Attachment B. Technical Appendix

SECTION 1. ANALYTIC APPROACH

The analysis described in this technical appendix evaluates the greenhouse gas (GHG) emissions impact of the GHG reduction measures in this application, which are designed to reduce emissions and build community resilience. This document addresses New York State's GHG reduction estimate methods, models or tools used, measure implementation assumptions, GHG reduction estimate assumptions, reference case scenarios, measure-specific activity data, and GHG emissions reduced.

Four measures were evaluated:

1) Support organics recycling and food waste diversion
2) Phase out hydrofluorocarbons and support natural refrigerants
3) Create green community cooling and heating centers
4) Support advanced energy performance contracting for local governments

To estimate the GHG emissions impact of this portfolio, Energy and Environmental Economics, Inc. (E3) developed an Excel-based tool that conducts a bottom-up analysis for each measure in the Climate Pollution Reduction Grants Program Priority Climate Action Plan for New York State. The tool is designed to comply with EPA guidance and incorporates inputs from publicly available literature, data, and tools. A custom-built tool was determined to be the best solution for organizing results and accounting for the various implementation timelines, activity levels, resulting energy and emissions impacts, and costs of each measure within the portfolio. The tool provides both annual measure-level results, as well as consolidated portfolio-level results for GHG emissions impact and cost.

In general, the GHG emissions reduction for each measure is calculated by multiplying the increase in measure 'activity' by its associated GHG emission factor. The reference case used for each measure assumes that the CPRG-funded measures result in incremental activity levels. For example, emissions impacts of the natural refrigerants measure are calculated as the difference in refrigerant leakage by refrigerant type, multiplied by their relative emissions factors for commercial food store (or other facilities that support food security) conversions supported by CPRG funding. The specific inputs and assumptions used to calculate emissions impacts vary by measure and are driven by each measure's given activity. This bottom-up approach to evaluating each measure is designed to ensure that only emissions impacts of incremental activities are calculated and aims to prevent potential double-counting of emissions reductions.

The calculation of co-pollutant benefits for each measure mirrors the bottom-up calculation used to estimate GHG emissions reductions. The increase in measure 'activity' was multiplied by its associated co-pollutant emissions factors for ammonia (NH_3), nitrogen oxides (NO_x), fine particulate matter ($PM_{2.5}$), sulfur dioxide (SO_2), and volatile organic compounds (VOC). Co-pollutant benefits were only calculated for measures that are expected to meaningfully impact co-pollutants, which are defined for the purpose of this analysis as measures that impact fuel consumption. EPA's Co-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA)[1] was then used to convert co-pollutant emissions impacts into estimated health impacts.

[1] EPA COBRA

The allocation of co-pollutant benefits to low income and disadvantaged communities (LIDAC) was then estimated based on the portion of a measure expected to be implemented within federally designated LIDAC census tracts or blocks. For example, the green community cooling/heating centers measure is expected to be applied exclusively within LIDAC communities, therefore the analysis assumes that co-pollutant benefits are allocated to LIDAC areas. The portion of New York's population that is estimated to live in LIDAC areas was estimated using EPA's Inflation Reduction Act Disadvantaged Communities Map.[2] While inputs and assumptions are naturally uncertain, the measure analyses are designed to minimize uncertainty through primary research and feedback from New York State agencies. The analyses included in the tool are intended to be easily updated as newer or more robust information becomes available and as program implementation guidelines are solidified.

SECTION 2. PROPOSAL-WIDE ASSUMPTIONS

Measures share a common set of emission assumptions including fuel GHG emissions factors, grid GHG emissions factors, global warming potentials (GWPs), and co-pollutant emission factors. In addition to accounting for combustion-related emissions, the analysis includes upstream GHG emissions. Tables 1 through 5 below provide an overview of the shared emissions assumptions, which have been sourced from publicly available data sets, including EPA and New York State sources.

Table 1. Global Warming Potentials (IPCC AR5)

GHG	100-year GWP
Carbon Dioxide (CO_2)	1
Methane (CH_4)	28
Nitrous Oxide (N_2O)	265

Table 2. Electricity Grid Emission Factors[3]

GHG	Unit	2025	2030	2035	2040
CO_2	MT/MWh	0.1812	0.0742	0.0474	0.0005
CH_4	MT/MWh	0.0010	0.0004	0.0003	0
N_2O	MT/MWh	0	0	0	0

Table 3. Combustion Fuel Emission Factors[4]

Fuel	Unit	CO_2	CH_4	N_2O
Natural Gas	kg/MMBtu	53.06	1.00	0.10
Fuel Oil No. 2	kg/MMBtu	73.96	3.00	0.60

Table 4. Upstream Fuel Emission Factors[5]

Fuel	Unit	CO_2	CH_4	N_2O
Natural Gas	kg/MMBtu	12.21	0.35	0.00014
Fuel Oil No. 2	kg/MMBtu	14.60	0.12	0.00025

[2] Inflation Reduction Act Disadvantaged Communities Map
[3] Climate Action Council Scoping Plan, Appendix G
[4] EPA GHG Emission Factors Hub
[5] 2022 NYS Statewide GHG Emissions Report

Table 5. Co-Pollutant Emission Factors[6]

Fuel	Unit	NH_3	NO_X	$PM_{2.5}$	SO_2	VOC
Natural Gas	Kg/cubic foot	0.22	44.44	0.19	0.27	2.44
Fuel Oil	Kg/gallon	0.36	8.89	0.00	0.09	0.15

Measures also share a common analytical approach, which involves establishing an activity-based reference case that is then compared to the mitigation case to understand the net emissions benefit of each measure. As the activities involved with each measure vary, the tool includes measure-specific assumptions to evaluate each measure. The following section identifies the activity-data, implementation assumptions, measure-specific assumptions, and emissions calculations used for each measure.

SECTION 3. MEASURE-SPECIFIC ASSUMPTIONS

NYSDEC and NYSERDA worked diligently to define each measure's scope, including a realistic implementation timeline for the measure, the lifetime of the measure, and the funding needed to implement. For each measure, E3 incorporated this information to develop an implementation timeline. These measure implementation assumptions are based on New York's extensive experience delivering GHG emission reduction programs. Where other funding sources would be leveraged, total implementation cost was then calculated based on the number of units of a given measure installed and the dollar-per-unit cost for each measure prorated by the amount attributable to CPRG, per the program guidance. The sections below outline the measure-specific assumptions that were identified through this process.

a. Support Organics Recycling

This measure seeks to fund efforts to increase mixed organic waste collection to be sent to composting facilities. Composting has a net negative emissions factor, meaning that as more organic waste is composted, associated GHG emissions decrease. This stems from the avoided fertilizer offset from compost usage, improved soil carbon storage, and diverted waste from landfills. With regards to implementation, this measure seeks to deploy two rounds of grants to recipients. One-third of projects in the first round of grants are assumed to be completed by 2027, and one-third of projects in the second round of grants are assumed to be completed by 2028. This analysis assumes funding supports 50% composting facilities and 50% education and collection programs. By 2029, all projects are assumed to have been completed, meaning that the pace of construction in the second round is faster than the first round. The grant lifetimes were assumed to last ten years.[7]

Table 6. Organics Measure Implementation Schedule

Year	2025	2026	2027	2028	2029
Cumulative First Round Projects Completed	0	0	7	14	20
Cumulative Second Round Projects Completed	0	0	0	6	20
Cumulative Total	0	0	7	20	40

[6] Climate Action Council Scoping Plan, Appendix G

[7] USDA Conservation Practice Overview for Composting Facilities

Table 7. Organics Measure Cost Assumptions

Budget component	Unit	Value
Grant amount per project	$	500,000
Cost matching per project	$	166,667
Program size	No. Grants	40
Total implementation cost	**$**	**26,666,667**
Cost sharing	$	(6,666,667)
Existing federal/state funding	$	N/A
CRPG funding need	**$**	**20,000,000**
GHGs Attributable to CPRG		**75%**

For this measure, the program budget was not related to specific program costs, but rather selected based off intended measure scale. With a total of 40 grants of $500,000 each, the total CPRG budget for this measure is $20 million. This value does not include cost matching, which is assumed to be 25% of the grant amount, which sums to $6.67 million overall. This also does not include costs to administer the program. A simplified cost of organic waste collection, in $/short ton, was used to translate grant amounts into additional compost collected. Then, the EPA Waste Reduction Model (WARM) was used to gather emissions factors for the CH_4 and CO_2 emissions associated with landfilling and composting mixed organic waste. The amount of additional compost collected is then scaled by emissions impact and number of projects funded to calculate total emissions reductions, as seen in the equations below.

$$AOC = \$/ton\ of\ Organics * Grant\ Budget$$

$$ER = N * AOC * (-EF_L - EF_C) * P$$

Where ER is aggregate emissions reductions, N is the number of grants provided, AOC is the amount of additional organic waste collected (short tons), EF_L and EF_C are the emissions factors of landfilling and composting respectively (MTCO2e/short ton), and *P* is the percent of abatement that can be attributed to CPRG based on the ratio of CPRG funding to implementation cost.

Note: EF_L is assigned a negative value here since landfilling is being avoided due to composting.

Table 8. Organics Measure Input Values and Sources

Measure	Value	Source
Landfilling Emissions Factor (MT CO_2e/short ton)	0.16	EPA WARM V16
Composting Emissions Factor (MT CO_2e/short ton)	-0.13	EPA WARM V16
Landfill Gas Composition (CH_4 to CO_2 Ratio)	1:1	EPA LMOP
Cost of Organics Collection ($/ton)	50	NYSDEC Prior Experience

b. Phase Out Hydrofluorocarbons and Support Natural Refrigerants

This measure seeks to support the phase out of high-GWP refrigerants in food refrigeration facilities such as food banks or food hubs and replace existing equipment with ultra-low or zero GWP refrigerant alternatives. The emissions reductions from this measure will be achieved through reduced leaking of high-GWP refrigerants from refrigeration equipment into the atmosphere. Implementation of this measure will begin in 2025, and 20 facilities are set to be converted each year until 2030, resulting in a

cumulative total of 100 refrigerant projects completed. Emissions impacts will begin accruing upon project completion.

Table 9. Natural Refrigerants Measure Implementation Schedule

Year	2025	2026	2027	2028	2029
Cumulative project completions	20	40	60	80	100

Table 10. Natural Refrigerants Measure Cost Assumptions

Budget component	Unit	Value
Full system replacement	$/project	750,000
Partial system replacement	$/project	250,000
Split between partial and full system replacements	%	50/50
Program Size	No. facilities	100
Total implementation cost	**$**	**50,000,000**
Cost sharing	$	N/A
Existing federal/state funding	$	N/A
CRPG funding need	**$**	**50,000,000**
GHGs Attributable to CPRG		**100%**

The California Air Resources Board (CARB) F-Gas Reduction Incentive Program (FRIP) was used to estimate cost parameters for this measure.[8] Specifically, Example Projects 2 and 3 from the CARB FRIP user guide were referenced for the cost of an ultra-low GWP refrigerant retrofit project. An equal split between partial and full refrigerant replacement projects was assumed, leading to 50 of each type of project implemented by 2030 respectively. There was assumed to be no existing funding available for this measure, nor were fund recipients assumed to share any of the cost. The total amount of CPRG funding requested is $50 million. Emissions reductions for this measure were calculated using the leakage rates and emissions factors of legacy and replacement refrigerants respectively. In this analysis, the counterfactual refrigerant was assumed to be R-507A, while the replacement was assumed to be R-744. The annual abatement per project was therefore calculated as the difference between the counterfactual refrigerant system and the replacement system emissions. Finally, the annual emissions reduction was scaled up by typical project lifetime of 15 years and total number of projects funded. The equations used to calculate emissions reduction are shown below.

$$ER_A = (L_L * EF_L) - (L_R * EF_R)$$

Where ER_A is annual emissions reductions, *L* is amount of legacy refrigerant [kg] multiplied by annual leakage rate [%], and EF is refrigerant emissions factor [kgCO2e/kg]. The subscripts *L* and *R* refer to legacy refrigerant and replacement refrigerant, respectively.

$$ER = ER_A * PL * N * P$$

Where *ER* is aggregate emissions reductions, *PL* is typical project lifetime, *N* is number of refrigerant retrofit projects implemented and *P* is the percent of abatement that can be attributed to CPRG based on the ratio of CPRG funding to total program cost.

[8] CARB F-Gas Reduction Incentive Program User Guide

Table 11. Natural Refrigerants Measure Input Values and Sources

Measure	Value	Source
R-507A Emissions Factor (kgCO2e/kg)	3,985	CARB F-gas Reduction Program
R-744 Emissions Factor (kgCO2e/kg)	1	CARB F-gas Reduction Program
Starting amount of refrigerant, full system replacement (kg)	1,361	NYSDEC Prior Experience
Ending amount of refrigerant, full system replacement (kg)	907	NYSDEC Prior Experience
Starting amount of refrigerant, partial system replacement (kg)	680	NYSDEC Prior Experience
Ending amount of refrigerant, partial system replacement (kg)	227	NYSDEC Prior Experience
Annual Leakage Rate, typical system (%)	24%	CARB F-gas Reduction Program

c. Create Green Community Cooling/Heating Centers

This measure will provide funding to retrofit cooling and heating centers in disadvantaged communities, to provide thermal safety to local communities. This analysis assumed all cooling/heating center retrofits will include some combination of an improved building shell and an electric heat pump such as an air source heat pump (ASHP). Implementation will begin once CPRG funding is received, and all 10 cooling/heating centers will be implemented by 2028. Emissions reductions are realized once a retrofit is completed, as the cooling/heating center transitions from fossil-fuel powered space conditioning to electric space conditioning. The measure lifetime used within this analysis is 16 years, reflecting a typical lifetime for a heat pump system.

Table 12. Cooling/Heating Centers Measure Implementation Schedule

Year	2025	2026	2027	2028	2029
Cumulative number of facilities with ASHP + envelope upgrade	0	0	5	10	10

Table 13. Cooling/Heating Centers Measure Cost Assumptions

Budget component	Unit	Value
Average project cost	$/facility	3,000,000
Program size	No. facilities	10
Total implementation cost	**$**	**30,000,000**
Cost sharing	$	N/A
Existing federal/state funding	$	(800,000)
CRPG funding need	**$**	**29,200,000**
GHGs Attributable to CPRG		**97%**

A dollar per facility cost provided by New York State agencies was used to estimate the total implementation cost of the Cooling/Heating Centers measure. This analysis also assumes that the Cooling/Heating Center measure qualifies for the federal Energy Efficient Commercial Building deduction.[9] Once existing federal funding is applied, CPRG program funding is used to cover the remaining retrofit cost for facilities. The volume of emissions that could be reduced via this measure is calculated based on the change in energy consumption between a facility with a reference fossil fuel HVAC system and envelope, and a building with an ASHP and improved building envelope. The energy savings used in this calculation are based on NREL's ComStock database and are specific to New York's building stock.[10] Emissions reductions attributable to the Cooling/Heating Centers measure are adjusted

[9] IRS Energy Efficient Commercial Buildings Deduction

[10] Comstock Database

based on the CPRG portion of the total measure cost (see Table 13). The equations used to calculate total measure emissions reductions are provided in the figure below.

$$ER = (\Delta F * EF_f + \Delta E * EF_e) * N * P$$

Where *ER* is emissions reductions due to measure, ΔF is the change in fuel consumption between baseline and measure, EF_f is fuel emissions factor, ΔE is the change in electricity consumption between baseline and measure, EF_e is electric emissions factor, *N* is number of buildings retrofit and *P* is the percent of abatement that can be attributed to CPRG based on the ratio of CPRG funding to total implementation cost.

Table 14. Cooling/Heating Centers Input Values and Sources

Building Type	Conditional sq. ft. per building	Post-measure fuel savings	Post-measure electricity savings	Source(s)
Office, gas heating	16,000	550 MMBtu	25,908 kWh	Energy savings: Comstock_NY_MediumOffice Conditioned sq. ft.: Agency input
Office, oil heating	16,000	496 MMBtu	21,580 kWh	Energy savings: Comstock_NY_MediumOffice Conditioned sq. ft.: Agency input

d. Support Advanced Energy Performance Contracting for Local Governments

Energy performance contracting (EPC) funding will be used to develop a contracting structure that municipalities can use to implement energy efficiency (EE) and electrification projects. Based on New York State agency feedback, this analysis assumes that municipal buildings consist of a mix of office buildings and equipment management shops. In modeling this measure, it was assumed that 50% of retrofits would be for office buildings and 50% would be for equipment management shops; within each building type, it was assumed that 75% of the buildings retrofitted would be buildings using natural gas for heating, and 25% would be using oil. Due to the relatively high cost of fuel oil and low cost of natural gas, it was assumed that buildings using gas for heating would undergo general EE upgrades, whereas buildings using oil would undergo ASHP installation and building envelope upgrades. 50 EPC portfolios will be retrofitted between 2027-2028, and each portfolio is assumed to cover 6 buildings. This timeline assumes 2 rounds of funding, with round 1 projects completed in 2027 and round 2 projects completed in 2028. However, the application leaves room for a 3rd round if funds are not fully awarded in 2 rounds of applications. In the event of a 3rd round, the deployment schedule would show a more gradual implementation schedule, with approximately 1/3rd of projects achieving completion in each of the following years: 2027, 2028, and 2029.

Table 15. Advanced EPCs Measure Implementation Schedule

Year	2025	2026	2027	2028	2029
Cumulative number of EPC portfolios retrofitted	**0**	**0**	**25**	**50**	**50**
Cumulative office (gas) retrofits – EE	0	0	56	113	113
Cumulative office (oil) retrofits – shell + ASHP	0	0	19	38	38
Cumulative equipment management shop (gas) retrofits – EE	0	0	56	113	113
Cumulative equipment management shop (oil) retrofits – shell + ASHP	0	0	19	38	38

Since this measure is not directly funding the emissions reductions interventions, but rather is enabling financing of those interventions, capital costs to implement projects are not included in the analysis. Accordingly, the analysis assumes that 100% of GHG reductions are attributable to CPRG.

The Advanced EPC measure abatement potential is calculated similarly to the Cooling/Heating Centers measure and is based on the emissions difference between an office building or vehicle service or repair building before and after the measure is completed. It was assumed that buildings heated with natural gas undergo EE improvements, while buildings heated with fuel oil undergo a full heat pump conversion. Energy savings for offices was based on upgrade package data from NREL's ComStock database. Energy savings for vehicle service or repair shops was calculated based on a combination of upgrade package data from NREL's ComStock database and Energy Information Administration's 2018 Commercial Buildings Energy Consumption Survey (CBECS) database.[11] This combination of data sources was selected to analyze vehicle service or repair shops as the ComStock database does not include a similar building type of vehicle service or repair shops and would not reflect an accurate starting energy intensity. The CBECS database was used to determine starting energy consumption for vehicle service or repair shops, based on that building type within the database. Energy savings for this building type was then estimated based on the proportion of energy saved per square foot calculated using ComStock upgrade package data for the office building type, assuming that a similar set of upgrades are made to all buildings within the EPC portfolio. This proportion of energy saved per square foot was then applied to the starting energy intensity and the conditioned square footage of vehicle service or repair buildings to estimate fuel and electricity savings.

$$ER = (\Delta F * EF_f + \Delta E * EF_e) * N_P * N_B * P$$

Where ER is emissions reductions due to measure, ΔF is the change in fuel consumption between baseline and measure, EF_f is fuel emissions factor, ΔE is the change in electricity consumption between baseline and measure, EF_e is electric emissions factor, N_P is number of portfolios retrofitted, N_B is the number of buildings per portfolio, and P is the percent of abatement that can be attributed to CPRG based on the ratio of CPRG funding to total program cost.

Table 16. Advanced EPCs Input Values and Sources

Building Type	Conditioned sq. ft. per building	Post-measure fuel savings	Post-measure electricity savings	Source(s)
Office, gas heating	16,000	163 MMBtu	5,830 kWh	Energy savings: Comstock_NY_MediumOffice Conditioned sq. ft.: Agency input
Office, oil heating	16,000	496 MMBtu	21,580 kWh	Energy savings: Comstock_NY_MediumOffice Conditioned sq. ft.: Agency input
Equip. shop, gas heating	100,000	1,364 MMBtu	27,167 kWh	Energy savings: CBECS_Vehicle service or repair; adjusted by ComStock savings Conditioned square feet: Agency Input
Equip shop, oil heating	100,000	3,096 MMBtu	73,908 kWh	Energy savings CBECS_Vehicle service or repair; adjusted by ComStock savings Conditioned square feet: Agency Input

[11] EIA Commercial Buildings Energy Consumption Survey (2018)

SECTION 4. GHG EMISSIONS REDUCED

Table 17 and Table 18 detail the measure-specific annual GHG emission reductions in metric tons of CO_2 equivalent ($mtCO_2e$) for each year from 2025 through 2050. Table 19 details the cumulative GHG emission reductions for the periods 2025-2030 and 2025-2050.

Table 17. Annual GHG Emission Reductions ($mtCO_2e$), 2025-2030

Measure	'25	'26	'27	'28	'29	'30
Organics Recycling	0	0	0	26	77	155
Natural Refrigerants	0	20	39	59	79	98
Cooling/Heating Center	0	0	0.1	0.3	0.4	0.4
Advanced EPCs	0	0	7	20	26	26
Total	**0**	**20**	**46**	**105**	**182**	**279**

Table 18. Annual GHG Emission Reductions ($mtCO_2e$), 2031-2050

Measure	'31	'32	'33	'34	'35	'36	'37	'38	'39	'40	'41	'42	'43	'44	'45-50
Organics Recycling	155	155	155	155	155	155	155	129	78	0	0	0	0	0	0
Natural Refrigerants	98	98	98	98	98	98	98	98	98	98	79	59	39	20	0
Cooling/Heating Centers	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.2	0
Advanced EPCs	26	26	26	26	26	26	26	25	25	25	25	25	25	13	0
Total	**279**	**279**	**279**	**279**	**279**	**279**	**279**	**253**	**202**	**124**	**104**	**85**	**65**	**33**	**0**

Table 19. Cumulative GHG Emission Reductions ($mtCO_2e$) for 2025-2030 and 2025-2050

Measure	2025-2030	2025-2050
Organics Recycling	257,211	1,546,667
Natural Refrigerants	295,228	1,476,141
Cooling/Heating Centers	1,313	6,967
Advanced EPCs	78,396	423,585
Total	**632,148**	**3,453,359**