

APPENDIX A: DOCUMENTATION OF GHG REDUCTION ASSUMPTIONS

1. Emission Factors

The two emission reduction measures identified in this proposal (Energy Efficiency Fund and Appliance Replacement Fund) reduce emissions by changing the amount and type of energy consumed by buildings. The two activities that emission factors were developed for estimating emission reductions were natural gas and electricity. As such, three greenhouse gases associated with energy production were included in the analysis: carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O). The IPCC Fifth Assessment global warming potential values were used to convert the metric tons (MT) of gases to MT carbon dioxide-equivalent (MT CO₂e) emissions.

Natural Gas

The emission factor for stationary combustion of natural gas in buildings was provided by the EPA Emission Factors for GHG Inventories, 2024, which was calculated to be the following, where CCF represents 100 cubic feet of natural gas.

0.005444	MT CO₂/CCF
0.000000103	MT CH₄/CCF
0.00000001	MT N₂O/CCF
0.00545	MT CO₂e/CCF

In addition, the upstream emissions associated with the production, storage, transmission, and distribution of natural gas was estimated using the EPA 2024 GHG Inventory by comparing the emissions from natural gas combustion (1,709 MMT CO₂e) and from natural gas systems (210 MMT CO₂e). It was estimated that for every 1 MT CO₂e created by combusting natural gas, an additional 0.123 MT CO₂e were emitted upstream. The final emission factor for natural gas was 0.00612 MT CO₂e/CCF.

Electricity

Ann Arbor is within the investor-owned utility DTE's territory. As required by the Michigan Public Service Commission, DTE reports their fuel mix of generated and purchased electricity, percent of purchased electricity, and carbon intensity of the fossil fuel-based energy generated. DTE currently produces 69% of their electricity from fossil fuel sources and purchases 18% of their electricity from a grid that uses 66% fossil fuel sources. The carbon intensity of the DTE grid and the market were provided at 2,180 lb/MWh and 1,927 lb/MWh, respectively. An emission factor of the current grid mix was calculated to be 0.000652 MT CO₂e/kWh.

In addition, DTE Electric is required to currently meet a 15% renewable portfolio, and to achieve a 50% renewable portfolio by 2030, a 60% renewable portfolio by 2035, and a 100% renewable portfolio by 2040. Because these levels are mandated by the State of Michigan, these renewable portfolio amounts were used to forecast the carbon intensity of the grid through 2050. It was assumed that mandates would not be achieved in a linear fashion, but ramped up as the deadline for improvements was required, with 50% of the target being achieved two years before the deadline, and 75% of the target being achieved one year before the deadline. From this, an annual emission factor for the grid was forecasted.

2. Baseline

The reduction measures proposed in this CPRG application target two groups of buildings: single family homes (SFH) in the North Bryant neighborhood, and multi-family condominiums (MF) in the Forest Hills Cooperative (South Bryant neighborhood).

North Bryant Single Family Homes

Through previous projects in the North Bryant neighborhood, the City of Ann Arbor has completed energy audits and gathered data on the energy consumption on multiple SFH. Of the 262 units, 250 units have provided energy data, and over 65 Snugg Pro energy audits have been completed. The median energy consumption was used as a baseline for electricity and natural gas consumption. IMEG, an engineering firm the City of Ann Arbor is working with to design a networked geothermal system, has modeled energy use by end-use. These models used ResStock data scaled to the median energy consumption of the SF units. These end-use estimates were used to identify how much energy was used by specific appliances (water heaters, dryers, space heating, and space cooling).

Bryant SFH Baseline Data Points and Assumptions

	Amount	Units	Source
Median Electricity Consumption	5,090.00	kWh	Energy Model
Median Natural Gas Consumption	623.00	CCF	Energy Model
Average Heating Load	83%	of natural gas consumption	IMEG Energy Model
Average Cooling Load	40%	Of electricity use	IMEG Energy Model
Clothes Dryer	53	Therms/year	IMEG Energy Model
Water Heater	100	Therms/year	IMEG Energy Model

South Bryant / Forest Hills MF Units

Less detailed data was available for the South Bryant / Forest Hills Cooperative MH units. Instead, NREL State Level Residential Building Stock and Energy Efficiency & Electrification Packages was used. The data was limited to Michigan, multi-family housing, with an AMI of less than 150%, a building vintage of 1940-1979, and a heating fuel of natural gas to align with what is known about these MH units. Average energy consumption provided by this resource was used to estimate baseline energy consumption of the MH units. In addition, state-wide average energy consumption by air conditioning and space heating was gathered from RECs.

	Amount	Units	Source
Average Energy Consumption	52	mmBtu	NREL ResStock
Average Electricity Consumption	6,237	kWh	NREL ResStock
Average Natural Gas Consumption	307	Therm	NREL ResStock
Total Energy Consumption per Household	108	mmBtu	RECs
AC Use	4	mmBtu	RECs
Space Heating	67	mmBtu	RECs

3. Reduction Measure Impacts

It was assumed that the reduction measures would be comprised for the following table of improvements and number of units that would receive each measure. These estimates are assumptions, and the scope of this project includes evaluating the highest-impact measures to implement across the North Bryant SFHs and South Bryant/Forest Hills MF units. The number of projects and location of projects may change to reflect what the real world needs looks like over the 4-year grant cycle.

It was assumed that of the 262 units, 200 would be willing to transition to a geothermal system. To avoid double-counting across both measures, the number of units receiving geothermal-based HVAC and weatherization were calculated separately from those not receiving geothermal-based HVAC. The emissions reductions associated with weatherization projects was attributed to the energy efficiency fund measure. Emissions reductions for the geothermal-based HVAC less the emissions reductions of the weatherization improvements for the 200 units receiving both were attributed to the appliance replacement fund emissions reduction measure.

Location of Projects		No. of Units
Energy Efficiency Fund		
Weatherization (Insulation & Air Sealing)	North Bryant SFH, also receiving geothermal HVAC	200
	North Bryant SFH, not receiving geothermal HVAC	50
	South Bryant/Forest Hills MF	300
Window Replacement	South Bryant/Forest Hills MF	110
Appliance Replacement Fund		
Geothermal HVAC	North Bryant SFH	200
Heat Pump Water Heaters		200
Heat Pump Dryers		220

Weatherization

It was assumed that the weatherization package of insulation and air sealing aligned with the basic enclosure upgrade of the [NREL State Level Residential Building Stock and Energy Efficiency & Electrification Packages](#). The basic enclosure package includes attic floor insulation, air leakage reduction, duct sealing, and drill-and-fill wall insulation in qualifying units.

The average energy savings of 19% for natural gas and 5% for electricity were estimated for single-family homes, with an AMI of less than 150%, of housing vintage 1940-1979, and using natural gas for a heating fuel. Based on the energy audits, most SF units have air conditioning. Therefore, a higher percentage of 7% electricity savings was used to scale for the 17% of similar units in the NREL data base that did not have any air-conditioning unit.

The average energy savings of 17% for natural gas and 2% for electricity were estimated for multi-family units, with an AMI of less than 150%, of housing vintage 1940-1979, and using natural gas for a heating fuel. A higher value of 4% for energy savings was used to account for air-conditioning, as 19% of the sample set of buildings in the NREL data base did not have any air-conditioning unit.

Window Replacements

The [EPA ENERGY STAR](#) provides regional estimates for energy savings from window replacements. From this resource, an energy savings of 6% was used for the replacement of double panel windows.

Geothermal-Based HVAC

IMEG provided an estimate that the average efficiency of existing HVAC systems was 75%, and that the new geothermal systems would have a COP of 4. IMEG provided an estimate that the geothermal system would improve the energy efficiency of existing air-conditioning units by a factor of 2.

Heat Pump Clothes Dryer

IMEG provided an estimate that heat pump dryers would use 1/3 less energy than standard dryers. It was assumed that the new washer would have a similar energy efficiency to the existing unit.

Heat Pump Water Heater

IMEG provided an estimate that heat pump water heater would use 1/3 less energy than water heaters.

4. Annual GHG Reductions

The following table shares the annual estimated emission impacts for each reduction measure.

	Energy Efficiency Fund	Appliance Replacement Fund	Total
	<i>MT CO2e</i>	<i>MT CO2e</i>	<i>MT CO2e</i>
2025	374	19	393
2026	397	292	690
2027	397	292	690
2028	377	368	744
2029	366	406	772
2030	356	443	799
2031	356	443	799
2032	356	443	799
2033	344	486	830
2034	339	507	846
2035	333	528	861
2036	333	528	861
2037	333	528	861
2038	313	603	915
2039	303	640	942
2040	292	677	969
2041	292	677	969
2042	292	677	969
2043	292	677	969
2044	292	677	969
2045	292	677	969

2046	292	677	969
2047	292	677	969
2048	292	677	969
2049	292	677	969
2050	292	677	969

Cumulative Energy Savings

The following table summarizes the cumulative GHG reduction savings for the periods 2025-2030 and 2025-2050.

	Energy Efficiency Fund	Appliance Replacement Fund	Total
	<i>MT CO₂e</i>	<i>MT CO₂e</i>	<i>MT CO₂e</i>
2025 - 2030	2,267	1,821	4,088
2025 - 2050	8,491	13,974	22,466