

Understanding Environmental Justice (EJ) areas' opportunities and challenges in energy transformation

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1 Motivation and Problem Statement

Ensuring equitable access to energy transformation for low- and moderate-income (LMI) communities will require a detailed understanding of the specific challenges and opportunities of clean energy deployment in these areas. Electric transportation, high-efficiency home heating, energy efficiency, and distributed energy resources may face barriers to adoption that limit customers in these communities from sharing the value of these options and enhancing long-term energy affordability. Therefore, it is important to understand the barriers and explore opportunities for underserved communities in the earlier stage of energy transformation. The Pennsylvania Department of Environmental Protection defines an EJ Area as any census tract or census block group where 20 percent or more individuals live at or below the federal poverty line, and/or 30 percent or more of the population identifies as any race/ethnicity other than Non-Hispanic White alone, based on data from the U.S. Census Bureau and the federal guidelines for poverty.

1.1 Statement

Utilizing the Pennsylvania Department of Environmental Protection's (PA DEP) definition of an Environmental Justice (EJ) area, can a representative EJ area in the Philadelphia region be selected for a case study to examine barriers and opportunities to deployment of EV, clean and efficient home heating systems, "whole home" energy efficiency measures, and distributed energy resources? Can recommendations be developed to remove barriers to adoption that are actionable by utilities and/or local/state/local government? Discuss if the selected EJ area is representative of Greater Philadelphia region, and if these barriers differ between urban and non-urban EJ areas.

1.2 Considerations

The Pennsylvania Department of Environmental Production enacted a new policy to determine the determining the Energy Justice Communities in Pennsylvania on September 16, 2023. The new policy, and the tools illustrating its use, override the old criteria of selecting Census tract or Census block group where 20 percent or more individuals live at or below the federal poverty line, and/or 30 percent or more of the population identifies as any race/ethnicity other than Non-Hispanic White alone.

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We first summarize the current methodology for determining the Energy Justice Communities in Pennsylvania. Then, we discuss programs available in the PPL and PECO service territories, as well as programs from utilities and directly from the federal government. We end with a summary of ongoing work in the area, including the outline of a methodology to select a representative EJ community, given the old EJ criteria.

2 Energy Justice Communities, New Policies

In this section we summarize the new methodology to determine EJ communities. The full documentation is available at [PADEP, 2023].

The purpose of the PennEnviroScreen tool is primarily to implement Energy Justice (EJ) policy. In this context EJ policy relates to permit applications, inspections, grants and enforcement actions. The screen tool indicates if EJ policy should apply, and it is updated on an annual basis.

The tool uses census block group geographic resolution. This is the Smallest geographic unit the U.S. Census Bureau publishes. Many EJ tools use a more complexified version to codify:

$$\text{Risk} = \text{Threat} \times \text{Vulnerability} \quad (1)$$

The model has two broad categories: **Pollution Burden** and **Population Characteristics**. Within those two categories, there are the following components.

1. Pollution Burden

- (a) Environmental Exposure: measure magnitude of exposure levels or proxies for pollution
- (b) Environmental Effects: adverse environmental conditions caused by pollution that is proximity-based

2. Population Characteristics

- (a) Sensitive Populations: Population health characteristics that result in increased vulnerability to environmental threats that may be caused by or increase adverse effects
- (b) Socioeconomic populations: Population-level demographic characteristics associated with impacts from pollution, which can affect the communities' ability to prevent adverse effects of environmental threats (e.g., race, poverty, unemployment)

Tables 1 and 2 summarize the indicators used. In [Lamadrid and Simons, 2023] we provide a spreadsheet with all indicators and sources of data.

2.1 Formulation

The **EJ score** has six steps, illustrated in Figure 1.

The score considers 32 indicators from different sources, including federal (e.g., EPA, Census Bureau) and state (e.g., Pennsylvania Department of Environmental Protection, DEP). For each one of the indicators selected, the documentation [PADEP, 2023] includes a rationale for inclusion with e.g., academic references, and data sources. There is also a reference for future indicators (e.g., hyper local data for Philadelphia and Pittsburgh, Broadband Internet Access), see page 90, [PADEP, 2023].

Each indicator has a value, and each block group is given a percentile based on its position in the statewide distribution of values. If data is absent, a value of zero is given and they are excluded from the percentiles. Even if an indicator is acceptable, it could be high according to the percentile.

Table 1: Indicators, Pollution related

#	Indicators	Category	Component
1	Ozone	Pollution Burden	Environmental Exposure
2	Fine < Pm 2.5	Pollution Burden or Population Characteristic	Environmental Exposure
3	Diesel Particulate Matter	Pollution Burden or Population Characteristic	Environmental Exposure
4	Toxic Air Emissions	Pollution Burden or Population Characteristic	Environmental Exposure
5	Pesticides	Pollution Burden or Population Characteristic	Environmental Exposure
6	Traffic Density	Pollution Burden or Population Characteristic	Environmental Exposure
7	Compressor Stations	Pollution Burden or Population Characteristic	Environmental Exposure
8	Children's Lead Risk	Pollution Burden	Environmental Exposure
9	Oil Gas Locations (Conventional Wells)	Pollution Burden	Environmental Exposure
10	Oil Gas Locations (Unconventional Wells)	Pollution Burden	Environmental Effects
11	Proximity to Railroads	Pollution Burden	Environmental Effects
12	Land Remediation	Pollution Burden	Environmental Effects
13	Hazardous Waste and Storage Sites	Pollution Burden	Environmental Effects
14	Municipal Waste Sites	Pollution Burden	Environmental Effects
15	Coal Mining	Pollution Burden	Environmental Effects
16	Impaired lakes and streams	Pollution Burden	Environmental Effects
17	Abandoned Mining Concerns	Pollution Burden	Environmental Effects
18	Flood Risk	Pollution Burden	Environmental Effects
19	Asthma	Pollution Burden	Environmental Effects

Table 2: Indicators, Population related

#	Indicators	Category	Component
20	No Health Insurance	Population Characteristic	Sensitive Population
21	Cancer	Population Characteristic	Sensitive Population
22	Disability	Population Characteristic	Sensitive Population
23	Heart Disease	Population Characteristic	Sensitive Population
24	Socioeconomic Population	Population Characteristic	Sensitive Population
25	Low Educational Attainment	Population Characteristic	Socio-Economic Population
26	Linguistic Isolation	Population Characteristic	Socio-Economic Population
27	Housing -Burdened Low-Income Households	Population Characteristic	Socio-Economic Population
28	Poverty	Population Characteristic	Socio-Economic Population
29	Unemployment	Population Characteristic	Socio-Economic Population
30	Race	Population Characteristic	Socio-Economic Population
31	Age over 64	Population Characteristic	Socio-Economic Population
32	Age under 5	Population Characteristic	Socio-Economic Population

$$P = \frac{v_i}{v_{\text{all}}} \times 100, \quad (2)$$

where,

P : Percentile score

v_i : Number of blocks with indicator values less than or equal to this block group's indicator value

v_{all} : total number of block groups

There are four components to the EJ score:

1. Environmental Exposures

2. Environmental Effects

3. Sensitive Populations

4. Socioeconomic populations

The score for each component is generally calculated by averaging percentile values of all of the indicators within those groups.

$$C = \frac{\sum c}{n} \quad (3)$$

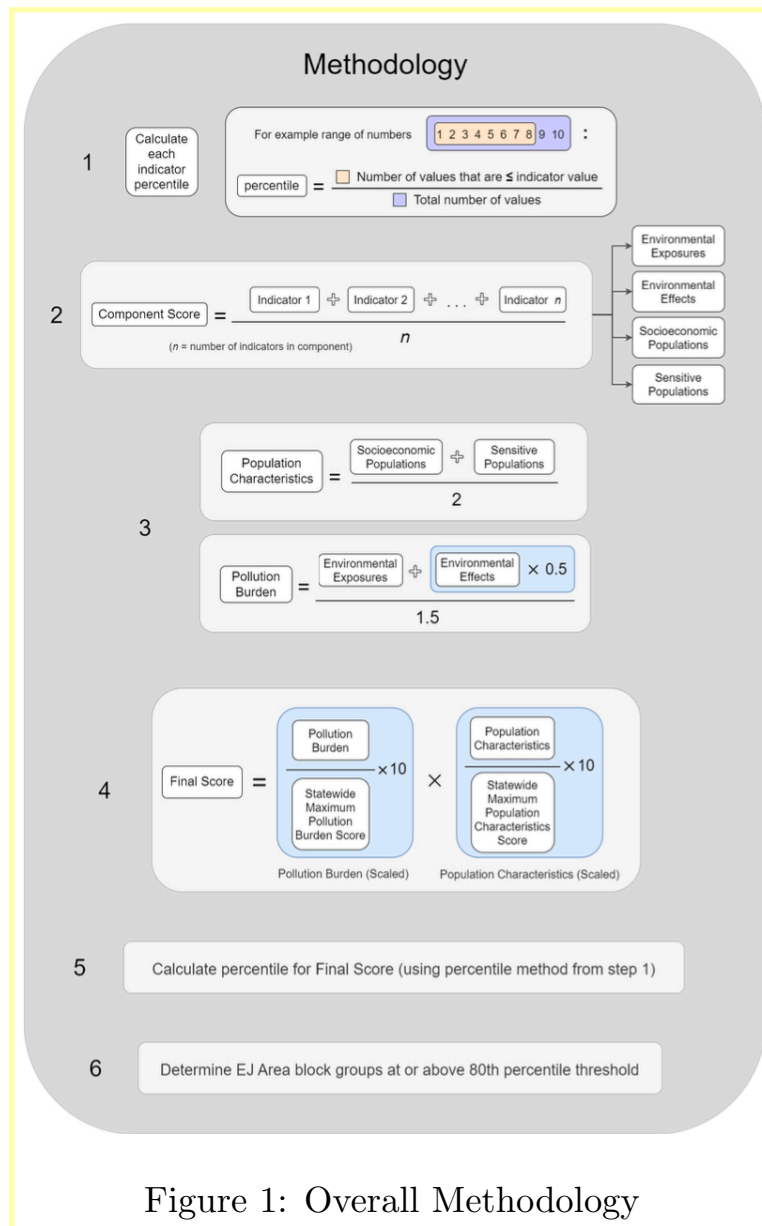


Figure 1: Overall Methodology

where,

C : Component score
 $\sum c$: Sum of all indicator percentiles within component
 n : number of indicators within component

The first two components (Environmental Exposures and Environmental Effects) are the Pollution Burden. The last two components (Sensitive Populations and Socioeconomic Populations) are the Population Characteristics.

2.2 Pollution Burden

The Pollution Burden (PB) score is calculated by taking the weighted average of Environmental Exposures (EXP) and Environmental Effects (EE), with environmental effects being weighted 0.5 of exposures.

$$PB = \frac{EXP_{avg} + (EE_{avg} \times 0.5)}{1.5} \quad (4)$$

where,

PB : Pollution Burden Score (index, 0-100)
 EXP_{avg} : Average of Environmental Exposure indicators
 EE_{avg} : Average of Environmental Effects indicators
 n : number of indicators within component

2.3 Population Characteristics

The population characteristic score is the average of the sensitive populations and socioeconomic populations component scores.

$$PC = \frac{SOC_{avg} + SP_{avg}}{2} \quad (5)$$

where,

- PC : Population Characteristic Score (index, 0-100)
- SOC_{avg} : Average of Socioeconomic populations indicators
- SP_{avg} : Average of Sensitive populations indicators

2.4 Final Score

The final score is calculated by scaling the PB and PC aggregates between 1 and 10 then dividing by the maximum block group and multiplying by 10. The final score percentile is calculated for each block group, then compared to the statewide distribution. The gradient of percentile shows the scale of EJ vulnerability throughout the state. Any block group is an EJ area if its final score percentile is greater than or equal to the 80th percentile.

$$F = \left(\frac{PB}{PB_{max}} \times 10 \right) \times \left(\frac{PC}{PC_{max}} \times 10 \right) \quad (6)$$

where,

- F : Final Score
- PB : Highest block group Population Burden Score in state (index, 0-100)
- PC : Highest block group Population Characteristic Score in state (index, 0-100)

3 Programs in Eastern Pennsylvania

In this section we summarize programs available in Pennsylvania for two electric utilities, PECO in the Philadelphia region and PPL, Covering the Lehigh Valley, Harrisburg and Lancaster.

Table 3 summarizes the main programs in Eastern Pennsylvania, including the PECO and PPL service territories.

Table 3: Programs in Eastern Pennsylvania

Entity	Category	Program	Benefit (\$)	Benefit type	Description
PECO	Clean and Efficient Home Heating Systems	Energy Star Air Source Heat Pump (Tier 1)	200	Rebate	-Product must be new, meet Efficiency Requirements, and installed in a residence that currently receives PECO residential electric service -Application for purchased/installed equipment must be submitted within 90 days of purchase/installation -Application must include a paid receipt with the model number, manufacturer, purchase price, and purchase date
PECO	Clean and Efficient Home Heating Systems	Energy Star Air Source Heat Pump (Tier 2)	300	Rebate	-Product must be new, meet Efficiency Requirements, and installed in a residence that currently receives PECO residential electric service

							-Application for purchased/installed equipment must be submitted within 90 days of purchase/installation -Application must include a paid receipt with the model number, manufacturer, purchase price, and purchase date -Product must be new, meet Efficiency Requirements, and installed in a residence that currently receives PECO residential electric service -Application for purchased/installed equipment must be submitted within 90 days of purchase/installation -Application must include a paid receipt with the model number, manufacturer, purchase price, and purchase date
PECO	Clean and Efficient Home Heating Systems	Energy Star Central Air Conditioning (Tier 1)	150	Rebate			-Product must be new, meet Efficiency Requirements, and installed in a residence that currently receives PECO residential electric service -Application for purchased/installed equipment must be submitted within 90 days of purchase/installation -Application must include a paid receipt with the model number, manufacturer, purchase price, and purchase date
PECO	Clean and Efficient Home Heating Systems	Energy Star Central Air Conditioning (Tier 2)	200	Rebate			-Product must be new, meet Efficiency Requirements, and installed in a residence that currently receives PECO residential electric service -Application for purchased/installed equipment must be submitted within 90 days of purchase/installation -Application must include a paid receipt with the model number, manufacturer, purchase price, and purchase date
PECO	Clean and Efficient Home Heating Systems	Energy Star Ductless Mini-Split Heat Pump (Tier 1)	150	Rebate			-Product must be new, meet Efficiency Requirements, and installed in a residence that currently receives PECO residential electric service -Application for purchased/installed equipment must be submitted within 90 days of purchase/installation -Application must include a paid receipt with the model number, manufacturer, purchase price, and purchase date
PECO	Clean and Efficient Home Heating Systems	Energy Star Ductless Mini-Split Heat Pump (Tier 2)	300	Rebate			-Product must be new, meet Efficiency Requirements, and installed in a residence that currently receives PECO residential electric service -Application for purchased/installed equipment must be submitted within 90 days of purchase/installation -Application must include a paid receipt with the model number, manufacturer, purchase price, and purchase date
PECO	Whole home energy efficiency	Virtual Energy Assessment	N/A				- Free virtual visit from a PECO energy advisor, free energy saving items (LED lightbulbs, smart power strip)
PECO	Whole home energy efficiency	In-home energy check up	250	Value up to			- Must be at or below 200% of the federal poverty line
PECO	Whole home energy efficiency	In-home energy check up (for electric heat)	375	Value up to			
PECO							
PECO PECO	Low Income Assistance	LIHEAP (Federally funded)	3,000	Cash or crisis grant			\$45,000 for household of 4 - CASH grant is a one-time direct payment - CRISIS grant is a direct payment for a heating emergency

					- Emergency include main heating source has been shut-off or within 15 days of being shut-off for non-payment, fuel payments, repairing leaking pipes and broken furnaces
PPL	Whole home energy efficiency	In-home audit rebate for Electric Heating and central air	350	Rebate	Rebate - Must use a certified building analysis - PPL has tool to find contractor
PPL	Whole home energy efficiency	In-home audit for electric heating or Central A/C	200	Rebate	Rebate - Must use a certified building analysis - PPL has tool to find contractor
PPL	Whole home energy efficiency	Virtual Home Energy Assessment	N/A	Energy audit	No cost
PPL	Clean and Efficient Home Heating Systems	Smart Thermostat (self install)	50	Rebate	-limit of five rebates per account between June 2021 and May 2026
PPL	Clean and Efficient Home Heating Systems	Smart Thermostat (professional install)	100	Rebate	-limit of five rebates per account between June 2021 and May 2026
PPL	Clean and Efficient Home Heating Systems	Heat Pump Water Heater	400	Rebate	- Limit of two rebates per account between June 1, 2021 and May 31, 2026. - Universal Energy Factor (UEF) ≥ 2.3
PPL	Clean and Efficient Home Heating Systems	Air Source Heat Pump (ASHP) (Tier 1)	350	Rebate	- Limit of two rebates per account between June 1, 2021 and May 31, 2026.
					- Rebates not available for new construction
PPL	Clean and Efficient Home Heating Systems	Air Source Heat Pump (ASHP) (Tier 2)	450	Rebate	-Limit of two rebates per account between June 1, 2021 and May 31, 2026.
					- Rebates not available for new construction
PPL	Clean and Efficient Home Heating Systems	Ductless Mini-Split Heat Pump	400	Rebate	-Rebates not available for new construction. -Limit of five rebates per account between June 1, 2021 and May 31, 2026. -Equipment already rebated via mid-stream or instant discount channel does not qualify for additional incentives.
PPL	Clean and Efficient Home Heating Systems	Central Air Conditioner (CAC) (Tier 1)	200	Rebate	-Limit of two rebates per account between June 1, 2021 and May 31, 2026.
					-Rebates are not available for new construction.
PPL	Clean and Efficient Home Heating Systems	Central Air Conditioner (CAC) (Tier 1)	300	Rebate	-Limit of two rebates per account between June 1, 2021 and May 31, 2026.
					-Rebates are not available for new construction.
PPL	Whole home energy efficiency	Attic Insulation (electric heated house)	500	Rebate	-New home construction does not apply
					- Limit of one attic insulation rebate per account and one attic insulation rebate per account between June, 2021 - May, 2026
PPL	Whole home energy efficiency	Attic Insulation (central A/C, non-electric heat)	200	Rebate	-New home construction does not apply
					- Limit of one attic insulation rebate per account and one attic insulation rebate per account between June, 2021 - May, 2026
PPL	Whole home energy efficiency	Basement Wall Insulation (electric heat)	500	Rebate	-New home construction does not apply
					- Limit of one attic insulation rebate per account and one basement wall insulation rebate per account between June, 2021 - May, 2026

PPL	Whole home energy efficiency	Basement Wall Insulation (central A/C, non-electric heat)	200	Rebate	-New home construction does not apply
PPL	Whole home energy efficiency	Air Sealing	200	Rebate	- Limit of one attic insulation rebate per account and one basement wall insulation rebate per account between June, 2021 - May, 2026 - must be installed in an existing permanent living space - limit of one rebate per account between June 1, 2021 - May 31, 2026
PPL	Whole home energy efficiency	When the above are combined an additional bonus rebate is given	350	Rebate	
PPL	Low Income Assistance	LIHEAP (Federally funded)	3,000	Cash or crisis grant	\$41,625 for household of 4 - Eligible to up to \$3,000 to help pay heating bill - Closed until early November

4 Ongoing Work

4.1 Programs beyond Pennsylvania

In Appendix B we include a list of other programs available from other utilities. The utilities we sample include ConEd in New York, PG&E in California, Columbia Gas of Ohio, Eversource and Green Mountain Power in the New England Region, and Dominion Energy In Virginia and the Carolinas.

We complement the information with select Federal programs from the Department of Energy (DOE), Department of Health and Human Services (HHS) and the Department of Agriculture (USDA) in Table 7.

4.2 Ongoing and Future Work

There are three main current areas for the work nowadays.

1. We are calculating summaries of the changes in the number of EJ communities with the old and new methodologies, according to the census year data used to create classifications
2. In order to determine a representative EJ are, we selected initially based on the two metrics used for EJ classification, namely income and ethnicity of Census block groups. The selection of Census block groups was based on the distribution of median household income and the rate of non-white populations within census tract block groups. We obtained this data, including median household income and non-white rate, from the American Community Survey (ACS) 5-year dataset, utilizing survey data from 2018 to 2022 [ACS, 2022].

We calculate the joint distribution of median household income and the rate of non-white populations, selecting data ranging from the 20th to the 80th percentile. The final dataset includes 498 census tract blocks in the PECO service area and 220 census tract block groups in the PPL service area. Table 4 summarizes demographics for EJ Census block groups between the 20th and 80th percentile in the PECO service territory.

Table 5 summarizes demographics for EJ Census block groups between the 20th and 80th percentile in the PPL service territory.

Variable Name	Mean	Standard Deviation	Minimum	Maximum
Number of White	505.6	390.2	19	2100
Number of Non-white	936.0	509.0	123	3464
Median house income	61,364	14,757	37,837	93,411
Non-white rate (%)	0.649	0.186	0.337	0.954

Variable Name	Mean	Standard Deviation	Minimum	Maximum
Number of White	946.1	427.6	198	2415
Number of Non-white	341.9	292.9	36	1464
Median house income	60,609	12,203	41,000	84,688
Non-white rate (%)	0.246	0.128	0.071	0.503

Given the new EJ criteria, we are considering a new method to select a representative EJ area

3. The Environmental Protection Agency (EPA) has a national EJ screening tool [EPA, 2023]. We are now working to compare these two tools and determine differences in using each one

References

[ACS, 2022] ACS (2022). 2022: Acs 5-year estimates subject tables. Technical report, United States Census Bureau.

[EPA, 2023] EPA (2023). Environmental justice screening and mapping tool, ejscreen. Technical report, Environmental Protection Agency.

[Lamadrid and Simons, 2023] Lamadrid, A. J. and Simons, K. (2023). Environmental justice indicators. Technical report, Lehigh University.

[PADEP, 2023] PADEP (2023). Pennsylvania environmental justice mapping and screening tool (pennenviroscreen) methodology documentation. Technical report, Pennsylvania Department of Environmental Protection.

A Sources of metrics for EJ Screening Tool

Please refer to <https://bit.ly/47jff3i> for a list of the sources used. An image of the dataset is included in Figure 2.

B Programs Available Beyond Pennsylvania

Indicator Number	Pollution Burden or Populat	Indicator Type	Indicator	Temporal Re	Agency	Source	Federal Link	Method
1	Pollution Burdern	Environmental Exposure	Ozone	1 Year	EPA	Daily summary data of- ozone concentrations (ppm) at air	Yes	Maximum daily v
2	Pollution Burden or Population Ct	Environmental Exposure	PM 2.5	1 Year	EPA NASA	Annual average PM2.5 concentrations (micrograms / cubi Satellite-generated, 1-km resolution, surface PM2.5 conc	Yes	Each airmonitor
3	Pollution Burden or Population Ct	Environmental Exposure	Diesel Particulat	1 Year	EPA	Census Tract-level AirToxScreen Diesel PM10 pollutant-s	Yes	
4	Pollution Burden or Population Ct	Environmental Exposure	Toxic Air Emissio	1 Year	EPA	Risk Screening Environmental Indicator AirToxScreen AirToxScreen: National All Hazard Indexes	Yes	Yearly average
5	Pollution Burden or Population Ct	Environmental Exposure	Compressor Sta	Continuously Upd	DEP	Compressor Station point emissions	No	Chemical values
6	Pollution Burden or Population Ct	Environmental Exposure	Toxic Water Emi	1 Year	EPA	Risk Screening Environmental Indicators (RSEI) geograp	Yes	
7	Pollution Burden or Population Ct	Environmental Exposure	Pesticides	5 Years	USGS EPA	USGS County-level estimated annual agricultural pesticid Toxic Release Inventory: EPA	Yes	Country wide pes
8	Pollution Burden	Environmental Exposure	Children's Lead	5 Years	U.S Census Bur	US Census American Community Survey 2019 5-year da	Yes	
+ variables Additional Links								

Figure 2: Sample of Detailed Metrics for EJ communities

Table 6: Programs in Other Utilities						
Entity	Category	Program	Benefit (\$)	Benefit type	Description	
ConEd	Clean and Efficient Home Heating Systems	Geothermal installa-tion credit	25,000	Credit on invoice	- Must get approved by a contractor from conEd approved list	
ConEd	Clean and Efficient Home Heating Systems	Geothermal in-stallation credit (Disadvantaged Community	35,000	Credit on invoice	- Must get approved by contractor from conEd approved list	
ConEd	Clean and Efficient Home Heating Systems	Heat Pump Water Heater swap	1,000	Rebate	-Must be member of disadvantaged community -Must purchase from a participating distributor	
ConEd	Clean and Efficient Home Heating Systems	Clean Heat Financ-ing		Financing	- Coned selected financing providers can help finance heat pump cost with little to no upfront cost - Qualified individuals include, income-eligible multifamily building with 5 or more units Commercial and industrial building owners - Commercial office tenants under triple-net leases who occupy large foot-prints - Long-term commercial leaseholders -Non-profits -Small business -Single-family homeowner	
ConEd	Clean and Efficient Home Heating Systems	Air-Source heat pump	10,000	Credit on invoice	- Up to \$10,000	
PG&E	Clean and Efficient Home Heating Systems	Energy Action Guide	N/A		- Approved contractors will visit home Online platform	
Dominion Energy	Clean and Efficient Home Heating Systems	Smart Thermostat	30	Rebate	- Limit of two rebate per household -must live in single-family detached residence -Home must have a heat pump -Purchaser must buy and activate En-ergy Star certified smart thermostat	
Green Moun-tain Power	Clean and Efficient Home Heating Systems	Induction Cooktop Rebate	200	Rebate	- Must be replacing fossil fuel cooktop - Must be used for new, installed elec-tric induction cooktop/range - One rebate per GMP account	
Eversource	Clean and Efficient Home Heating Systems	Demand Response Solution: Smart thermostat	70	Annual Savings	- Receive \$50 reward for successfully enrolling and an addition \$20 for each summer enrolled	

Eversource	DER	Demand Response Solution: Home Battery Storage	1,375	Annual Savings	- Incentives are based on average kW per event
Columbia Gas of Ohio	Low Income Assistance	Income-Eligible Weatherization	N/A	Up to 200% of the federal poverty line	
Table 7: Federal Programs					
Entity	Category	Program	Benefit (\$)	Benefit type	Description
U.S DOE	Low Income Assistance	Weatherization Assistance Program (WAP)	7,669	Grant	- At or below 200% of the poverty income guidelines - Or receive supplemental security income -Or Aid to families with Dependent children
U.S HHS	Low Income Assistance	Low-Income Home Energy Assistance Program (LIHEAP)	300-1,000	Grant	- Must meet income guideline, \$45,000 for a family of 4
U.S Department of Agriculture	Low Income Assistance	Single Family Housing Repair Loans and Grants	10,000-40,000	Loan	- Rent or own a home - Inside USDA eligible location - Must be over 62 or older 0 Unable to afford credit elsewhere