# Technical Appendix

## Overall Documentation

### Tool Used

City of Miami utilized ICLEI Clearpath software for conducting GHG inventories as well as forecasting business as usual scenarios and modelling impact of GHG reduction measures. For this grant, we utilized the “Forecast and Planning Wizard” and the predeveloped calculators to determine impact.

### Business as Usual Scenario

#### Baseline

City of Miami used its 2019 GHG inventory as the baseline scenario for its business-as-usual (BAU) scenario. The 2019 inventory was conducted using the Global Protocol for Community-scale Greenhouse Gas Inventories (GPC) BASIC framework and the global warming potentials (GWP) established in IPCC 5th Assessment Report.

City of Miami has only modeled a BAU scenario and associated GHG reductions to residential electricity as that is the only GHG-emitting source that will be impacted by the proposed programs. The Miami Climate Ready Homes Program Suite targets emissions in the residential sector and focuses on electricity use reduction or generation of electricity from carbon-free sources. Natural gas is a small proportion of residential sector emissions (5%) and is mostly associated with cooking. This projection does not include impact from any large-scale GHG reducing initiatives or non-CPRG federal incentives as none were active in the City of Miami at the time of the inventory.

In 2019, residential electricity accounted for 2,149,121 MWh of electricity usage and 651,569 MT of CO2e. Electricity use data was received directly from the only electricity utility that serves the City of Miami, Florida Power and Light (FPL). CO2 emission factor was received from FPL but CH4 and N2O were taken from eGRID. FPL does not report on CH4 and N2O as they feel their presence in their fuel mix is negligible.

#### Projection to 2050

###### Population

To scale energy use projections to 2050, City of Miami utilized population projections calculated by the City and approved by the State of Florida in the City’s Municipal Comprehensive Neighborhood Plan, “Miami: Envisioning 2035/2045.” The population projections for the City of Miami are comprised of data received from the US Census and Miami-Dade County. The City of Miami is the anchor of both Miami-Dade County and the Miami-Fort Lauderdale-Pompano Beach Metropolitan Statistical Area (MSA). The estimated population in the City of Miami in 2020 was 442,241. The population is expected to increase by 86,816, or 19.63%, to 529,057 by 2035 and by 146,566 people, or 33.14%, to 588,807 by 2045.

A close-up of numbers

Description automatically generated

To project population for 2050, the City calculated the population growth rate between 2040 and 2045 (5.22%), determined the annual growth rate (1.044%), assumed a flat growth rate, and applied these values to the population growth formula to determine that the projected population in 2050 is 620,191.

###### Grid Emissions Intensity

To project changes in grid emissions intensity, the City utilized Florida statewide grid intensity projections calculated by NREL. The Southeast Florida Priority Climate Action Plan (PCAP) used this projection in their BAU scenario so City of Miami utilized this projection as well to stay as aligned as possible. The City utilized an excel-based tool “State Grid Intensity Projections” developed by ICLEI which compiled the NREL projections and eGRID reported MWh/lb grid emissions intensity values. Projected values are reported every two years – those values were inputted into the ICLEI forecasting wizard.

###### Table 1.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Year** | ‘24 | ‘26 | ‘28 | ‘30 | ‘32 | ‘34 | ‘36 | ‘38 | ‘40 | ‘42 | ‘44 | ‘46 | ‘48 | ‘50 |
| **Grid Emissions Intensity lbs/MWh** | 748.887 | 642.140 | 573.951 | 535.436 | 511.847 | 497.847 | 488.434 | 563.170 | 566.874 | 555.101 | 515.154 | 509.091 | 521.834 | 546.856 |

## Measure-Specific Documentation

### PCAP Data

City of Miami utilized GHG reduction calculations from the Southeast Florida Priority Climate Action Plan (PCAP) which were compiled by a consulting team at WSP. Utilizing market data, flat energy reduction potentials were calculated for each GHG reduction measure. The City of Miami utilized their “Energy Reduction Percentage” values where possible and applied to our own adoption scenarios. Where not possible, “Electricity Reduction MWh” values were scaled to per-unit numbers and then scaled to City of Miami adoption scenarios. Specific ICLEI Clearpath calculators used and inputs are detailed below.

### GHG Reduction Estimate Method

To measure the GHG reduction potential of each measure, City of Miami measured the difference in CO2e from the baseline Business As Usual scenario once the measure has been applied. GHG reduction potentials were taken from the Southeast Florida PCAP and then modeled using different implementation values based on each climate program in ICLEI Clearpath. This calculator then output estimated reductions in CO2e per year through 2050. In instances where a measure is present in multiple programs (for example, Keep Safe Miami and Miami Cools) the CO2e reduction for each instance of the measure was calculated and then summed to determine the total projected CO2e reduction potential for each measure as a whole. City of Miami only evaluated impacts from retrofits, the Miami Clate Ready Homes Program Suite does not address new construction. Specific values and assumptions are detailed below.

###### GHG Reduction Estimate Assumptions

We assumed that GHG reductions were derived from reduced electricity use and improved grid emissions intensity (via NREL Florida projections). See Table 1.

### Inputs and Assumptions

###### Generally Applied Assumptions

To determine GHG reduction impact of each GHG reduction measure, City of Miami developed implementation scenarios for each of the three programs: Keep Safe Miami (KS), the Homeownership Preservation Program (HPP), and Miami Cools (MC). According to the American Community Survey (Table B25001) City of Miami had 228,213 housing units in 2022. A study conducted by Construction Coverage reported that in 2023 48.4% of existing housing units in the Miami-Fort Lauderdale- Pompano Beach MSA were in multi-family buildings and 51.6% were single-family residences.[[1]](#footnote-2) We applied these percentages to City of Miami’s total housing units to approximate how many housing units are in multifamily buildings (110,455) and how many are single-family residences (117,758). Through this grant we intend to complete 100 projects per program over the 5 year grant period. We intend for these projects to have a geographic spread across the City will 20 projects per program being completed in each of the City’s 5 districts each year over the period of the grant. The Keep Safe Miami program targets buildings with 4-20 units so we used a 20 unit building to evaluate impact. The Miami Cools program addresses efficiency on a per unit basis and therefore will assume 4 units per multifamily housing building.

Table 2a.

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| --- | --- | --- | --- |
| *Program* | **Keep Safe Miami (KS)** | **Homeownership Preservation Program (HPP)** | **Miami Cools (MC)** |
| *Implementation Total* | 100 multifamily buildings / 2,000 housing units | 100 single-family homes/housing units | 50 single-family homes/housing units  50 multifamily buildings / 200 housing units |
| *Implementation Rate* | 400 housing units per year  0.18% of total housing | 20 housing units per year  0.009% of total housing | 50 housing units per year  0.02% of total housing |

Table 2b.

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| --- | --- | --- |
| **Housing** | **Value** | **Percentage of total units** |
| Total housing units | 228,213 | 100% |
| Multifamily housing units | 110,455 | 48.4% |
| Single family housing units | 117,758 | 51.6% |

Anticipated energy savings per measure were calculated for the Southeast Florida PCAP and those values were utilized for GHG emission reduction calculations, see Table 3. In addition, the Southeast Florida PCAP established a 10kW solar install as the baseline size for solar photovoltaic installations.

Table 3.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **R-01** | **R-02** | **R-03** | **R-04a** | **R-04b** | **R-05** | **R-06** | **R-07** | **R-08** | **R-09** |
| *Programs* | KS, MC | KS, HPP | KS, MC | KS, HPP, MC | KS, HPP | KS, HPP | KS | KS | KS | KS, MC |
| *Savings* | 11% | 10kW/ install | 4.5% | 118.26 kWh/ home/ year | 295.66 kWh/ home/ year | 168.3 kWh/ home/ year | 12% | 6.9% | 7% | 2% |

###### Measure-Specific Inputs and Assumptions

**R-01** **Residential Heat Pump or High-Efficiency A/C Retrofits and Commissioning**

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| --- | --- |
| **Models/Tools Used** | ICLEI Clearpath Planning and Forecast Wizard tool, “High Impact Action - Residential Electrification And Efficiency” calculator. This calculator asks for energy use in baseline year (2019), “percent of existing housing units receiving efficiency retrofit per year,” and “savings from efficiency retrofit of existing buildings.” |
| **Measure Implementation Assumptions** | Applied the implementation values for both KS and MC. See Table 2a. We modeled that the measures were implemented from 2026 to 2030. |
| **Reference Case Scenario (GHG Emissions or Activity Level)** | The BAU scenario used projects 2019 Residential Electricity Use values out to 2050. Residential energy use scaled with population and is not influenced by other GHG reduction programs. |
| **Measure-Specific Activity Data** | Using values calculated by the PCAP, we assumed R-01 measures equated to a 11.3% energy savings per housing unit installed. See Table 3 and Attachment “SEFL PCAP Calculations GHG Residential Measures.” GHG reduction estimate calculated for R-01 with KS and MC implementation rates and then summed. |
| **GHG Emissions Reduced (all values in MT CO2e)** | Annual reduction 2025-2030: 271.83  Total reduction 2025-2030: 1631  Annual reduction 2025-2050: 355.73  Total reduction 2025-2050: 9249 |

**R-02** **Solar Photovoltaics (PV)**

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| **Models/Tools Used** | ICLEI Clearpath Planning and Forecast Wizard tool, “Increased Residential Solar Photovoltaic” calculator. We also used the PVWatts calculator and Google Environmental Insights Explorer Solar Potential tool to determine solar generation potential. |
| **Measure Implementation Assumptions** | Applied the implementation values for both KS and HPP. See Table 2a. We modeled that the measures were implemented from 2026 to 2030 only. |
| **Reference Case Scenario (GHG Emissions or Activity Level)** | The BAU scenario used projects 2019 Residential Electricity Use values out to 2050 (see above for what inputs were used in this projection). |
| **Measure-Specific Activity Data** | The PCAP uses 10kW as the standard size solar installation. For Keep Safe, we assumed 4,000kW of solar installed per year. For HPP, we assumed 200kW of solar installed per year. Next, we used PVWatts to determine that the average solar install in City of Miami has a generation potential of 1559 kWh/kW. We utilized (25.77, -80.22) as the location to serve as proxy for the City due to its central location in City and representative of the general city PV potential according to Google EIE Solar Potential tool. See Table 3 and Attachment “SEFL PCAP Calculations GHG Residential Measures.” |
| **GHG Emissions Reduced (all values in MT CO2e)** | Annual reduction 2025-2030: 3330  Total reduction 2025-2030: 19980  Annual reduction 2025-2050: 4358.04  Total reduction 2025-2050: 113309 |

**R-03 Residential LED Lighting**

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| **Models/Tools Used** | ICLEI Clearpath Planning and Forecast Wizard tool, “High Impact Action - Residential Electrification And Efficiency” calculator. This calculator asks for energy use in baseline year (2019), “percent of existing housing units receiving efficiency retrofit per year,” and “savings from efficiency retrofit of existing buildings.” |
| **Measure Implementation Assumptions** | Applied the implementation values for both KS and MC. See Table 2a. We modeled that the measures were implemented from 2026 to 2030 only. |
| **Reference Case Scenario (GHG Emissions or Activity Level)** | The BAU scenario used projects 2019 Residential Electricity Use values out to 2050 (see above for what inputs were used in this projection). |
| **Measure-Specific Activity Data** | Using values calculated by the PCAP, we assumed R-03 measures equated to a 4.5% energy savings per housing unit installed. See Table 3 and Attachment “SEFL PCAP Calculations GHG Residential Measures.” GHG reduction estimate calculated for R-03 with KS and MC implementation rates and then summed. |
| **GHG Emissions Reduced (all values in MT CO2e)** | Annual reduction 2025-2030: 108.17  Total reduction 2025-2030: 649  Annual reduction 2025-2050: 141.62  Total reduction 2025-2050: 3682 |

**R-04a** **Weatherization and Air Leakage**

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| **Models/Tools Used** | ICLEI Clearpath Planning and Forecast Wizard tool, “Low Income Weatherization Programs” calculator. |
| **Measure Implementation Assumptions** | Applied the implementation values for both KS, HPP, and MC. See Table 2a. We modeled that the measures were implemented from 2026 to 2030 only. |
| **Reference Case Scenario (GHG Emissions or Activity Level)** | The BAU scenario used projects 2019 Residential Electricity Use values out to 2050 (see above for what inputs were used in this projection). |
| **Measure-Specific Activity Data** | The PCAP estimates 308,257,990 kWh reduction per year in the region from measure R-04a. The total number of residential units used for this calculation is 2,220,031. The equates to 295.66 kWh saving/unit. See Table 3 and Attachment “SEFL PCAP Calculations GHG Residential Measures.” |
| **GHG Emissions Reduced (all values in MT CO2e)** | Annual reduction 2025-2030: 811.17  Total reduction 2025-2030: 4867  Annual reduction 2025-2050: 1061.35  Total reduction 2025-2050: 27595 |

**R-04b** **Roof Insulation**

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| **Models/Tools Used** | ICLEI Clearpath Planning and Forecast Wizard tool, “Low Income Weatherization Programs” calculator. |
| **Measure Implementation Assumptions** | Applied the implementation values for both KS and HPP. See Table 2a. We modeled that the measures were implemented from 2026 to 2030 only. |
| **Reference Case Scenario (GHG Emissions or Activity Level)** | The BAU scenario used projects 2019 Residential Electricity Use values out to 2050 (see above for what inputs were used in this projection). |
| **Measure-Specific Activity Data** | The PCAP estimates 123,303190 kWh reduction per year in the region from measure R-04b. The total number of residential units used for this calculation is 2,220,031. The equates to 118.26 kWh saving/unit. See Table 3 and Attachment “SEFL PCAP Calculations GHG Residential Measures.” |
| **GHG Emissions Reduced (all values in MT CO2e)** | Reduction evaluated as R-04 as a whole. See R-04a for values. |

**R-05 Window, Door, and Skylight Replacement**

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| **Models/Tools Used** | ICLEI Clearpath Planning and Forecast Wizard tool, “Low Income Weatherization Programs” calculator. |
| **Measure Implementation Assumptions** | Applied the implementation values for both KS and HPP. See Table 2a. We modeled that the measures were implemented from 2026 to 2030 only. |
| **Reference Case Scenario (GHG Emissions or Activity Level)** | The BAU scenario used projects 2019 Residential Electricity Use values out to 2050 (see above for what inputs were used in this projection). |
| **Measure-Specific Activity Data** | The PCAP estimates 373,646,040 kWh reduction per year in the region from measure R-04b. The total number of residential units used for this calculation is 2,220,031. The equates to 168.3 kWh saving/unit. See Table 3 and Attachment “SEFL PCAP Calculations GHG Residential Measures.” |
| **GHG Emissions Reduced (all values in MT CO2e)** | Annual reduction 2025-2030: 344.17  Total reduction 2025-2030: 2065  Annual reduction 2025-2050: 450.19  Total reduction 2025-2050: 11705 |

**R-06** **Appliances and Plug Load Management**

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| **Models/Tools Used** | ICLEI Clearpath Planning and Forecast Wizard tool, “High Impact Action - Residential Electrification And Efficiency” calculator. This calculator asks for energy use in baseline year (2019), “percent of existing housing units receiving efficiency retrofit per year,” and “savings from efficiency retrofit of existing buildings.” |
| **Measure Implementation Assumptions** | Applied the implementation value for KS. See Table 2a. We modeled that the measures were implemented from 2026 to 2030 only. |
| **Reference Case Scenario (GHG Emissions or Activity Level)** | The BAU scenario used projects 2019 Residential Electricity Use values out to 2050 (see above for what inputs were used in this projection). |
| **Measure-Specific Activity Data** | Using values calculated by the PCAP, we assumed R-06 measures equated to a 12% energy savings per housing unit installed. See Table 3 and Attachment “SEFL PCAP Calculations GHG Residential Measures.” |
| **GHG Emissions Reduced (all values in MT CO2e)** | Annual reduction 2025-2030: 236.17  Total reduction 2025-2030: 1417  Annual reduction 2025-2050: 309.04  Total reduction 2025-2050: 8035 |

**R-07** **Domestic Hot Water – Heat Pump**

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| **Models/Tools Used** | ICLEI Clearpath Planning and Forecast Wizard tool, “High Impact Action - Residential Electrification And Efficiency” calculator. This calculator asks for energy use in baseline year (2019), “percent of existing housing units receiving efficiency retrofit per year,” and “savings from efficiency retrofit of existing buildings.” |
| **Measure Implementation Assumptions** | Applied the implementation value for KS. See Table 2a. We modeled that the measures were implemented from 2026 to 2030 only. |
| **Reference Case Scenario (GHG Emissions or Activity Level)** | The BAU scenario used projects 2019 Residential Electricity Use values out to 2050 (see above for what inputs were used in this projection). |
| **Measure-Specific Activity Data** | Using values calculated by the PCAP, we assumed R-07 measures equated to a 6.9% energy savings per housing unit installed. See Table 3 and Attachment “SEFL PCAP Calculations GHG Residential Measures.” |
| **GHG Emissions Reduced (all values in MT CO2e)** | Annual reduction 2025-2030: 135.67  Total reduction 2025-2030: 814  Annual reduction 2025-2050: 177.69  Total reduction 2025-2050: 4620 |

**R-08 Domestic Hot Water – Solar Water Heater**

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| **Models/Tools Used** | ICLEI Clearpath Planning and Forecast Wizard tool, “High Impact Action - Residential Electrification And Efficiency” calculator. This calculator asks for energy use in baseline year (2019), “percent of existing housing units receiving efficiency retrofit per year,” and “savings from efficiency retrofit of existing buildings.” |
| **Measure Implementation Assumptions** | Applied the implementation values for KS. See Table 2a. We modeled that the measures were implemented from 2026 to 2030 only. |
| **Reference Case Scenario (GHG Emissions or Activity Level)** | The BAU scenario used projects 2019 Residential Electricity Use values out to 2050 (see above for what inputs were used in this projection). |
| **Measure-Specific Activity Data** | Using values calculated by the PCAP, we assumed R-08 measures equated to a 7% energy savings per housing unit installed. See Table 3 and Attachment “SEFL PCAP Calculations GHG Residential Measures.” |
| **GHG Emissions Reduced (all values in MT CO2e)** | Annual reduction 2025-2030: 137.67  Total reduction 2025-2030: 826  Annual reduction 2025-2050: 180.19  Total reduction 2025-2050: 4685 |

**R-09 Smart Thermostat**

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| **Models/Tools Used** | ICLEI Clearpath Planning and Forecast Wizard tool, “High Impact Action - Residential Electrification And Efficiency” calculator. This calculator asks for energy use in baseline year (2019), “percent of existing housing units receiving efficiency retrofit per year,” and “savings from efficiency retrofit of existing buildings.” |
| **Measure Implementation Assumptions** | Applied the implementation values for both KS and MC. See Table 2a. We modeled that the measures were implemented from 2026 to 2030 only. |
| **Reference Case Scenario (GHG Emissions or Activity Level)** | The BAU scenario used projects 2019 Residential Electricity Use values out to 2050 (see above for what inputs were used in this projection). |
| **Measure-Specific Activity Data** | Using values calculated by the PCAP, we assumed R-09 measures equated to a 2% energy savings per housing unit installed. See Table 3 and Attachment “SEFL PCAP Calculations GHG Residential Measures.” GHG reduction estimate calculated for R-09 with KS and MC implementation rates and then summed. |
| **GHG Emissions Reduced (all values in MT CO2e)** | Annual reduction 2025-2030: 43.67  Total reduction 2025-2030: 262  Annual reduction 2025-2050: 57.19  Total reduction 2025-2050: 1487 |

## Cumulative Effectiveness

### Magnitude of GHG Reductions

###### 2025-2030

From 2025-2030, the City of Miami Climate Ready Housing Program Suite will reduce GHG emissions by 32,511 MT CO2e total. On an annual basis, that equates to 5,418.5 MT CO2e.

###### 2025-2050

From 2025-2050, the City of Miami Climate Ready Housing Program Suite will reduce GHG emissions by 184,367 MT CO2e total. On an annual basis, that equates to 7,091.04 MT CO2e.

### Cost Effectiveness of GHG Reductions

The total proposed cost of the Miami Climate Ready Housing Program Suite is $36,880,459. From 2025-2030, this program will eliminate 32,511 MT CO2e from the atmosphere. That is the sum of reductions from the three climate ready housing programs and their associated GHG reduction measures. Investment in this program equates to $1,134.40/MTCO2e removed from the atmosphere.

1. https://constructioncoverage.com/research/cities-building-the-most-multi-family-housing [↑](#footnote-ref-2)