.3.1 Non-energy Impacts

The literature notes that fuel conversion generates non-energy impacts (NEIs), which typically are not quantified (EMI, 2014, Ecotope, 2014). The Vermont Energy Investment Corporation (2018) recommends incorporating NEIs such as comfort, GHG reduction, fuel security, health benefits, and economic development, into cost-benefit tests to provide a more complete picture of the related impacts.

3.3.2 Factors that May Affect Customers' Decision-making

To address program attribution, the PAs will need to consider other causal factors that may induce customers to pursue a fuel conversion, including support from other organizations for fuel conversions or related equipment. The Massachusetts Clean Energy Center (MassCEC) currently offers substantial rebates for the installation of "clean heating and cooling technologies." These include air source heat pumps (up to $2,500 for residential and up to $250,000 for commercial), ground source heat pumps (up to $20,000 residential and up to $25,000 for commercial), and solar water heaters (up to $6,000 for residential and $100,000 for commercial).[7] By 2020, the MassCEC plans to end its support for these technologies. Any assessment of program attribution by the Massachusetts PAs should take this into consideration. None of the studies that we reviewed accounted for other organizations that may influence customers' decision-making in their program attribution models.

Another important consideration related to program attribution is the impact of customer education efforts on decision-making. Although none of the literature that we reviewed explicitly examined the influence of education, two of the program evaluations that we reviewed did account for the impact of program marketing and outreach in their NTG assessments. Neither of the evaluations separately assessed the impact of the fuel conversion from the program.

[7] Residential rebates: http://www.masscec.com/residential/clean-heating-and-cooling. Commercial rebates: http://www.masscec.com/business/clean-heating-and-cooling.

- **Emera Maine:** The NTG methodology for the evaluation of the Heat Pump Pilot relied on self-report participant surveys and assessed free-ridership and spillover. The free-ridership estimate accounted for partial and full free riders. Partial free riders included respondents who indicated that the program had influenced their decision to install the ductless min-split heat pump. According to the evaluation, possible explanations associated with the program's impact included respondents' suggestions that the program "provided useful information about heat pumps and/or increased their confidence in the claims made about heat pump savings." Respondents who indicated program influence on their decision-making were documented as partial free riders.
- **Avista Utilities:** The Avista evaluation team calculated NTG ratios at the program level, rather than the equipment level, using participant self-reports collected via surveys. The free-ridership estimates consisted of the sum of two components: change and influence. The change and influence scores ranged between 0 and 0.5 depending on the response. Free-ridership change was based on the self-report of what participants would have done if the program had not provided an incentive for their upgrade. Free-ridership influence was based on how much influence the program had on the participant's decision to pursue the upgrade. The evaluation team accounted for various aspects of the program's influence, including information on Avista's website as well as advertising and other information from Avista.

Section 4 Discussion of Attribution and NTG

As the literature review showed, we were unable to find NTGRs measured for conversions from delivered fuels. While Vermont publishes equipment-specific NTGRs for conversions from delivered fuels, we found that these NTGRs were negotiated, not measured. Given this, we developed an approach for PAs to consider both for now and for the future.

- The approach could be used now as a framework for developing negotiated NTGRs for 2019-2021 and applying them appropriately to gross savings in this period.
- In the future, the approach could be used as a framework for developing prospective NTGRs for 2022-2024 that are informed by observed 2019-2021 conversion rates and other empirical data, and for applying them to gross savings for those years.

This approach leverages the limited insights from the studies reviewed here, discussion with the PAs and input from the PAs and EEAC on a previous draft, and additional insights from NTG evaluation team members Mimi Goldberg of DNV GL and Rich Hasselman of Tetra Tech.

Note that this approach, for PA consideration now and in 2022-2024, assumes that all fuel conversions are from delivered fuels to electricity or natural gas, are residential, and that no incentive is offered for the fuel conversion.[8] The approach does not address C&I conversions, as the plans for energy optimization do not currently extend to commercial or industrial customers.

4.1 Overall Approach

The overall approach involves measuring six separate types of gross savings and applying a specific NTGR to each type. We group conversions into two scenarios: (1) Fuel Oil/Propane Furnace/Boiler to Gas Furnace/Boiler and (2) Fuel Oil/Propane Furnace/Boiler to Electric Heat Pump. Since the second scenario provides cooling and heating, it involves two measurements of gross savings and attribution, one for heating and one for cooling.

The six types of gross savings that we expect would be generated from the energy optimization initiative are based on three customer decisions or outcomes, as follows:

1. The decision to convert fuels, whether partially or fully (*fuel conversion*)[9]
2. The outcome of adding cooling or heating where previously there was none, or reducing cooling load (*service change*)
3. The decision to install higher-efficiency equipment in association with the fuel conversion (*high-efficiency*)

[8] As of late September of 2018 the PAs had not decided whether to offer incentives for conversion. We have built the approach on the assumption that there will be no incentives for conversion. The addition of incentives would make it easier for PAs to identify customers that convert and calculate baselines in future.

[9] The "Period 1: Conversion" component of the savings described in this section is still under review, particularly because it may include true early replacement savings that should be separated and assigned a NTGR different than for fuel conversion.

The approach involves calculating gross savings separately for each of these decisions or outcomes. In each case, the calculation is the difference between the MMBTU baseline consumption and consumption with the decision that was made or outcome generated.

The approach assumes that all fuel conversions that occur in conjunction with the installation of program-supported equipment are, in effect, early retirement, regardless of rebate type. The reason for this in the case of conversions to gas is that these conversions require planning, which makes it quite unlikely that customers who use delivered fuels would convert to gas when HVAC equipment truly fails unexpectedly. It also seems unlikely that customers would convert to heating with electricity when HVAC equipment truly fails unexpectedly. This is because in Massachusetts' cold climate, customers who convert to a central heat pump or ductless mini-split heat pump usually keep the old heating equipment as a backup for very cold days. To act as a backup, the old equipment must function. However, customers may plan ahead to replace equipment that has required a lot of repairs, so ROF may not be uncommon with fuel switching. If the PAs decide to address ROF as well as ER, they may use the Period 2 formulation outlined below, substituting TXC34 NTGR for the RES36 NTGR.

The gross savings is divided in two parts:

Period 1: Addresses savings of the new equipment compared to the remaining useful life of the old equipment. For the energy impacts of basic conversion and of heating/cooling service change, the comparison is between the existing fuel oil/propane furnace/boiler and an ISP gas furnace/boiler. For the high-efficiency impact, the comparison is between the existing unit and the high-efficiency unit.

For Period 1, the total change in energy use (E) associated with the conversion, service level change, and high efficiency over the remaining useful life of the old equipment can be decomposed as E(New fuel HE, New Service) – E(Old fuel old equipment, Old Service) =

E(New fuel ISP, Old Service) – E(Old fuel old equipment, Old Service)

+ E(New fuel ISP, New Service) – E(New fuel ISP, Old Service)

+E(New fuel HE, New Service) – E(New fuel ISP, New Service)

= Conversion Impact + Service Change Impact + High Efficiency Savings

Period 2: Addresses savings from ISP equipment compared to the high-efficiency equipment, minus the remaining useful life of the old equipment. For conversions, the comparison is between the ISP fuel oil/propane furnace/boiler at the old service level and an ISP gas furnace boiler at the old service level for conversions. For service level, the comparison is the ISP gas furnace boiler at the old service level compared to the ISP gas furnace/boiler at the new service level. For the high-efficiency impact, the comparison is between the ISP gas furnace/boiler at the new service level and the high-efficiency gas furnace/boiler at the new service level.

For Period 2, the total change in energy use (E) associated with the conversion, service level change, and high efficiency over the effective useful life of the efficient equipment can be decomposed as E(New fuel HE, New Service) – E(Old fuel ISP, Old Service) =

E(New fuel ISP, Old Service) – E(Old fuel ISP, Old Service)

+ E(New fuel ISP, New Service) – E(New fuel ISP, Old Service)

+ E(New fuel HE, New Service) – E(New fuel ISP, New Service)

= Conversion Impact + Service Change Impact + High Efficiency Savings

To estimate savings attributable to the energy optimization initiative, we propose calculating one NTGR from the observed incremental conversion rate and applying this to the service level change, with the assumption that the program is responsible for the service level change to the same extent that it is responsible for the conversion. We propose using the same NTGRs for both P1 and P2.

As Table 6, Table 7, and Table 8 show, we propose that for **2019-2021**, PAs consider using negotiated NTGRs for **conversion and service change**. For **high-efficiency equipment impacts**, we propose PAs consider the following:

- *When conversions are to gas heating equipment,* the early retirement prospective NTG ratios from the Early Retirement of Heating/Cooling Study (RES36)
- *When conversions are to electric heat pump equipment,* a negotiated NTGR

For **2022-2024**, we suggest that the PAs consider undertaking a new study late in the 2019-2021 period to estimate retrospective NTGRs for early retirement, and develop prospective 2022-2024 NTGRs informed by the retrospective NTGRs. At that time, the PAs could determine whether to use a prospective NTGR from the new study or to renegotiate the NTGR for conversions to electric heat pump equipment.

The reasons that we propose PAs consider different NTGRs for electric heat pump equipment are that the Residential HVAC Net-to-Gross and Market Effects Study found much higher rates of conversion from delivered fuels to gas than from delivered fuels to electricity, and the 2017 RASS found a low level of electric heating with heat pumps. Given these findings, we would expect the prospective NTG ratios for early retirement that were developed via RES36 would be too low for conversions from delivered fuels to electric heat pumps.

4.2 Approach by Scenario

4.2.1 Fuel Oil/Propane Furnace/Boiler to Gas Furnace/Boiler

Table 6: Gross and Net Savings Approach for Conversion from Fuel Oil/Propane Furnace/Boiler to Gas Furnace/Boiler

	Period 1: Remaining Useful Life (RUL) of Old Equipment			Period 2: Effective Useful Life of Efficient Equipment Minus Old Equipment RUL		
	Conversion**	Service Level Change	High Efficiency	Conversion	Service Level Change	High Efficiency
Gross						
Baseline	Old fuel oil/propane furnace/boiler, old service level[10]	ISP gas furnace/boiler, old service level	ISP gas, new service level	ISP fuel oil/propane furnace/boiler, old service level	ISP gas furnace/boiler, old service level	ISP gas furnace/boiler, new service level
New	ISP gas furnace/ boiler, old service level	ISP gas furnace/boiler, new service level	High-efficiency gas furnace/boiler, new service level	ISP gas furnace/boiler, old service level	ISP gas furnace/boiler, new service level	High-efficiency gas furnace/boiler, new service level
NTG						
	NTGR 1: Increase in rate of conversions from Residential Baseline Study, based on remaining fuel oil customers each year (negotiated for prospective)	NTGR 1*	NTGR 2: NTGR from RES36 for gas furnace/boiler	NTGR 1	NTGR 1*	NTGR 2

* For heating the service level, change is more likely to be negative than positive because people are more likely to increase rather than decrease the amount of the house that is heated when they install a new system, such as by enclosing a porch or finishing a basement area.

** The "Period 1: Conversion" component of the savings described in this section is still under review, particularly because it may include true early replacement savings that should be separated and assigned a NTGR different than for fuel conversion.

[10] The old service level is the amount customers used heating or cooling before the new equipment installation; the new service is the amount they used after.

4.2.2 Fuel Oil/Propane Furnace/Boiler to Electric Heat Pump – Heating

Table 7: Gross and Net Savings Approach for Conversion from Fuel Oil/Propane Furnace/Boiler to Electric Heat Pump – Heating[11]

	Period 1: Remaining Useful Life (RUL) of Old Equipment			Period 2: Effective Useful Life of Efficient Equipment Minus Old Equipment RUL		
	Conversion**	Service Level Change	High Efficiency	Conversion	Service Level Change	High Efficiency
Gross						
Baseline	Old fuel oil/propane furnace/boiler, old service level	ISP electric furnace/boiler, old service level	ISP electric furnace/boiler, new service level	ISP fuel oil/propane furnace/boiler, old service level	ISP heat pump, old service level	ISP heat pump, new service level
New	ISP heat pump, old service level	ISP heat pump, new service level	High-efficiency heat pump, new service level	ISP heat pump, old service level	ISP heat pump, new service level	High-efficiency heat pump, new service level
NTG						
	NTGR 1: Increase in rate of conversions from Residential Baseline Study, based on remaining fuel oil customers each year (negotiated for prospective)	NTGR 1*	Negotiated	NTGR 1	NTGR 1*	Negotiated

* For heating the service level, change is more likely to be negative than positive because people are more likely to increase rather than decrease the amount of the house that is heated when they install a new system, such as by enclosing a porch or finishing a basement area.

** The "Period 1: Conversion" component of the savings described in this section is still under review, particularly because it may include true early replacement savings that should be separated and assigned a NTGR different than for fuel conversion.

[11] This memo assumes that given the small number of conversions from heating with delivered fuel to heating with electricity, most new heat pump systems installed in such homes would not have been installed in the absence of PA programs. We envision that one mechanism by which these customers end up with heat pumps is that once they become interested in converting from heating with delivered fuel, they seek further information about what to do, and are moved by PA programs to convert to electric instead of to gas – or, if they do not have access to gas, are simply moved to convert to electric. Another mechanism by which customers end up with heat pumps might be that, while looking into air conditioning, they find that heat pumps can provide heating as well as AC, and if they have no ducts, that some heat pumps do not require ducts. They therefore decide to go with heat pumps. Some customers may choose heat pumps to avoid burning fossil fuels in the home. Assessing the frequency with which these scenarios actually happen is a baseline issue for possible future research.

4.2.3 Fuel Oil/Propane Furnace/Boiler to Electric Heat Pump – Cooling

Table 8: Gross and Net Savings Approach for Conversion from Fuel Oil/Propane Furnace/Boiler to Electric Heat Pump – Cooling

	Period 1: Remaining Useful Life (RUL) of Old Equipment			Period 2: Effective Useful Life of Efficient Equipment Minus Old Equipment RUL		
	Conversion**	Service Level Change	High Efficiency	Conversion	Service Level Change	High Efficiency
Gross						
Baseline	Old cooling equipment, old service level	ISP heat pump, old service level	ISP heat pump, new service level	ISP cooling equipment equivalent to old equipment,[12] old service level	ISP heat pump, old service level	ISP heat pump, new service level
New	ISP heat pump, old service level	ISP heat pump, new service level	High-efficiency heat pump, new service level	ISP heat pump, old service level	ISP heat pump, new service level	High-efficiency heat pump, new service level
NTG						
	NA	NTGR 1: Increase in rate of conversions from Residential Baseline Study, based on remaining fuel oil customers each year (negotiated for prospective)*	Negotiated	NA	NTGR 1*	Negotiated

* For cooling, load impacts could go either direction. Examples of reduced load for cooling include multiple room AC units replaced with a ductless mini-split heat pump, or older central AC replaced with an efficient heat pump. Examples of increased load for cooling include going from no cooling before the fuel conversion to cooling with an efficient heat pump, or replacing just a few room AC units with a ductless mini-split heat pump. Examples of no change in MMBTU usage for cooling include continued use of room AC after equipment replacement, or no cooling before or after equipment replacement.

** The "Period 1: Conversion" component of the savings described in this section is still under review, particularly because it may include true early replacement savings that should be separated and assigned a NTGR different than for fuel conversion.

[12] Equivalent to old equipment means one-for-one replacement of the old equipment with new equipment of the same type (e.g., old room air conditioners replaced with ISP room air conditioners, or old central AC replaced with ISP central AC).

4.3 Considerations for Negotiating 2019-2021 NTGRs

In negotiating the 2019-2021 conversion and service change NTGRs, shown in Table 6, Table 7, and Table 8, the PAs may want to consider the following information.

For electric conversion and service level impacts NTGRs, consider the following:

- The conversion rate from 2011-2016, the likely increase each year in conversions over that, and the percentage of the increase in conversions that it is reasonable to attribute to the influence of energy optimization.
- The possibility that other programs and market factors may influence the rate of conversion.
- The likely number of households that have no gas available and so would not be able to convert to gas

For gas conversion and service level impacts NTGRs, consider the following:

- The forecast supply plan, the likely increase each year in conversions over that, and the percentage of the increase in conversions that it is reasonable to attribute to the influence of energy optimization.
- The possibility that other programs and market factors may influence the rate of conversion.
- The likely number of remaining possible conversions to gas in areas with it, or future expansions of gas service areas, which will change over time.

4.4 Other Considerations

4.4.1 Estimating Heating Load After Fuel Conversion

We suggest calculating gross savings for conversion and service change – either separately or combined – as well as high-efficiency impacts, for both heating and cooling.

4.4.2 Conversion Rates

Since it appears that the PAs may not be able to break out conversions from oil versus propane or wood, we suggest that PAs consider applying the conversion rates associated with oil to all delivered fuels.

4.4.3 Data Tracking and Analysis Needs

We suggest that the PAs consider identifying participants who convert fuels via the rebate application. This is based on our understanding that there will be no differentiation among rebates when fuel conversion is involved, and that there will be no rebate for energy optimization. If the energy optimization initiative does not affect incentives, there will be no reason to cheat on the application form. If residential heating support eventually moves upstream, this approach would need to change.

We propose the PAs consider tracking the following data on the rebate form. The PAs could offer customers and contractors the option of submitting some of the information as pictures of equipment nameplates when applying for rebates on-line.

- Customer and contractor contact information
- Capacity, efficiency, brand, and model number of program-supported equipment installed
- Type and fuel source of previous heating equipment
- Age of previous heating equipment or brand, model number, and serial number if age is not available (to improve identification of early retirement)
- Efficiency of previous heating equipment, if available, with a space in which the contractor can write the appropriate units
- Whether the previous heating or water heating equipment was removed or is still in use
- Whether there was cooling equipment in place at the time of conversion, the type of equipment and number of units, and whether the equipment was removed or is still in use

To calculate gross savings, PAs will also need to:

- Obtain pre-conversion electric and gas usage
- If delivered fuels are involved, collect the previous two years of bills from the customer (if available)
- Develop assumptions about the RUL of previous equipment by type, fuel source, and age
- Develop assumptions about the efficiency of previous equipment by type, fuel source, and age (to use when the efficiency information is missing)

We recognize that many customers will not be able to locate, or may not be willing to provide, two years of delivered fuel bills, especially without an incentive for the fuel conversion. With this in mind, we also suggest that to prepare for calculating gross savings, the PAs consider developing estimates of average delivered fuel use for each type of equipment replaced, categorized by age and capacity, using secondary data.

4.4.4 NEIs

The literature review suggests that there may be NEIs from fuel conversion that are substantial enough to warrant measurement. Given this, the PAs may wish to consider estimating the non-energy impacts (NEIs) associated with energy optimization.

4.5 Preparing for Measuring NTG for 2022-2024

As we note above, to prepare for **2022-2024**, we suggest that the PAs consider undertaking a new study to estimate new NTGRs for early retirement, similar to the RES36 study.

Appendix A Details from the Literature Review

A.1 Gross Savings Methodology

Emera Maine Heat Pump Pilot: This evaluation used a metering study to isolate the changes in electricity and fuel use due to the heat pump program for delivered fuel to electric conversions. The results do not aggregate gross impacts, but the team estimated average annual use and customers' cost impacts.

Avista: The Avista evaluation team estimated gross verified savings for the program by conducting a billing analysis. Because the program involves fuel conversions from electric to natural gas equipment, the electricity savings is offset to some extent by increased natural gas consumption. The Avista evaluation factored in the increased gas load as a savings penalty.

Efficiency Vermont: In Vermont, incentives for fuel conversion are separate from incentives for installation of cold climate ductless mini-split heat pumps (ccHPs). Distribution utilities in the State promote the fuel conversion to a baseline heat pump and claim the fuel savings after accounting for a penalty for increased electric load. Efficiency Vermont claims the incremental electric savings of a more efficient cold climate heat pump compared to a baseline heat pump. The Vermont Public Service Department conducted an evaluation between 2015 and 2017 of ccHPs operating in Vermont. The evaluation included a metering study to assess the incremental electric savings of a more efficient cold climate heat pump compared to a baseline of previous heating systems. The study found negative electric energy (kWh) savings because the majority (93%) of heat was provided by oil, propane, or wood-burning systems prior to ccHP installation. The evaluation also included analysis of AMI data, and a participant survey. The study used survey data to assess the likelihood that electric load increased during summer due to participation in a ccHP program and determined that the ccHP program is not producing increased summer cooling load.

Pennsylvania Programs: The PA PUC's Technical Reference Manual includes gross savings algorithms for several fuel conversion measures: residential HVAC (Section 2.2.2 of the TRM), residential water heating (Sections 2.3.3 and 2.3.4), residential appliances (Section 2.4.6), commercial HVAC (Section 3.2.5), and commercial water heating (Sections 3.4.4 and 3.4.5). Measures currently supported include conversion from electricity to either non-electric fuels or natural gas specifically, but fuel conversion to or from any fuel is allowed under Act 129.

For all measures except residential clothes dryers, gross savings is the full energy consumption of the electric equipment that was removed. Increased gas consumption from fuel conversion does not count against PA Act 129 energy savings, though it is included in the program Total Resource Cost (TRC) test. Section L of the TRC covers fuel conversion measures and requires that the equipment earn an ENERGY STAR® performance rating (if applicable to the equipment) and that the benefit/cost analysis include the "increase in costs for the new fuel that will be used as well as the reduction in costs of the old fuel."

For residential clothes dryers, the deemed gross savings includes both the electricity savings and the increased gas consumption.

Puget Sound Energy: On behalf of Puget Sound Energy (PSE), DNV GL used a billing analysis and simple difference-in-difference approach to generate program level savings estimates. The billing analysis consisted of billing regressions that were applied to both gas and electric consumption for pre- and post-conversion periods. Specifically, each site had modeled estimates of (overall) normalized annual consumption, normalized heating consumption, and baseload consumption for both pre- and post-conversion periods for both gas and electric. Program effect was calculated by subtracting the control group's differences over the pre- and post-period (due to natural trends and exogenous factors) from the treatment group's over the pre- and post-period (due to natural trends, exogenous factors, and the program effect).

Cost-effectiveness was determined by calculating the net benefit associated with conversion and comparing that to the net cost associated with the conversion. Using an avoided cost schedule provided by PSE, DNV GL defined the net benefit of the conversion program as the dollar value of the electricity savings resulting from the conversion minus the dollar value of the commensurate increase in gas consumption. The logic model for the residential program is included in Appendix B.1.10.

ComEd: On behalf of ComEd, Navigant used the IL TRM v4.0 Section 5.3.8 to calculate gross savings for geothermal heat pumps (GSHP), which was the only measure that included fuel switching savings at the time. The gross savings algorithms in the TRM allowed for savings to be calculated for standard replacement or early replacement and for fuel switching or continued electric HVAC use. When using the fuel switching equation, the TRM assuming switching from natural gas to electricity.

The TRM states "For the purposes of forecasting load reductions due to fuel switch GSHP projects…changes in site energy use at the customer's…adjusted for utility line losses (at-the-busbar savings), customer switching estimates, NTG, and any other adjustment factors deemed appropriate, should be used. The savings estimate takes into account both heating and cooling savings.

A.2 NTG Methodology

Emera Maine Heat Pump Pilot: The NTG methodology for the evaluation of the Heat Pump Pilot relied on self-report participant surveys and assessed free-ridership and spillover (NTG=1 – FR + SO). In addition to assessing sources of program influence such as program marketing and outreach, the rebate amount, and availability of on-bill financing, the free-ridership estimate also accounted for partial and full free riders. While the program required participating customers to have been using oil, propane, electric resistance heat, or kerosene as a primary heat source, and thus involved those relying on oil, propane or kerosene for heating to convert heating fuel, none of the NTG questions referenced fuel conversion in any way because the evaluator did not separate the impact of the fuel conversion from the program.

Avista: The Avista evaluation team calculated net-to-gross (NTG) ratios at the program level, rather than the equipment level, using participant self-reports collected via surveys. It appears that Avista calculated NTG just for its market-rate Fuel Efficiency program. The NTG methodology took into account free-ridership and spillover. The estimates accounted for program influences such as the rebate amount, marketing materials, and the sales person or contractor. Note that the NTG evaluation was part of a portfolio evaluation, which would have made it difficult to ask questions specific to fuel conversion.

Efficiency Vermont: NMR confirmed with program staff that Efficiency Vermont uses deemed NTG values for all measures, including measures installed in conjunction with a fuel conversion. Efficiency Vermont lists NTG in conjunction with fuel conversion for the following sets of individual measures: water heating equipment, air conditioning equipment, industrial process equipment, refrigerators, cook stoves, dryers, custom measures, furnace, space heaters, biomass, boilers, various types of heat pumps, and displaced load from space heating fuel conversion for a wide variety of equipment types. With the exception of heat pumps, the NTG values typically reflect the program-level estimates. Because of the targeted efforts to promote cold climate and other types of heat pumps, Efficiency Vermont uses measure-specific NTG values for this equipment. The NTG values are developed with input from the distribution companies, Public Utilities Commission, and Public Service Department.

Pennsylvania Programs: The PA PUC uses gross savings for compliance rather than net savings, but does calculate a NTG ratio for program planning and determining cost-effectiveness. The standard method from the Evaluation Framework is used for the overall residential program, but is not specific to the fuel conversion rebates.

SMUD: SMUD has not yet developed an NTG ratio for its electrification programs, due to the small number of rebates processed so far (there were 17 HPWH rebates processed in the first half of 2018 with a smaller rebate, but this has jumped to 18 in one month after the rebate was increased to $3,000 in the second half of 2018). There are plans to develop a new NTG methodology as the program expands.

Puget Sound Energy: Puget Sound Energy does not calculate NTG ratios for its programs and claims gross savings.

ComEd: ComEd uses a deemed value for all replaced HVAC equipment (NTG = 0.99). The value was agreed upon in 2014, using a combination of customer and trade ally surveys from 2011 and 2012.

Appendix B Program Descriptions and Supporting Documents

This appendix provides brief descriptions of the programs, reports, and resources included in the literature review.

B.1 Programs

We identified and reviewed websites and publicly-available reports for the following programs.

B.1.1 Emera Maine Heat Pump Pilot Program

Description: The Heat Pump Pilot Program provided $600 rebates for ductless heat pumps installed in residential homes and small commercial buildings. Qualifying participants used oil, propane, electric resistance heat, or kerosene as a primary heating source, and eligible heat pumps had an HPSF rating of 10 or greater. The 2014 evaluation found that participants saved an average of $622 in heating costs when they offset their use of fuel oil. Participants also reported non-energy benefits, such as increased comfort.

Related Evaluation Reports and Documents:

EMI Consulting for Emera Maine. September 30, 2014. "Emera Maine Heat Pump Pilot Program." http://www.emeramaine.com/media/41789/emera-maine-heat-pump-pilot-final-report-nov-2014.pdf.

B.1.2 Connecticut Ductless Heat Pump Program

Description: Ductless heat pump rebates are available via whole house retrofit and HVAC rebate programs. Low-income customers are eligible for the (Home Energy Solutions – Income-Eligible (HES-IE) Program and may qualify to receive a ductless heat pump at no cost. Evaluated savings were based on installations in spaces that were previously electrically conditioned, but nearly 70% of participants had a pre-existing fossil fuel heating system in 2013-2015.

Related Evaluation Reports and Documents:

DNV GL for the Connecticut Energy Efficiency Board. June 27, 2016. "R113 Ductless Heat Pump Evaluation." https://www.energizect.com/sites/default/files/R113%20Ductless%20Heat%20Pump%20Evaluation_Final%20Report_6.27.16.pdf.

B.1.3 NYSERDA Heat Pump Potential Study

Description: This 2014 study looks in-depth at fuel conversion cost-effectiveness for heat pumps under a variety of heating, cooling, and water heating scenarios that included converting between oil, natural gas, and electricity.

Related Evaluation Reports and Documents:

Heat Pumps' Potential for Energy Savings in New York State

New York State Energy Research and Development Authority. July 2014. "Heat Pumps Potential for Energy Savings in New York State." https://www.nyserda.ny.gov/-/media/Files/EDPPP/Energy-Prices/Current-Outlook/Presentations/Heat-Pumps-Potential.pdf.

B.1.4 UGI Residential and Small Commercial Fuel Switching Program

Description: UGI offers rebates for converting from electricity to natural gas or solar thermal space heating, water heating, and clothes drying.

Related Evaluation Reports and Documents:

UGI Corporation. August 31, 2017. "UGI Utilities, Inc. Electric Division Energy Efficiency and Conservation Plan Program Year 5 (June 1, 2016 – May 31, 2017) Annual Report." http://www.puc.pa.gov/pcdocs/1534301.pdf.

B.1.5 PECO Energy Smart Home Rebate (SHR) and Smart On-site (SOS) Programs

Description: PECO customers completed projects in which electric heating, water heating, and electric dryers were converted to gas.

Related Evaluation Reports and Documents:

Navigant Consulting, Inc. for Pennsylvania Public Utility Commission. November 15, 2016. "EDC Program Year 7 Annual Report." http://www.oracle.com/us/industries/utilities/navigant-peco-py7-2016-3697554.pdf.

B.1.6 PPL Electric Fuel Switching Pilot Program

Description: In 2009, PPL Electric Utilities offered rebates to the first 100 applicants (residential and nonresidential) in three programs. Through the Residential Rebate Program, water heaters were the only available fuel conversion measure. Only 1% of customers reported they converted fuels on the application for a heat pump water heater rebate, though the actual number of fuel conversion customers was estimated to be 4.5%. PPL offered fuel conversion for air source heat pumps and ductless mini-split heat pumps through the Residential Home Comfort Program. Over one-third (70%) of participants reported replacing equipment that was in working condition. The Fuel Switching Pilot Program was also available for the Prescriptive Equipment Program; however, the sample size for the entire pilot was only three people.

Related Evaluation Reports and Documents:

PPL. 2015. "PY5 Annual Report – Fuel Switching." https://www.pplelectric.com/-/media/PPLElectric/Save-Energy-and-Money/Docs/Act129_Phase2/PY5AnnualReportFuelSwitchingAppendix212015.pdf?la=en.

B.1.7 Efficiency Vermont (Various Programs)

Description: Residential and commercial customers can receive incentives for eligible equipment to convert or supplement existing heating and hot water systems. Efficiency Vermont does not offer one program focused solely on fuel conversions. Fuel conversions occur primarily under the auspices of the Heating and Cooling programs, which offer rebates for high-efficiency equipment.

Related Evaluation Reports and Documents:

Efficiency Vermont. April 4, 2017. "2016 Gross-to-Net Factors." https://www.efficiencyvermont.com/Media/Default/docs/plans-reports-highlights/2016/efficiency-vermont-gross-to-net-factors-2016.pdf.

The Cadmus Group, Inc. for the Vermont Public Service Department. November 3, 2017. "Evaluation of Cold Climate Heat Pumps in Vermont." http://publicservice.vermont.gov/sites/dps/files/documents/Energy_Efficiency/Reports/Evaluation%20of%20Cold%20Climate%20Heat%20Pumps%20in%20Vermont.pdf.

Vermont Department of Public Service. 2016. "Comprehensive Energy Plan 2016." https://outside.vermont.gov/sov/webservices/Shared%20Documents/2016CEP_Final.pdf

B.1.8 SMUD Electrification Programs

Description: SMUD has programs for single-family and multifamily new construction and existing homes, offering rebates up to $3,000 for heat pump space heaters and heat pump water heaters.

Related Evaluation Reports and Documents:

B.1.9 Avista Utilities Fuel Efficiency Program

Description: The Fuel Efficiency program provides a rebate for conversion of electric furnaces and/or water heaters to natural gas. Qualifying homes must have used 4,000 or more kWh of electric space heat during the previous winter season to be eligible for flat-rate rebates ranging from $600 to $3,200. If natural gas is not available or not suitable for the home, the installation of an air source heat pump is permitted by the program.

Related Evaluation Reports and Documents:

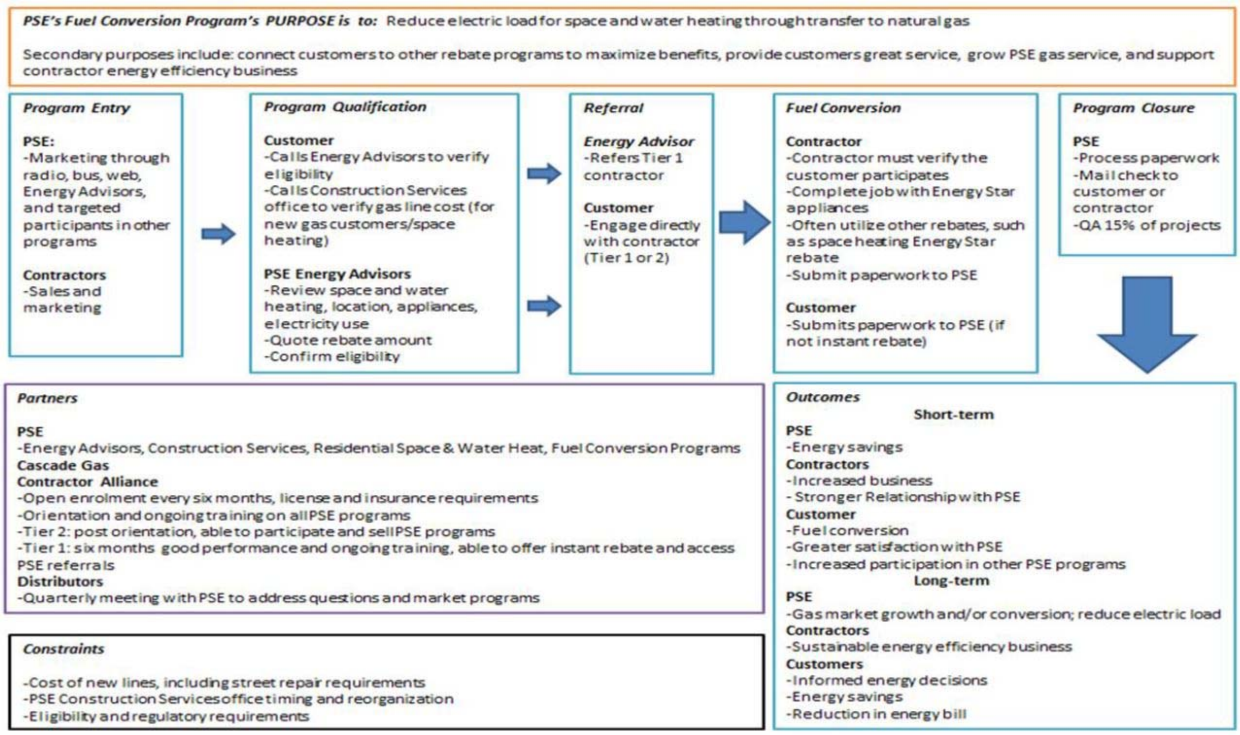
Nexant, Inc. and Research Into Action for Avista Utilities. May 26, 2016. "Impact Evaluation of Washington Natural Gas 2014-2015 Energy Efficiency Programs." https://www.utc.wa.gov/_layouts/15/CasesPublicWebsite/GetDocument.ashx?docID=32&year=2013&docketNumber=132046.

Nexant, Inc. and Research Into Action for Avista Utilities. May 26, 2016. "Process Evaluation of Avista's 2014-2015 Energy Efficiency Programs. https://www.google.com/url?q=https://www.utc.wa.gov/_layouts/15/CasesPublicWebsite/GetDocument.ashx%3FdocID%3D25%26year%3D2013%26docketNumber%3D132046&usg=AFQjCNEZe4AXVIOt5AXV67yZfE_mhz8u-A

B.1.10 Puget Sound Energy Fuel Conversion Program

Description: The Fuel Conversion Program offered rebates for PSE electric customers converting to energy-efficient gas products such as space and water heating and clothes dryers. It was retired in January 2018 due in part to reductions in cost effectiveness. The program also fell short of savings targets; electric-to-gas range and dryer installation were an easy conversion but are low-savings compared to space or water heating.

Program Logic Model:



Related Evaluation Reports and Documents:

Puget Sound Energy. April 2, 2018. "2017 Annual Report of Energy Conservation Accomplishments." https://pse.com/aboutpse/Rates/Documents/ees_2017_annual_rpt_energy_conservation_accomplishments.pdf.

DNV GL for Puget Sound Energy. August 9, 2015. "Fuel Conversion Impact & Process Evaluation." https://conduitnw.org/_layouts/Conduit/FileHandler.ashx?RID=2964

B.1.11 Massachusetts COOL SMART Program

Description: Massachusetts' COOL SMART Program provides a $100-$300 rebate per indoor unit for mini-split heat pump installation. The program encourages participations who have already chosen to install a ductless mini-split heat pump to select a high-efficiency system. A 2016 evaluation examined average energy savings, consumption, and performance of a sample of 2012-2014 Massachusetts program participants and 2014 National Grid Rhode Island High-Efficiency Heating and Cooling Rebate Program participants. The evaluation team estimated savings in fuel-conversion and non-fuel-conversion scenarios, leading to different recommendations for MSHP installation in propane-heated and oil-heated homes. Nearly all (95%) of participants surveyed indicated their previous heating system was still in place after the installation of the heat pump. Additionally, this study found that MSHP have a lower efficient full life hours (EFLH) than specified in the TRM, suggesting that MSHP are used in different ways than conventional heating or cooling technology.

Related Evaluation Reports and Documents:

Cadmus, Navigant and Tetra Tech for the Massachusetts and Rhode Island Program Administrators. April 27, 2016. "Ductless Mini-Split Heat Pump (DMSHP) Draft Cooling Season Results." https://nmrgroupinc.sharepoint.com/MAXC2017-19/Projects/TXC56_EnergyOptim/Team-only%20working%20files/Resources/MA-specific/Ductless-Mini-Split-Heat-Pump-Draft-Cooling-Season-Results-Memorandum.pdf?csf=1&e=kwkfys.

The Cadmus Group, Inc. for the Massachusetts and Rhode Island Program Administrators. December 30, 2016. "Ductless Mini-Split Heat Pump Evaluation." http://ma-eeac.org/wordpress/wp-content/uploads/Ductless-Mini-Split-Heat-Pump-Impact-Evaluation.pdf.

Korn, Dave and Ari Jackson. 2016. "Interaction of Cold Weather Heat Pumps and Primary Fossil Systems." ACEEE 2016 Conference Proceedings. https://aceee.org/files/proceedings/2016/data/papers/1_914.pdf.

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B.1.12 ComEd Heating, Cooling, and Weatherization Rebates Program

Description: ComEd offers residential rebates for ground source heat pumps and includes fuel switching and early replacement as components of their gross savings calculations.

Related Evaluation Reports and Documents:

Navigant Consulting Inc. for the ComEd. January 27, 2017. "ComEd Heating, Cooling, and Weatherization Rebates Program Evaluation Report." http://ilsagfiles.org/SAG_files/Evaluation_Documents/ComEd/ComEd_EPY8_Evaluation_Reports_Final/ComEd_PY8_HVAC_Wx_Rebates_Program_Evaluation_Report_2017-01-27_Final.pdf

Illinois Energy Efficiency Stakeholder Advisory Group. June 28, 2018. "IL Statewide Technical Reference Manual, Version 7.0." http://www.ilsag.info/il_trm_version_7.html

Navigant Consulting for ComEd. "EPY9 NTG Recommendations." http://ilsagfiles.org/SAG_files/NTG/2016_NTG_Meetings/Final_Documents/ComEd_NTG_History_and_PY9_Recommendations_2016-02-26_Final.xlsx.

B.2 Other Background Literature

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Nadel, Steven. 2018. Energy Savings, Consumer Economics, and Greenhouse Gas Emissions Reductions from Replacing Oil and Propane Furnaces, Boilers, and Water Heaters with Air-

Source Heat Pumps. ACEEE. http://aceee.org/sites/default/files/publications/researchreports/a1803.pdf.

Neme, Chris. 2014. "Comparative Analysis of Fuel-Switching from Oil or Propane to Gas or Advanced Electric Heat Pumps in Vermont Homes." Conducted for Vermont Public Interest Research Group. https://www.vpirg.org/wp-content/uploads/2014/11/VPIRG-NEME-Report.pdf.

Vermont Energy Investment Corporation. 2018. "Driving the Heat Pump Market: Lessons Learned from the Northeast." Paper Prepared for the Natural Resources Defense Council. https://www.veic.org/documents/default-source/resources/reports/veic-heat-pumps-in-the-northeast.pdf.