Providence City-Wide GHG Inventory Handbook

An evolving document for the methodology and procedure of preparing Providence's City-Wide Greenhouse Gas Emission Inventory.

This guide is based around the free Community Track of ICLEI's (Local Governments for Sustainability) ClearPath tool.

Link: https://clearpath.icleiusa.org/users/sign_in
Last updated 14th December 2023 by Adelmo Intrieri.

Creating a new Inventory

1. Navigate to ClearPath's "Inventories" page. Use Community-Scale Track for City Wide Inventories.
2. Click the "New Inventory" button.
3. Supply a name… the format that has been used previously is "Providence City Wide [YYYY]" where [YYYY] is the year of the inventory.
4. Supply the year of the inventory. This field will restrict which factor sets can be used with the inventory. For example, a factor set named "eGRID 2016" could be used on a 2018 inventory if and only if the "year" field on the Factor Set and this field are equal.
5. Population estimates for the current year can be found through the Census Bureau.
6. GDP is estimated at the level of Statistical Metropolitan areas. Because we cannot source a City-specific value, this is omitted. It does not impact emissions estimations.
7. Checking the "Official Inventory for Selected Year" enables year over year comparisons in certain reporting functions. Only one inventory per year may be assigned this designation at a time.
8. The 2015 and 2018 Inventories used the IPCC 2nd Assessment for the Global Warming Potential.
9. Do not check "Make public" until the Inventory is completed.

All parameters of an Inventory (fields set when creating) can be altered by clicking "Edit parameters" for the Inventory in the Inventories page.

Warning: At time of writing, clicking "Recalculate Outputs" when editing parameters of an inventory can cause errors in some records, and corrupt data in others.

Factor Sets

Factor Sets enable you to provide ClearPath with conversions and other figures which may be shared between multiple records in one or several inventories of the same year. Although some Factor Sets are not utilized for previous inventory functionality. Here is a list Factor Sets available:

- Transportation
- Waste Characterization
- Grid Electricity
- Growth Rates
- Fuel Prices
- Net Present Value Parameters

Note: The year set for each factor, not the set's name, determines which inventories will be able to use the information contained within.

Transportation

ICLEI provides a default factor set each inventory year, but a more accurate set should be created. The name of sets providence will use is in the following format " YYYY Transportation Emissions Factors".

A majority of these values can be obtained from the EPA GHG Emission Factors Hub (Locate the specific year, Tables 3,4,&8) and the Federal Highway Administration's Highway Statistics (Locate the specific year and Table VM-1).

When data for other rows cannot be found, copy the US National Defaults ICLEI provides in the factor set editor or from the previous inventory factor set.

The following are the transportation factors contained within the most recent (2021) factor set:

Inventory Name	Value
Gas Passenger Vehicle Fuel Economy (MPG)	25.2
Gas Passenger Vehicle g CH_4/mi	0.0050
Gas Passenger Vehicle g N_2O/mi	0.0014
Gas Light Truck Fuel Economy (MPG)	17.9
Gas Light Truck g CH_4/mi	0.0079
Gas Light Truck g N_2O/mi	0.0012
Gas Heavy Truck Fuel Economy	7.5

(MPG)	
Gas Heavy Truck g CH_4/mi	0.0328
Gas Heavy Truck g N_2O/mi	0.0098
Gas Transit Bus Fuel Economy (MPG)	7.3
Gas Transit Bus g CH_4/mi	0.0063
Gas Transit Bus g N_2O/mi	0.0011
Gas Para Transit Bus Fuel Economy (MPG)	18.2
Gas Para Transit Bus g CH_4/mi	0.0117
Gas Para Transit Bus g N_2O/mi	0.0087
Gas Motorcycle Fuel Economy (MPG)	44.0
Gas Motorcycle g CH_4/mi	0.0084
Gas Motorcycle g N_2O/mi	0.0069
Electric Vehicle Fuel Economy (MPGe)	
Diesel Passenger Vehicle Fuel Economy (MPG)	25.3
Diesel Passenger Vehicle g CH_4/mi	0.0302
Diesel Passenger Vehicle g N_2O/mi	0.0192
Diesel Light Truck Fuel Economy (MPG)	18.0
Diesel Light Truck g CH_4/mi	0.0290
Diesel Light Truck g N_2O/mi	0.0214
Diesel Heavy Truck Fuel Economy (MPG)	6.561615
Diesel Heavy Truck g CH_4/mi	0.0095
Diesel Heavy Truck g N_2O/mi	0.00431
Diesel Transit Bus Fuel Economy (MPG)	7.3
Diesel Transit Bus g CH_4/mi	0.0206
Diesel Transit Bus g N_2O/mi	0.0009

Diesel Para Transit Bus Fuel Economy (MPG)	7.3
Diesel Para Transit Bus g CH_4/mi	0.0206
Diesel Para Transit Bus g N_2O/mi	0.0009
Diesel Motorcycle Fuel Economy (MPG)	44.0
Diesel Motorcycle g CH_4/mi	0.0005
Diesel Motorcycle g N_2O/mi	0.001

Waste Characterization

For each inventory year, ClearPath requires a breakdown of Municipal Solid Waste Generation by material. We have used national statistics provided by the EPA for the 2015 and 2018 Factor Sets. If local information can be sourced, that may be usable.

Data for these Factor Sets have been sourced specifically from the EPA's Advancing Sustainable Materials Management Facts and Figures Report. (Locate the latest data here). For the 2021 inventory, the latest Facts and Figures Fact Sheet released was 2018. The data can be found in a pie chart (Figure 4) with the title name "Total MSW Generation (by material)".

Each Factor Set requests 10 percentages, which should sum to 100%. Unfortunately, each of these categories is not individually reported in the pie chart. The values from that chart are divided and combined according to the following to fill the set completely.

Factor Set Row	Value from EPA Report	Rationale
Mixed MSW	0	This is a default for when valid data is not collected. (0% in the case data was entered, 100% in the case valid data was not collected)
Newspaper	$\frac{\text{Paper}}{4}$	We assume that equal parts of "paper" are used for these four categories. Please use more precise distribution if available.
Office Paper		
Corrugated Cardboard		
Magazines/Third Class Mail		
Food Scraps	Food Scraps	
Grass	$\frac{\text{Yard Trimmings}}{2}$	We assume that equal parts of "yard trimmings" are distributed over these two categories. Please use more precise distribution if available.
Leaves		
Branches	$\frac{\text{Wood}}{4}$	We assume that equal parts of

Dimensional Lumber		"wood" are distributed over these two categories. Please use more precise distribution if available.

The following are the waste factors contained within the most recent (2021) factor set:

Percentage Mixed MSW	0
Percentage Newspaper	5.775
Percentage Office Paper	5.775
Percentage Corrugated Cardboard	5.775
Percentage Magazines / Third Class Mail	5.775
Percentage Food Scraps	21.6
Percentage Grass	6.05
Percentage Leaves	6.05
Percentage Branches	3.1
Percentage Dimensional Lumber	3.1

Grid Electricity

For each inventory year, ClearPath requires emissions outputs rates for grid electricity production. For previous inventories, Providence has used data from the EPA's Emissions & Generation Resource Integrated Database (eGRID). To extract information for the factor set:

1. Visit the eGRID website.
2. Navigate to "Download the full eGRID datasets" and download eGRID2021.xlsx file.
3. Open the downloaded file (eGRID2021_data) and navigate to the State year data. The excel sheet is referenced in the Table of Contents sheet as ST21.
4. Identify the row labeled with "RI" for Rhode Island. Amongst other information, this row contains the values for the factor set.

The following table identifies factor set row relationship to data column in eGRID 2021.

Factor Set Row	eGRID 2021 Column	eGRID 2016 Column Title	Conversion
CO_2 lbs/MWh	AL	State annual CO_2 combustion output emission rate (lb/MWh)	None
CH_4 lbs/GWh	AM	State annual CH_4 combustion output emission rate (lb/MWh)	Convert lbs/MWh to lbs/GWh by multiplying eGRID value by a factor of 1000.
N_2O lbs/GWh	AN	State annual N_2O combustion output emission	

		rate (lb/MWh)	

Note: CH_4 and N_2O figures are given in lbs/MWh and must be converted to the lbs/GWh required by ClearPath.

The following are the grid electricity factors contained within the most recent (2018) factor set:

CO_2 lbs/MWh	875.794
CH_4 lbs/GWh	16
N_2O lbs/GWh	2

Other Factor Sets

ClearPath's Forecast Growth Rates, Fuel Prices, and Net Present Value Parameters Factor Sets have not been utilized. They do not seem to be needed for ClearPath's Inventory functionality.

Inventories

An Inventory contains a series of records grouped into 10 categories:

- Residential Energy
- Commercial Energy
- Industrial Energy
- Transportation & Mobile Sources
- Solid Waste
- Water & Wastewater
- Agriculture (AFOLU)
- Process & Fugitive Emissions
- Upstream Impacts of Activity
- Consumption Based

Each category comes with a preset series of "calculators." Calculators are tools that represent records… they allow you to input different types of information and, using built in methods and information provided in Factor Sets, calculates emissions. These calculators/records are used to represent a specific source or type of emissions.

Categories also come with direct record options and notation factors.

Please reference the Global Protocol for Community-Scale GHG Emission Inventories (GPC) for all information that should be included in inventories and

What's in a record/calculator?

The format for this section is as follows. The orange header indicates the name of the record used in the inventory. Field names that appear in ClearPath are **bolded**. Values/text that should be entered in directly without any calculations on your part are in light blue.

> **Note:** Each sector has a corresponding spreadsheet located in the Inventory Data Collection heading. Start by collecting data before creating any records/calculators.

Residential Energy

Residential Electricity Use

Calculator Type: Emissions from Grid Electricity

Factor Set/Grid Electricity: eGRID for Inventory Year

Were emissions calculated externally? No

Electricity Used: This figure is sourced directly from the Electric sheet kWh.

Number of Households: This figure is sourced directly from the Electric sheet Households.

Population: This is the same figure used for the Inventory Parameters, sourced from the Census Bureau.

Data Quality: Activity Data: High

Data Quality: Emissions Factor: Medium

Residential Natural Gas Use

Calculator Type: Emissions from Stationary Fuel Combustion

Were emissions calculated externally? No

Fuel Type: Natural Gas

Fuel Use: This figure is sourced directly from the Natural Gas sheet Therms.

Data Source: Measured usage.

Number of Households: This figure is sourced directly from the Electric sheet Households.

Population: This is the same figure used for the Inventory Parameters, sourced from the Census Bureau.

Data Quality: Activity Data: High

Data Quality: Emissions Factor: Medium

Residential Wood Combustion Use

Calculator Type: Emissions from Stationary Fuel Combustion

Were emissions calculated externally? No

Fuel Type: Wood

Fuel Use: This figure is sourced directly from the Misc sheet Tons.

Data Source: Estimation using EIA usage.

Number of Households: This figure is sourced directly from the Misc sheet Households.

Population: This is the same figure used for the Inventory Parameters, sourced from the Census Bureau.

Residential Distillate Oil Use

Calculator Type: Emissions From Stationary Fuel Combustion

Were emissions calculated externally? No

Fuel Type: Distillate Fuel Oil No. 2

Fuel Use: This figure is sourced directly from the Misc sheet Gallons.

Data Source: Estimation using EIA usage.

Number of Households: This figure is sourced directly from the Misc sheet Households.

Population: This is the same figure used for the Inventory Parameters, sourced from the Census Bureau.

Residential LPG Use

Calculator Type: Emissions From Stationary Fuel Combustion

Were emissions calculated externally? No

Fuel Type: LPG

Fuel Use: This figure is sourced directly from the Misc sheet Gallons.

Data Source: Estimation using EIA usage.

Number of Households: This figure is sourced directly from the Misc sheet Households.

Population: This is the same figure used for the Inventory Parameters, sourced from the Census Bureau.

Commercial Energy

Commercial & Industrial Electric Use

Calculator Type: Emissions from Grid Electricity

Factor Set: eGRID for Inventory Year

Were emissions calculated externally? No

Electricity Used: This figure is sourced directly from the Electric sheet kWh.

Data Quality: Activity Data: High

Data Quality: Emissions Factor: High

Commercial / Industrial Natural Gas Use

Calculator Type: Emissions from Stationary Fuel Combustion

Were emissions calculated externally? No

Fuel Type: Natural Gas

Fuel Use: This figure is sourced directly from the Natural Gas sheet Therms.

Data Quality: Activity Data: High

Data Quality: Emissions Factor: High

Commercial Gasoline Use

Calculator Type: Emissions from Stationary Fuel Combustion

Were emissions calculated externally? No

Fuel Type: Gasoline

Fuel Use: This figure is sourced directly from the C&I Misc sheet Gallons.

Commercial Workforce Size: This figure is sourced directly from the LODES sheet Employees.

Data Quality: Activity Data: Medium

Data Quality: Emissions Factor: High

Commercial Residual Fuel Oil Use

Calculator Type: Emissions from Stationary Fuel Combustion

Were emissions calculated externally? No

Fuel Type: Residual Fuel Oil No. 5

Fuel Use: This figure is sourced directly from the C&I Misc sheet Gallons.

Commercial Workforce Size: This figure is sourced directly from the LODES sheet Employees.

Data Quality: Activity Data: Medium

Data Quality: Emissions Factor: High

Commercial LPG Use

Calculator Type: Emissions from Stationary Fuel Combustion

Were emissions calculated externally? No

Fuel Type: LPG

Fuel Use: This figure is sourced directly from the C&I Misc sheet Gallons.

Commercial Workforce Size: This figure is sourced directly from the LODES sheet Employees.

Data Quality: Activity Data: Medium

Data Quality: Emissions Factor: High

Commercial Distillate Fuel Oil Use

Calculator Type: Emissions from Stationary Fuel Combustion

Were emissions calculated externally? No

Fuel Type: Distillate Fuel Oil No. 2

Fuel Use: This figure is sourced directly from the C&I Misc sheet Gallons.

Commercial Workforce Size: This figure is sourced directly from the LODES sheet Employees.

Data Quality: Activity Data: Medium

Data Quality: Emissions Factor: High

Industrial Energy

Manchester Street Power Plant Natural Gas Auxiliary Combustion

Calculator Type: Emissions from Stationary Fuel Combustion At Energy Industries

Were emissions calculated externally? Yes

Do you wish to use Custom or Default Emissions Factors? Use Default

Energy End Use Type: Auxiliary Energy Use

Fuel Type: Natural Gas

Fuel Use: This figure is sourced directly from the Manchester St. Power Plant sheet Gallons.

Energy Use Attribution: 100%

Data Quality: Activity Data: Medium

Data Quality: Emissions Factor: High

Grid Electricity Use at Energy Industries

Calculator Type: Record for Notation Keys For Energy Industries & Non Specified Sources

Information Only: Yes

GPC Reference Number: I.4.2

Notation Keys: IE

Industrial/Manufacturing Electricity Use

Calculator Type: Record for Emissions From Grid Electricity

Factor Set/Grid Electricity: eGRID for Inventory Year

Notation Keys: IE

Industrial/Manufacturing Natural Gas Use

Calculator Type: Emissions from Stationary Fuel Combustion

Notation Keys: IE

Manchester Street Power Plant Natural Gas Use

Calculator Type: Emissions from Stationary Fuel Combustion At Energy Industries

Were emissions calculated externally? No

Do you wish to use Custom or Default Emissions Factors? Use Default

Energy End Use Type: Electricity Generation

Fuel Type: Natural Gas

Fuel Use: This figure is sourced directly from the Manchester St. Power Plant sheet MMBtu.

Data Source: EPA Mandatory Reporting

Energy Use Attribution: 100%

Data Quality: Activity Data: High

Data Quality: Emissions Factor: High

Non-Specific Emissions From Grid-Supplied Energy Consumed Within the City Boundary

Calculator Type: Notation Keys for Energy Industries & Non Specified Sources

Information Only: Yes

GPC Reference Number: I.6.2

Notation Keys: NO

Manchester Street Power Plant Fuel Oil Use

Calculator Type: Emissions from Stationary Fuel Combustion At Energy Industries

Were emissions calculated externally? No

Do you wish to use Custom or Default Emissions Factors? Use Default

Energy End Use Type: Electricity Generation

Fuel Type: Distillate Fuel Oil No. 2

Fuel Use: This figure is sourced directly from the Manchester St. Power Plant sheet MMBtu.

Data Source: EPA Mandatory Reporting

Energy Use Attribution: 100%

Data Quality: Activity Data: Medium

Data Quality: Emissions Factor: High

Emissions From Non-Specific Fuel Combustion Sources

Calculator Type: Notation Keys for Energy Industries & Non Specified Sources

Information Only: Yes

GPC Reference Number: I.6.1

Notation Keys: IE

Electricity Use From Non-Specific Sources

Calculator Type: Notation Keys for Energy Industries & Non Specified Sources

Information Only: Yes

GPC Reference Number: I.6.1

Notation Keys: IE

Industrial Distillate Fuel Oil Use

Calculator Type: Emissions from Stationary Fuel Combustion

Were emissions calculated externally? No

Fuel Type: Distillate Fuel Oil No. 2

Fuel Use: This figure is sourced directly from the C&I Misc sheet Gallons.

Data Quality: Activity Data: Medium

Data Quality: Emissions Factor: High

Industrial Residual Fuel Oil Use

Calculator Type: Emissions from Stationary Fuel Combustion

Were emissions calculated externally? No

Fuel Type: Residual Fuel Oil No. 5

Fuel Use: This figure is sourced directly from the C&I Misc sheet Gallons.

Data Quality: Activity Data: Medium

Data Quality: Emissions Factor: High

Industrial LPG Use

Calculator Type: Emissions from Stationary Fuel Combustion

Were emissions calculated externally? No

Fuel Type: LPG

Fuel Use: This figure is sourced directly from the C&I Misc sheet Gallons.

Data Quality: Activity Data: Medium

Data Quality: Emissions Factor: High

Industrial Gasoline Use

Calculator Type: Emissions from Stationary Fuel Combustion

Were emissions calculated externally? No

Fuel Type: Gasoline

Fuel Usage: This figure is sourced directly from the C&I Misc sheet Gallons.

Data Quality: Activity Data: Medium

Data Quality: Emissions Factor: High

Transportation & Mobile Sources

On-Road Gasoline

Calculator Type: On Road Transportation

Factor Sets/Transportation: Transportation Emissions Factor

Factor Sets/Grid Electricity: eGRID for Inventory Year

Calculation Method: VMT & MPG

VMT Location: In-Boundary

Travel Type: Passenger

Fuel Type: Gasoline

VMT: This data is calculated in the Transportation Sources spreadsheet. This figure comes directly from **cell C90.**

Percent Motorcycles: This data is sourced from ICLIE

Percent Passenger Vehicles: This data is sourced from ICLIE

Percent Light Trucks: This data is sourced from ICLIE

Percent Trucks: This data is sourced from ICLIE

Data Quality: Activity Data: Medium

Data Quality: Emissions Factor: Medium

On-Road Diesel

Calculator Type: On Road Transportation

Factor Sets/Transportation: Transportation Emissions Factor

Factor Sets/Grid Electricity: eGRID for Inventory Year

Calculation Method: VMT & MPG

VMT Location: In-Boundary

Travel Type: Freight

Fuel Type: Diesel

VMT: This data is calculated in the Transportation Sources. This figure comes directly from **cell C90.**

Percent Motorcycles: This data is sourced from ICLIE

Percent Passenger Vehicles: This data is sourced from ICLIE

Percent Light Trucks: This data is sourced from ICLIE

Percent Trucks: This data is sourced from ICLIE

Data Quality: Activity Data: Medium

Data Quality: Emissions Factor: Medium

On-Road Electricity

Calculator Type: Notation Keys For Transportation

GPC Reference Number: II.1.2

Notation Keys: IE

On-Road Diesel Buses

Calculator Type: Notation Keys For Transportation

GPC Reference Number: II.1.2

Notation Keys: IE

Electricity Use Within City Boundary for Railways

Calculator Type: Notation Keys For Transportation

GPC Reference Number: II.2.2

Notation Keys: IE

Electricity Use for Off-Road Transportation

Calculator Type: Notation Keys For Transportation

GPC Reference Number: II.5.2

Notation Keys: IE

Off-road vehicles

Calculator Type: Emissions from Off Road Vehicles

Were emissions calculated externally?? Yes

Previously Calculated CO_2: Refer to the Boston University Methodology Non-road mobile Sources section.

Emissions from Fuel Combustion for Off-Road Transportation Occurring Within the City Boundary

Calculator Type: Notation Keys For Transportation

GPC Reference Number: II.5.1

Notation Keys: NO

Rail Transportation

Calculator Type: Rail Transportation

Factor Set/Grid Electricity: eGRID for Inventory Year (See Factor Sets/Grid Electricity Guide)

Were emissions calculated externally?? Yes

Location: In-Boundary

Rail Type: Passenger

Local Attribution: 100%

Fuel Type: Diesel

Previously Calculated CO_2: In preparing the 2018, the exact methodology used in the 2015 inventory was not discernable. The rail section of the Boston University Methodology was attempted, but results were continually inconsistent with the results of the BU findings. The specific rules they used for distributing emissions to the rail line shapefile in GIS was not specific. Using the 2011 files, I was unable to find a combination of specific shapes (joined with their emissions fractions) that yielded the result

used in 2015. Selecting line contained entirely within City boundaries produced a value that was too low, and selecting lines adjacent or partially within the city yielded a value that was too high.

For the 2018 Inventory, an imprecise method was adopted. Comparing the files for Shape Fractions mentioned in the report for both years, it was observed that when filtered for State and County FIPS code of 44007 (for Providence County), the lengths of track and their emissions fractions were identical. Therefore, for these years, the change in relative usage did not change, or at least was not reported. Therefore, the ratio of emissions for Providence city to Providence county should be proportional between the 2011 and 2014 NEIs, and therefore between the 2015 and 2018 Inventories. By simply filtering, converting, and summing emissions for the 2011 dataset as described by the methodology, and dividing the reported metric tonnage of CO_2 reported in the 2015 inventory by that number, a coefficient was arrived at: **0.7947732**. This figure was then applied to the filtered, converted, and summed emissions data for the 2015 inventory to estimate the figure for the 2015 inventory.

In the future, this methodology will need to be revisited and refined.

Port and Harbor Marine Emissions

Calculator Type: Water Transportation

Factor Set/Grid Electricity: eGRID for Inventory Year (See Factor Sets/Grid Electricity Guide)

Were emissions calculated externally?? Yes

Location Type: Within Jurisdiction

Local Attribution: 100

Fuel Type: Diesel

Previously Calculated CO_2:

Data Quality: Activity Data: Medium

Data Quality: Emissions Factor: High

Electricity Use for Waterborne Navigation

Calculator Type: Notation Keys For Transportation

GPC Reference Number: II.3.2

Notation Keys: IE

Fuel Combustion for Off-Road Transportation

Calculator Type: Notation Keys For Transportation

GPC Reference Number: II.5.2

Notation Keys: IE

Helicopter / Heliport Emissions

Calculator Type: Aviation Travel

Were emissions calculated externally?? Yes

Aviation Type: Within Jurisdiction

Local Attribution: 100%

Fuel Type: Jet Kerosene

Previously Calculated CO_2: This calculation is completed in the Additional Calculations section because its length would impair the readability of this section. Click here to view.

Data Quality: Activity Data: Medium

Data Quality: Emissions Factor: Medium

Solid Waste

Collection and Transportation Emissions

Calculator Type: Collection and Transportation Emissions

Notation Keys: IE

In-Jurisdiction Landfills

Calculator Type: In-Jurisdiction Landfills

Attribution Percentage: 100%

Generation Location: Generated within Jurisdiction

Disposal Location: Within Jurisdiction

Notation Keys: NO

Process Emissions Associated with Landfilling

Calculator Type: Process Emissions Associated with Landfilling

Notation Keys: NO

Biologic Treatment of Solid Waste (Composting) Inside City Boundary

Calculator Type: Biologic Treatment of Solid Waste (Composting)

Disposal Location: Generated and disposed in-boundary.

Key Notation: NO

Biologic Treatment of Solid Waste (Composting) Outside City Boundary

Calculator Type: Biologic Treatment of Solid Waste (Composting)

Were emissions calculated externally? No

Quantity of Waste Composted: This information is provided by the RIRRC.

Waste Type: Green Waste

Disposal Location: Exported

Data Quality: Activity Data: High

Data Quality: Emissions Factor: Medium

Combustion Of Solid Waste Inside City Boundary

Calculator Type: Combustion of Solid Waste Generated by The Community.

Percent of Total Combusted MSW: 0

Is Electricity Generated from Waste? No

Waste Generation & Disposal Location: Generated and disposed in boundary.

Notation Keys: NO

Combustion Of Solid Waste Outside City Boundary

Calculator Type: Combustion of Solid Waste Generated by The Community.

Is Electricity Generated from Waste? No

Waste Generation & Disposal Location: Exported.

Notation Keys: NO

Providence MSW Generation

Calculator Type: Waste Generation (Alternative)

Factor Set/Waste Characterization: Waste Characterization for Inventory Year.

Were emissions calculated externally? No

Total Waste Generated: This value is reported by the RIRRC. For the 2021 inventory, RIRRC Total Waste Diverted was subtracted from Total Waste Generated (for all waste, not just MSW). These figures are found in the below document. The percentage of non-diverted waste (88.0%) was found by subtracting the percentage diverted (12.0%) from 1. Ultimately, the calculation was: $85{,}024 \text{ Tons Waste} \times 88.0\% \text{ Non-diverted rate} = 74{,}821.12 \text{ Tons MSW}$.

Does the receiving landfill have Methane Collection? Yes

Disposal Location: Outside the Jurisdiction

Data Quality: Activity Data: High

Data Quality: Emissions Factor: Medium

Water & Wastewater

Fields Point Emissions from Combustion of Biosolids and Sludges

Calculator Type: Emissions from Combustion Of Biosolids And Sludges

Daily Quantity of Sludge or Biosolids Incinerated (MT/day): This figure is an estimate provided by the Narragansett Bay Commission Metric Tons per Day.

Population Served: This figure is an estimate provided by the Narragansett Bay Commission People.

Is Energy Recovered from Combustion: Yes-used on site

Wastewater Generation and Treatment Location: Exported

Data Quality: Activity Data: High

Data Quality: Emissions Factor: Medium

Field's Point Process N_2O from Effluent Discharge to River

Calculator Type: Process N2O From Effluent Discharge to Rivers And Estuaries

Were emissions calculated externally? No

Do You have daily N load data from your effluent discharge? Yes

Daily N Load: This figure is an estimate provided by the Narragansett Bay Commission kg N/day.

Population Served: This figure is an estimate provided by the Narragansett Bay Commission People.

Wastewater Generation and Treatment Location: Generated and treated in boundary.

Notation Keys: NO

Field's Point Nitrification/Denitrification Process N_2O Emissions from Wastewater Treatment

Calculator Type: Process N2O Emissions from Wastewater Treatment

Were emissions calculated externally? No

Nitrification/Denitrification as a step in the treatment process? Yes

Population Served: This figure is an estimate provided by the Narragansett Bay Commission People.

Industrial Commercial Discharge Multiplier: 1.25

Wastewater Generation and Treatment Location: Generated and treated in boundary

Emissions from the Supply of Potable Water

Calculation Type: Emissions from the Supply Of Potable Water

Factor Set/Grid Electricity: eGRID for Inventory Year

Notation Keys: IE

Emissions from Flaring of Digester Gas

Calculation Type: Emissions from Flaring of Digester Gas

Fraction of CH_4 in Digester Gas: 0.65 Decimal.

Destruction Efficiency: 0.99 Decimal.

Notation Keys: NO

Emissions from the Combustion of Digester Gas

Calculation Type: Emissions from The Combustion of Digester Gas

Notation Keys: NO

Fugitive Emissions from Septic Systems

Calculation Type: Fugitive Emissions from Septic Systems

Notation Keys: NO

CO_2 Emissions from the Use of Fossil Fuel Derived Methanol

Calculation Type: CO2 Emissions from The Use Of Fossil Fuel Derived Methanol

Notation Keys: NO

Emissions from Wastewater Treatment Energy Use

Calculator Type: Emissions from Wastewater Treatment Energy Use

Factor Set/Grid Electricity: eGRID for Inventory Year

Notation Keys: IE

Agriculture

Agriculture & Forestry Natural Gas Use

Calculator Type: Emissions from Stationary Fuel Combustion

Notation Keys: IE

Agriculture & Forestry Electricity Use

Calculator Type: Emissions from Grid Electricity

Notation Keys: IE

Process & Fugitive Emissions

Coal Industry Emissions

Calculator Types: Fugitive Emissions from Mining, Processing, Storage, And Transportation Of Coal

Notation Keys: NO

Process & Fugitive Emissions from Natural Gas Distribution

Calculator Type: Fugitive Emissions from Natural Gas Distribution

Quantity of Natural Gas Used: This figure is the sum of the Residential Natural Gas use and Commercial & Industrial Natural Gas use.

Leakage Rate: 0.3%

Nature [sic.] Gas Energy Density: 1028 btu/scf

Natural Gas Density: 0.8 kg / m^3

Natural Gas % CH_4: 93.4%

Natural Gas % CO_2: 1%

Upstream Impacts of Activities

No records in this category.

Consumption Based

No records in this category.

Inventory Data Collection

These working documents group similar calculations and shared resources. They are each used in calculations for multiple records.

Copies of these files can be found in City of Providence O:\Sustainability\GHG Reporting\Data Collection

DO NOT edit these files directly from this word document. They are for reference only. Please save separate copies… simply opening these files and editing them for your inventory year will alter the files embedded in this document.

Residential & Commercial/Industrial

All residential, Commercial, and Industrial energy has been combined into one excel document. This section outlines the steps necissary to collect all data reported for these three sections.

To create this file:

Overview

This sheet should outline a description of each sheet in the excel file.

Residential Electric & Residential Natural Gas:

This data was provided directly by RI Energy. The following points were requested via email. Save an unedited version of the data recived from RI Energy. An unedited version of these excel sheets were included in the data request email and should be used as an example for future GHG Inventory data requests.

- Residential Electricity and Natural Gas Use
- C&I Electricity Natural Gas and Use

POC: Angela Li – ACLi@RIEnergy.com / Marisa Albanese - MAAlbanese@rienergy.com / Andrea Moshier - AMoshier@rienergy.com

Residential Misc.

This sheet has been created to calculate the residential energy use of Distillate Oil, LPG, and Wood combustions. The EIA only reports energy use in SEDS (State Energy Data Systems) on a state basis. This is adjusted to the city level using data from the ACS 5-Year estimates.

How this sheet is created:

1. Go to data.censu.gov.
2. Search for the table "B25040: Home Heating Oil"
3. Select ACS 5-Year Estimates Detailed Tables
4. Use the following on the tool bar.
    a. Geography > State > Providence
    b. Geography > County > Rhode Island > Providence
    c. Toggle off margin of error
5. Extract the following data into an excel file (note the table is available for download but not all information is necessary). Assuming this link does not break, here is the 2021 data.

ACS Row Name	Corresponding Fuel Type	"Rhode Island" Geography Corresponding Cell	"Providence city, Rhode Island" Geography Corresponding Cell
Fuel oil, kerosene, etc.	Distillate Fuel Oil	B3	B2
Bottled, tank, or LP gas	LPG	D3	D2
Wood	Wood	F3	F2

6. Located SEDS Table CT4, Residential Sector Energy Consumption Estimates. Filter this data for only the State of Rhode Island. As of time of writing, this table could be found here.
7. Use the following values from the applicable/most recent year to fill in cells C5, E5, and G5:

SEDS Column Name	Corresponding Fuel Type	Corresponding Cell	SEDS/Cell Unit
Distillate Fuel Oil	Distillate Fuel Oil	C5	Thousands of Barrels
HGL	LPG	E5	Thousands of Barrels
Wood	Wood	G5	Trillion BTUs

> **Note:** "HGL" is Hydrocarbon Gas Liquids, assumed to be Petroleum-only by the EIA.

8. These values are adjusted to Providence estimates using ACS data, and converted to units accepted by ClearPath:

Fuels	SEDS/Input Unit	ClearPath/Output Unit	Conversions
Distillate Fuel Oil, LPG	Thousands of Barrels	Gallons	42 Gallons/Barrel
Wood	Trillion BTUs	Short Tons	1 cord/20,000,000 BTU wood; 1.25 short tons wood/cord

9. Final values are bolded in row 7.

Fuel	Cell Containing Final Value	Unit
Distillate Fuel Oil	C7	Gallons
LPG	E7	Gallons
Wood	G7	Short Tons

C&I Misc.

This sheet uses data from the Census Bureau to estimate commercial and industrial consumption of Gasoline, Residual Oil, Distillate Oil, and LPG. This table requires the data from SEDS (Sector Energy Consumption Estimates) and LODES (LEHD Origin – Destination Employment Statistics). It is necessary to complete the LODES sheet below to estimate data values.

Column	SEDS Table	Link (at time of writing)
Commercial	CT5	Link
Industrial	CT6	Link

For the desired/most recent year in the SEDS data, fill in the "Inputs from SEDS" columns in the "Commercial & Industrial Figures," according to units already stored in that sheet.

The "Unit Conversion" columns convert the inputs to units expected by ClearPath, according to the following:

Fuels	SEDS/Input Unit	ClearPath/Output Unit	Conversions
Distillate Oil, LPG, Residual Oil, Gasoline	Thousands of Barrels	Gallons	42 Gallons/Barrel
Wood	/Trillion BTUs	MMBtu	1 MMBtu = 1 Million BTU

The “Adjusted for Providence” Columns use the previously calculated ratios to estimate final values from the conversions. These are the final values to be inputted into ClearPath.

LODES

The LODES sheet is used to analyze workplace data in the following two sheets. LODES – RI Crosswalk Data and LODES – RI WAC. These can be found at the Census Bureau’s LEHD (Longitudinal Employer – Household Dynamics).

To create this sheet, navigate to the LEHD/LODES website. There are two downloads and both files will need to be decompressed to access the excel format.

1. The first method is outlined here.
    I. Find the LEHD Origin-Destination Employment Statistics (LODES) section.
    II. Select the latest version of LODES (LODES8 was used for the 2021 Inventory).
    III. Set the “State/Territory” field to “Rhode Island,”.
    IV. Set “Type” to “Workplace Area Characteristics (WAC)”.
    V. Click view files.
        i. Click the “Geography crosswalk for RI” link to download.
        ii. Navigate to file named “ri_wac_S000_JT00_2021.csv.gz”
2. The second method is through the FTP portal.
    I. Select the latest version of LODES (LODES8 was used for the
    II. Select “ri”
        i. Download “ri_xwalk.csv.gz”
    III. Select “wac”
        i. Download "ri_wac_S000_JT00_2021.csv.gz”

LODES Technical Guides provided guidance in making sense of the format of this data. The latest guidance sheet for 2021 inventory was LODES 8.0 Tech Doc. WAC dataset structure can be found on pages 8 and 9. Geography Crosswalk dataset structure can be found on pages 10 and 11.

Add these downloads to the “Energy Sources” excel file. A simple filter setting has been added to analyze the data.

The “LODES – RI Crosswalk Data” is used to identify Providence level data instead of all of RI. To do this, filter the city names (Column F) to show only Providence sidewalks. Confirm the providence range of

"Block Codes" in column A. For the 2021 report the range was 440070001011000 – 440070037004017. This is the range of w_geocodes that apply to providence in the LODES – RI WAC sheet.

The "LODES – RI WAC" was used to estimate the number of commercial & industrial jobs.

The Boston University methodology guide acknowledges the North American Industry Classification System (NAICS) for job classification. Industrial/Manufacturing jobs are listed as NAICS sectors 31 – 33 whereas Commercial jobs are listed as NAICS sectors 42 – 82.

According to LODES Dataset Structure (Version 8.0, page 8), Industrial/Manufacturing was outlined as CNS05 (Column M) and Commercial was outlined as CNS06 – CNS19 (Columns N – AA). Column BB was created to summarize the entire commercial jobs.

In the "LODES" sheet, use the [sumif] function of excel to find the total values for all of RI and Providence. Then calculate the ratio percentages for calculations in the "C&I Misc." sheet.

Manchester St. Power Plant

This sheet uses data from the EPA's Greenhouse Gas Reporting Program (GHGRP) Facility Level Information on GHGs Tool (FLIGHT) to calculate emissions for the Manchester Street Power Station. This record in the inventory accounts for emissions produced by Manchester Street for energy used internally, and not for grid distribution.

To create this sheet, navigate to the On the FLIGHT page for Manchester Street (GHGRP ID 1000905) and click "View reported data." The 2021 data can be found here.

1. Under Subpart D: Electricity Generation, a record will be listed for each of the three generators at the facility. For all three generators there will be a subheading titled "Electricity Fuel Details."
2. Each of these subheadings will contain two boxes, one for natural gas and the other for distillate fuel oil. Copy these values into the appropriate cells and sum the final MMBtu values.

Stationary Boiler Calculations: This boiler is responsible for generation.

1. The stationary boiler named "B001" is reported in Subpart C: General Stationary Fuel Combustion. For the 2021 inventory, there was no reported fuel consumption use for continuous years. An estimate from the previous reported years (2015, 2016, and 2017) were averaged to find the total MMBtu's.
2. This is reported in Subpart C: General Stationary Fuel Combustion in FLIGHT. One boiler, **B001**, is responsible for the generation. Under that entry, locate the "Tier Fuel Details" heading, in which there is another subheading for "**Equation C2a / C9a Inputs**."
3. The value for this field is located by multiplying the values for Fuel Quantity and High Heat Value to arrive at a final value in **MMBtu**. The fuel quantity factor reports the Standard Cubic Feet of natural gas used annually, while High Heat Value provides the maximum MMBtu per SCF of gas. We assume that the heat input of gas is always its maximum.

4. **CO_2:** In Subpart C of the aforementioned FLIGHT data page, locate a subheading titled "Gas Information Details." Locate the table with "Gas Name" = "Carbon Dioxide." The "Gas Quantity" row provides the value for ClearPath input in **metric tons**.
5. **CH_4:** In Subpart C of the aforementioned FLIGHT data page, locate a subheading titled "Gas Information Details." Locate the table with "Gas Name" = "Methane." The "Gas Quantity" row provides the value for ClearPath input in **metric tons**.
6. **N_2O:** In Subpart C of the aforementioned FLIGHT data page, locate a subheading titled "Gas Information Details." Locate the table with "Gas Name" = "Nitrous Oxide." The "Gas Quantity" row provides the value for ClearPath input in **metric tons**.

Transportation

ICLEI has partnered with Google EIE Environmental Insight Explorer (EIE) to source transportation data. To create this spreadsheet.

Overview: This sheet explains additional information contained in the spreadsheet

EIE-Transportation:

1. Visit GOOGLE EIE and sign up. Requirements to sign up are any google account and employment of a city government.
2. Once approved by google, navigate to the Transportation Emissions, and download the data as an excel sheet.

EIE VMT Directions & National Defaults: These sheets were provided by ICLEI and are a step-by-step guide on how to enter this data into ClearPath.

Solid Waste

2021 RIRRC Municipal Summary.p

This data is provided by the Rhode Island Resource Recovery Corporation (RIRRC). Each year the RIRRC publishes a Municipal Summary (Detailed) report. Each year can be found under Annual Metrics on their website.

Water & Wastewater

The Narragansett Bay Commission Field Point location is the only wastewater treatment facility within the city boundaries. The following data points were requested via email.

- Effluent total nitrogen

- Daily quantity of sludge or biosolids incinerated.
- Estimated population served.

POC: Jim Kelly – jkelly@narrabay.com (Primary) / Eliza Moore – emoore@narrabay.com / Jamie Samons – Jsamons@narrabay.com

Additional Calculations

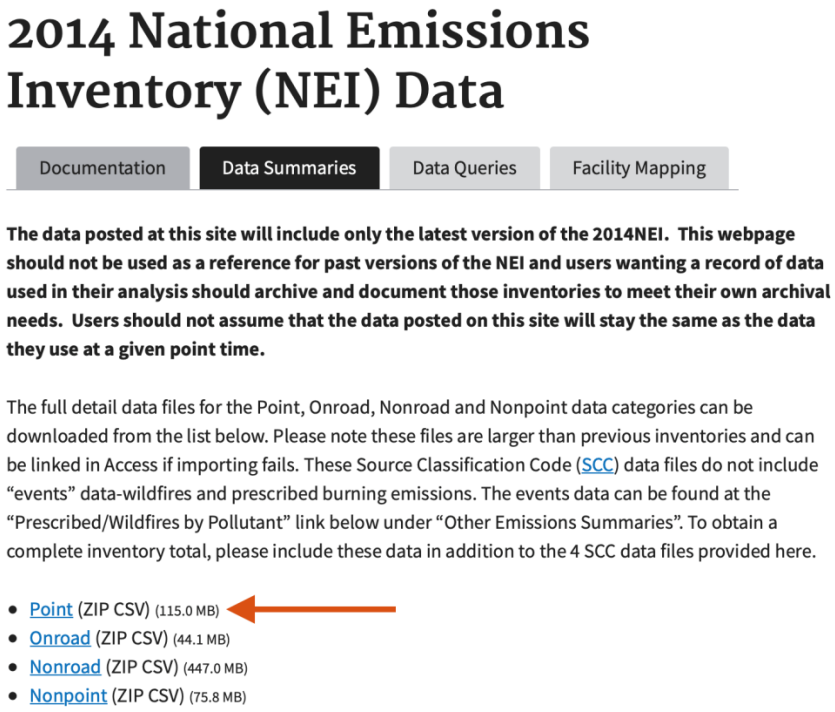
This section was not used

Calculations for Helicopter/Heliport Emissions

This figure is sourced from the EPA's National Emissions Inventory (NEI). The NEI is updated every few years, and there is always a lag in updating. As the 2018 Inventory is being prepared in the summer of 2019, the 2014 NEI is the latest available for use. The main NEI page is located here at time of writing.

According to the Boston University methodology, this record "Comprises only emissions from aircraft taxiing, take-off and landing operations. Other emissions associated with airport facilities such as ground-based mobile vehicles and stationary combustion sources are reported in the 'Non-road' emissions sector."

For this, we will use the NEI point sources. According to the EPA, "NEI point sources include emissions estimates for larger sources that are located at a fixed, stationary location. Point sources in the NEI include large industrial facilities and electric power plants, airports, and smaller industrial, non-industrial and commercial facilities. A small number of portable sources such as some asphalt or rock crushing operations are also included. Some states voluntarily also provide facilities such as dry cleaners, gas stations, and livestock facilities, which are otherwise included in the NEI as nonpoint sources. The emissions potential of each facility determines whether that facility should be reported as a point source, according to emissions thresholds set in the Air Emissions Reporting Rule (AERR). NEI Point Sources are all included in the EIS Point Data Category." At time of writing, the full, compressed file of point sources can be downloaded for an inventory year under that inventory year's "Data Summaries" tab.



Once decompressed, the download may result in two or more files, as one would be too large to work with. Regardless, for the 2014 Inventory, each of the two CSV files present was in excess of 1.4 GB. Excel will require time to load this data, and depending on the hardware limitations of the system, may be unable to load the entire file. In completing the 2018 Inventory, the R environment was used due to its greater capacity for datasets of this size.

Regardless of tool used, the following must be accomplished. Also, while in the 2014 NEI all Providence-relevant data was contained in the first file in the download, "process_12345.csv," this is not guaranteed, so the following will need to be applied to all files in the future, so as not to miss any records.

Isolating emissions as tons of Carbon Monoxide

Filter the dataset to Providence County. This will eliminate most of the records, significantly speeding up further operations and making manipulations easier. In the 2014 NEI, the most efficient way to do this is to filter the CSV column named "state_and_county_fips_code." This column specifies the County in which each point source is located by FIPS code. The FIPS code for Providence County, Rhode Island is 44007. Filter the dataset so that the specified code is exactly equal to this value.

In Excel, this is a normal filter function. In R, the following command would create a copy named `filtered_county` from the original dataset:

```
filtered_county <- process_12345[process_12345$state_and_county_fips_code == 44007,]
```

We can further refine the dataset to sources within the City of Providence. This is indicated in the "locality" column. For the 2014 NEI, the matching value is "PROVIDENCE". Again, Excel is a normal filter, while in R, the following would yield a further filtered `filtered_city` from the aforementioned filter_county:

```
filtered_city <- filtered_county[filtered_county$locality == "PROVIDENCE",]
```

The NEI does not, unfortunately, report CO2 emissions for point sources, but rather it reports in Carbon Monoxide, CO. A further filtering of the "pollutant_cd" column (for "CO") or the "pollutant_desc" column (for "Carbon Monoxide") will further eliminate unneeded records.

```
filtered_co <- filtered_city[filtered_city$pollutant_cd == "CO",]
```

Or

```
filtered_co <- filtered_city[filtered_city$pollutant_desc == "Carbon Monoxide",]
```

After this point of filtering, the 2014 NEI dataset has been narrowed from approximately 8,000,000 records to 139. Simply filtering to "Airport Operations" in the "naics_description" column will accomplish a final layer of filtering in this case. The only active heliport within City limits is Rhode Island Hospital's (which can be verified by looking at the "facility_site_name" column). A simple sum of the remaining records' "total_emissions" values will yield the tonnage of Carbon Monoxide emissions. This same value could also be sourced from the "Facility Mapping" tab on the NEI Inventory, filtered to Rhode Island and then sorted by Facility Type. However, a more thorough process of filtering is available, should other emission sources be added to future NEIs. The following steps will walk through this.

According to the Boston University Methodology, we should be filtering records so that we only list facilities with an EIS Level 1 specification of "Mobile Sources" AND without an EIS Level 3[1] specification of "Airport Ground Support Equipment". Unfortunately, the NEI point source files, at time of writing, do not include EIS levels. They do, however, provide Source Classification Codes (SCCs). The EPA provides a tool for querying a full list of SCCs, but that page also allows you to download a list of all SCCs (click "Download List" button). A version of this list downloaded at time of writing is embedded in this document, under SCC Full List. Download or extract this file.

If using Excel:

1. Insert the contents of the SCC List into a new worksheet in the workbook(s) used for filtering the NEI point data. For this guide, we will name that new worksheet "SCCs."

[1] The Boston University Methodology document actually says EIS Level 1 does not equal "Airport Ground Support Equipment." However, this classification only exists in EIS Level 3.

2. On the NEI data sheet, add two new columns following the filtered data, one called “SCC Level 1” and the other “SCC Level 3”.
3. Use the `VLOOKUP` Function to find the levels described in the SCCs sheet based on the referenced SCC code for each record in the NEI data. In the included SCC CSV, level 1 is the 13th column and level 3 in the 14th. In the 2014 NEI, SCCs are stored in the first column. Therefore, the formula for the “SCC Level 1” in Row 2 would be `=VLOOKUP(J2,SCCs!A:Y,13, FALSE)` where column J is titled “scc” in the NEI data. “SCC Level 3” in Row 2 would be `=VLOOKUP(J2,SCCs!A:Y,14, FALSE)`. These formulas should be filled down for all remaining records.
4. Filtering can now begin. “SCC Level 1” should be set to only equal “Mobile Sources” and “SCC Level 3” should be set to not equal “Airport Ground Support Equipment”.

If using R:

1. Import the contents of the SCC List into the R environment. Here, we will term the data `sccs`.
2. Use the included `merge` command to create a new table that is the result of a left join between the above created `filtered_co` and `sccs`. The following is used to accomplish this, storing the result in merged: `merged <- merge(filtered_co, sccs, by.x = "scc", by.y = "SCC", all.x = TRUE)`
3. Filtering can now begin:

```
final_filter <-
merged[merged$"scc level one" == "Mobile Sources" &
merged$"scc level three" != "Airport Ground Support Equipment",]
```

The “total_emissions” column can now be summed using a simple `SUM` formula in Excel or `sum(final_filter$total_emissions)` in R. This total is the quantity of Carbon Monoxide emissions in Tons.

Converting Tons of Carbon Monoxide to Metric Tons of Carbon Dioxide

Emission factors are sourced from the EPA’s WebFIRE database, part of the Clearinghouse for Inventories and Emissions Factors (CHIEF). A detailed search (Link at time of writing) is used to locate CO and CO_2 emissions factors for jet fuel, which is the methodologies suggested conversion. Alternatively, all emissions factors can be downloaded from the site as a CSV and be filtered via Excel or R.

The following factors were used for the 2018 inventory:

130 lbs. of Carbon Monoxide per 1,000 Gallons of Jet Fuel burned

9.57 kg of Carbon Dioxide per Gallon of Jet Fuel Burned

Therefore, to arrive at a final value:

$$\text{Metric Tons } CO_2 = \text{ Tons CO} \times \frac{2000 \text{ lbs. CO}}{\text{Ton CO}} \times \frac{1000 \text{ Gallons Jet Fuel}}{130 \text{ lbs. CO}} \times \frac{9.57 \text{ kg } CO_2}{\text{Gallon Jet Fuel}} \times \frac{1 \text{ Metric Ton } CO_2}{1000 \text{ kg } CO_2}$$

$$\text{Metric Tons } CO_2 = \text{Tons CO } \times \frac{1914}{13}$$

Calculations for Port and Marine Emissions

The following working spreadsheet has been created to simplify the methods described in the Boston University methodology.

First, the current nonpoint data file must be downloaded for the desired/latest NEI. This link, at time of writing, is located under the data summaries tab. The file downloads as a compressed folder containing a CSV. This CSV contains a national summary, and is too large to work with directly in Excel. The 2014 NEI version is close to 1 GB in file size (when decompressed), and contains more than the 1,048,577 rows of data allowed by Excel.

Automatic Computation

Marine Emissions Calculations.xlsm

The above is a spreadsheet designed to make the calculations of Port and Marine Emissions as simple as possible. Notice the extension: *.xlsm* indicates that this spreadsheet has embedded Macros. A Macro is an embedded script that can be triggered to manipulate the contents of the spreadsheet.

In this case, the macro prompts the user to select the two CSV files, the NEI nonpoint and SCC list. It then runs a Microsoft Query on the nonpoint data in order to eliminate rows that pertain to data outside of Providence, and to only focus on records pertaining to Carbon Monoxide emissions. Using the VLOOKUP function, SCCs are then matched from the imported SCC CSV, and EIS Levels are extracted and used in further filtration. The results are summarized with a Pivot Table, and the user is taken to a results page. That page is pre-loaded with conversion factors (explained below) used for the 2018 Inventory. These are used to convert Carbon Monoxide Emissions to Carbon Dioxide Emissions, which are then summed in cell G6.

This spreadsheet requires some database connection capability and various drivers. If these are not available on your system, the same methodology can be followed. Manually splitting the CSV in a text editor is an option, as is using R.

Underlying Methodology

The Boston University Methodology recommends filtering nonpoint data to records that have SCC Codes corresponding to EIS Level 2 values of “Marine Vessels, Commercial”. Records can further be filtered to those with a FIPS State and County code of 44007, that pertaining to Providence county, Rhode Island.

There is no way, based on the dataset, to disaggregate by municipality. However, due to the nature of Providence County, it can be assumed that all emissions of this nature are produced within the City (most notably at the Port of Providence).

Note: The Boston University Methodology includes a brief overview of using spatial distributions (likely with a GIS Application) sourced from EPA supplied shapefiles to find a more accurate figure.

The assumption taken here, when applied retroactively to the 2015 Inventory, yields the same result as their supplied figure.

Records are further identified by their corresponding EIS levels 3 and 4. Level 3 is used to report the fuel source responsible for the emissions: diesel or residual oil. Level 4 is used for a variety of specifications, but for Providence County it is used to distinguish port emissions from underway emissions.

These four variables can be combined in four configurations. Each configuration is treated differently in converting the NEI supplied CO emissions to CO2 emissions.

$V_{d,p}$ = Vessels with EIS Level 3 = Diesel and EIS Level 4 = Port

$V_{d,u}$ = Vessels with EIS Level 3 = Diesel and EIS Level 4 = Underway

$V_{r,p}$ = Vessels with EIS Level 3 = Residual Oil and EIS Level 4 = Port

$V_{r,u}$ = Vessels with Level 3 = Residual Oil and EIS Level 4 = Underway

Conversion factors are sourced from the EPA's "Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories" Final Report, published in April 2009. This report provides emissions factors for two main classes of vessels: Ocean-Going Vessels and (OGVs) and Harbor Craft (HC).

OGVs, for the purposes of this inventory, can burn either Residual Oil (RO) or Marine Diesel Oil (MDO). Emissions factors for OGVs are calculated for vessels at port and underway.

HC are not further defined by fuel type or activity (port or underway). However, there are two categories of HC with different emissions factors. For the purposes of this inventory, 75% HC are assumed to be HC Category 1, and the remaining 25% are considered HC Category 2.

$$HC_1 = \frac{3}{4}HC$$

$$HC_2 = \frac{1}{4}HC$$

The following factors (F_{CO} for g CO/kWh; F_{CO_2} for g CO_2/kWh), and their sources, are determined from this report.

Emission Factors for MSD OGVs:

Fuel	**Vessel Activity**	F_{CO}	F_{CO_2}	$B = \frac{F_{CO_2}}{F_{CO}}$	**Report Source**
Marine Diesel Oil (MDO)	Port	1.10	690.71	$627.91\overline{81}$	Table 2-16
Residual Oil (RO)	Underway	1.10	677.91	$616.2\overline{81}$	Table 2-9
	Port	1.10	722.54	$656.8\overline{54}$	Table 2-16

Emission Factors for HC:

	$\boldsymbol{HC}$ Category	$\boldsymbol{F_{CO}}$	$\boldsymbol{F_{CO_2}}$	$\boldsymbol{B = \frac{F_{CO_2}}{F_{CO}}}$	Report Source
$\boldsymbol{HC_1}$	Cat. 1	1.50	690	460	Table 3-8
$\boldsymbol{HC_2}$	Cat. 2	1.10		$627.\overline{27}$	

All V_r are assumed, for the purpose of this inventory, to have the emissions characteristics of Medium-Speed Diesel (MSD) OGVs as defined by the report:

$$OGV_{ro,u_{CO}} = V_{r,u}$$

$$OGV_{ro,p_{CO}} = V_{r,p}$$

Half of $V_{d,p}$ are assumed to be OGVs, while the other half are assumed to be HC. All $V_{d,u}$ are assumed to be HC:

$$OGV_{mdo,p_{CO}} = \frac{V_{d,p}}{2}$$

$$HC_{CO} = V_{d,u} + \frac{V_{d,p}}{2}$$

For a vessel class (for report calculation method), T:

$$T_{CO_2} = T_{CO} \times \frac{1\ \text{kWh}}{F_{CO}\ \text{g}} \times \frac{F_{CO_2}\text{g}}{1\ \text{kWh}}$$

$$T_{CO_2} = T_{CO} \times \frac{F_{CO_2}}{F_{CO}}$$

Let $B = \frac{F_{CO_2}}{F_{CO}}$:

$$T_{CO_2} = T_B \times T_{CO}$$

So, CO_2 emissions for OGVs would be:

$$OGV_{ro,u_{CO_2}} = OGV_{ro,u_{CO}} \times OGV_{ro,u_B} = V_{r,u} \times 616.2\overline{81}$$

$$OGV_{ro,p_{CO_2}} = OGV_{ro,p_{CO}} \times OGV_{ro,p_B} = V_{r,p} \times 656.8\overline{54}$$

$$OGV_{mdo,p_{CO_2}} = OGV_{mdo,p_{CO}} \times OGV_{mdo,p_B} = \frac{V_{d,p}}{2} \times 627.91\overline{81}$$

And for HC:

$$HC_{1_{CO_2}} = HC_{1_B} \times \frac{3}{4}HC = 460 \times \frac{3}{4}\left(V_{d,u} + \frac{V_{d,p}}{2}\right) = 345\left(V_{d,u} + \frac{V_{d,p}}{2}\right)$$

$$HC_{2_{CO_2}} = HC_{2_B} \times \frac{1}{4}HC = 627.\overline{27} \times \frac{1}{4}\left(V_{d,u} + \frac{V_{d,p}}{2}\right) = 156.\overline{81}\left(V_{d,u} + \frac{V_{d,p}}{2}\right)$$

Summing these to find overall emissions A:

$$A = OGV_{ro,u_{CO_2}} + OGV_{ro,p_{CO_2}} + OGV_{mdo,p_{CO_2}} + HC_{CO_2} + HC_{1_{CO_2}} + HC_{2_{CO_2}}$$

$$A = \left(V_{r,u} \times 616.2\overline{81}\right) + \left(V_{r,p} \times 656.8\overline{54}\right) + \left(\frac{V_{d,p}}{2} \times 627.91\overline{81}\right) + 345\left(V_{d,u} + \frac{V_{d,p}}{2}\right) + 156.\overline{81}\left(V_{d,u} + \frac{V_{d,p}}{2}\right)$$

This can be rewritten as:

$$A = \left(V_{r,u} \times 616.2\overline{81}\right) + \left(V_{r,p} \times 656.8\overline{54}\right) + \left(V_{d,p} \times 564.86\overline{81}\right) + \left(V_{d,u} \times 501.\overline{81}\right)$$

Each Coefficient C can be recalculated and adjusted using the following sheet:

Marine Coefficienct Calculations.xlsx

$$A = \left(V_{r,u} \times C_{r,u}\right) + \left(V_{r,p} \times C_{r,p}\right) + \left(V_{d,u} \times C_{d,u}\right) + \left(V_{d,p} \times C_{d,p}\right)$$

Data Collection (Edit)

These working documents group similar calculations and shared resources. They are each used in calculations for multiple records.

Copies of these files can be found in City of Providence O:\Sustainability\GHG Reporting\Data Collection

DO NOT edit these files directly from this word document. They are for reference only. Please save separate copies… simply opening these files and editing them for your inventory year will alter the files embedded in this document.

Miscellaneous Residential Energy Sources

This sheet has been created to calculate the residential energy use of Distillate Oil, LPG, and Wood combustions. The EIA only reports energy use in SEDS (State Energy Data Systems) for a state basis. This is adjusted to the City level using data from the ACS 5-Year estimates.

How this sheet is created:

10. Go to data.censu.gov.
11. Search for the table "B25040: Home Heating Oil”
12. Select ACS 5-Year Estimates Detailed Tables
13. Use the following on the tool bar.
    a. Geography > State > Providence

b. Geography > County > Rhode Island > Providence

c. Toggle off margin of error

14. Extract the following data into an excel file (note the table is available for download but not all information is necessary). Assuming this link does not break, here is the 2021 data.

ACS Row Name	Corresponding Fuel Type	"Rhode Island" Geography Corresponding Cell	"Providence city, Rhode Island" Geography Corresponding Cell
Fuel oil, kerosene, etc.	Distillate Fuel Oil	B3	B2
Bottled, tank, or LP gas	LPG	D3	D2
Wood	Wood	F3	F2

15. Located SEDS Table CT4, Residential Sector Energy Consumption Estimates. Filter this data for only the State of Rhode Island. As of time of writing, this table could be found here.

16. Use the following values from the applicable/most recent year to fill in cells C5, E5, and G5:

SEDS Column Name	Corresponding Fuel Type	Corresponding Cell	SEDS/Cell Unit
Distillate Fuel Oil	Distillate Fuel Oil	C5	Thousands of Barrels
HGL	LPG	E5	Thousands of Barrels
Wood	Wood	G5	Trillion BTUs

Note: "HGL" is Hydrocarbon Gas Liquids, assumed to be Petroleum-only by the EIA.

17. These values are adjusted to Providence estimates using ACS data, and converted to units accepted by ClearPath:

Fuels	SEDS/Input Unit	ClearPath/Output Unit	Conversions
Distillate Fuel Oil, LPG	Thousands of Barrels	Gallons	42 Gallons/Barrel
Wood	Trillion BTUs	Short Tons	1 cord/20,000,000 BTU wood; 1.25 short tons wood/cord

18. Final values are bolded in row 7.

Fuel	Cell Containing Final Value	Unit
Distillate Fuel Oil	C7	Gallons

LPG	E7	Gallons
Wood	G7	Short Tons

Miscellaneous C&I Energy Sources 2021

This sheet uses data from SEDS and Workplace Area Characteristics data from the Census Bureau's LEHD (Longitudinal Employer-Household Dynamics) Origin-Destination Employment Statistics (LODES) to estimate commercial and industrial consumption of:

- Gasoline (Commercial/Institutional | Industrial)
- Residual Oil (Commercial/Institutional | Industrial)
- Distillate Oil (Commercial/Institutional | Industrial)
- LPG (Commercial/Institutional | Industrial)

To create this document, navigate to the LEHD/LODES website. There are two downloads and oth files will need to be decompressed to access the excel .

3. The first method is outline here.
    I. Find the LEHD Origin-Destination Employment Statistics (LODES) section.
    II. Select the latest version of LODES (LODES8 was used for the 2021 Inventory).
    III. Set the "State/Territory" field to "Rhode Island,".
    IV. Set "Type" to "Workplace Area Characteristics (WAC)".
    V. Click view files.
        i. Click the "Geography crosswalk for RI" link to download.
        ii. Navigate to file named "ri_wac_S000_JT00_2021.csv.gz"
4. The second method is through the FTP portal.
    I. Select "LODES8"
    II. Select "ri"
        i. Download "ri_xwalk.csv.gz"
    III. Select "wac"
        i. Download "ri_wac_S000_JT00_2021.csv.gz"

Click the link to download the crosswalk and decompress. This file can be copied into the spreadsheet if needed.

LODES Technical Guides provided guidance in making sense of the data available. According to the LODES 8.0 Tech Doc (used for the 2021 Inventory), the following procedure was developed for extracting workplace data:

According to the WAC section of the document (page 8 & 9),
"Filenames of the WAC datasets are described by the following template:
[ST]_wac_[SEG]_[TYPE]_[YEAR].csv.gz
where:
[ST] = lowercase, 2-letter postal code for a chosen state
[SEG] = Segment of the workforce, can have the values of "S000", "SA01", "SA02", "SA03", "SE01", "SE02", "SE03", "SI01", "SI02", or "SI03". These correspond to the same segments of the workforce as are listed in the OD file structure above.
[TYPE] = Job Type, can have a value of "JT00" for All Jobs, "JT01" for Primary Jobs, "JT02" for All Private Jobs, "JT03" for Private Primary Jobs, "JT04" for All Federal Jobs, or "JT05" for Federal Primary Jobs.
[YEAR] = Year of job data. Can have the value of 2002-2015 for most states."

In our case, [ST] = "RI" for the Rhode Island data set. Using the OD structure listed in the document, we determined the use of [Seg] = "S000," indicating that we want data for the total number of jobs. [TYPE] = "JT00" indicating we want all jobs included. Use the appropriate year for the [YEAR] variable.

Therefore, the file downloaded for the 2021 Inventory was listed as "ri_wac_S000_JT00_2021.csv.gz"

This file can be downloaded from the portal on the LODES site or via FTP.

This file is inserted into "RI WAC – LODES" sheet from cell A1. When inserted correctly, the 2015 data set fills cells A1:B8145.

A calculating column is added in Column BB, titled "Commercial Jobs (NAICS 42-82)." The purpose of this column is to calculate the number of commercial jobs contained within each record.

The Boston University methodology guide (contained within the spreadsheet on the "LODES Adjustment Calculations" sheet), "Commercial" refers to North American Industry Classification System (NAICS) sectors/codes 42-82.

According to the Workplace Area Characteristics (WAC) File Structure table on page 7 of the LODES7.3 Tech Doc, WAC variables CNS06-CNS19 correspond to these NAICS codes (some codes are not represented in the WAC data). These variables are represented as columns N:AA in the WAC data. Each record contains an integer value in each of these columns to describe the number of jobs in each code range per record. Thus, for any record, the total number of commercial jobs in each of these records is a summation of columns N:AA. The formula for BB2, filled downwards, is `=SUM(N2:AA2)`

For manufacturing, the methodology guide specifies NAICS codes 31-33. These are covered by a single variable in WAC, CNS05. The column containing CNS05, M, therefore fills the same function column BB2 does in providing a sum of jobs, only in manufacturing and not commercial.

The table at the top of the "LODES Adjustment Calculations" sheet automatically calculates Providence and Rhode Island sums of these record summations.

The Providence Row sums appropriate cells when their geocodes are in the range of 440070001011000-440070037004011 inclusive, which are the geographies that lie with Providence as per the aforementioned crosswalk data.

A percentage for each is calculated, representing Providence's share of Rhode Island's Commercial and Manufacturing jobs.

In the "Commercial & Industrial Figures" sheet, SEDS data is added. Commercial data will be adjusted using the Providence ratios for "Commercial" in the "LODES Adjustment Calculations" sheet, while Industrial data will use the "Manufacturing" column. SEDS Data is sourced from the following:

Column	SEDS Table	Link (at time of writing)
Commercial	CT5	Link
Industrial	CT6	Link

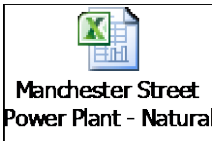
For the desired/most recent year in the SEDS data, fill in the "Inputs from SEDS" columns in the "Commercial & Industrial Figures," according to units already stored in that sheet.

The "Unit Conversion" columns convert the inputs to units expected by ClearPath, according to the following:

Fuels	SEDS/Input Unit	ClearPath/Output Unit	Conversions
Distillate Oil, LPG, Residual Oil, Gasoline	Thousands of Barrels	Gallons	42 Gallons/Barrel
Wood	Trillion BTUs	MMBtu	2 MMBtu = 1 Million BTU

The "Adjusted for Providence" Columns use the previously calculated ratios to estimate final values from the conversions. These are the final values to be inputted into ClearPath.

Manchester Street Power Plant – Natural Gas, Distillate Oil Use



This sheet uses data from the EPA's Greenhouse Gas Reporting Program (GHGRP) Facility Level Information on GHGs Tool (FLIGHT) to calculate emissions for the Manchester Street Power Station, both from Natural Gas and Distillate Oil.

3. On the FLIGHT page for Manchester Street (GHGRP ID 1000905, Link at time of writing), select "View reported data."
4. Under Subpart D: Electricity Generation, a record will be listed for each of the three generators at the facility. For each, there will be a subheading titled "Electricity Fuel Details."
5. Each of these subheadings will contain two boxes, one for natural gas and the other for distillate fuel oil. For example:

Electricity Fuel Details:

Fuel type: Natural Gas (Weighted U.S. Average)
Annual heat input: 5080027.804 (mmBtu)
CH_4 Emissions CO_2 Equivalent: 127.0 (Metric Tons)
N_2O Emissions CO_2 Equivalent: 151.4 (Metric Tons)

Fuel type: Distillate Fuel Oil No. 2
Annual heat input: 122281.0813 (mmBtu)
CH_4 Emissions CO_2 Equivalent: 9.2 (Metric Tons)
N_2O Emissions CO_2 Equivalent: 21.9 (Metric Tons)

6. For each of these, copy the values into the appropriate cells. They will be summed automatically to yield final values in MMBtu.
7. **Stationary Boiler Calculations.**
8. Data is sourced from the EPA's Greenhouse Has Reporting Program (GHGRP) Facility Level Information on GHGs Tool (FLIGHT). Using FLIGHT, locate the Manchester Street Power Plant with **GHGRP ID 1000905** (Link at time of writing), and view the facilities reported info for the desire/latest year (Link at time of writing).
9. This record in the inventory accounts for emissions produced by Manchester Street for energy used internally, and not for grid distribution. This is reported in Subpart C: General Stationary Fuel Combustion in FLIGHT. One boiler, **B001**, is responsible for the generation. Under that entry, locate the "Tier Fuel Details" heading, in which there is another subheading for "**Equation C2a / C9a Inputs**."
10. The value for this field is located by multiplying the values for Fuel Quantity and High Heat Value to arrive at a final value in **MMBtu**. The fuel quantity factor reports the Standard Cubic Feet of natural gas used annually, while High Heat Value provides the maximum MMBtu per SCF of gas. We assume that the heat input of gas is always its maximum.
11. **CO_2:** In Subpart C of the aforementioned FLIGHT data page, locate a subheading titled "Gas Information Details." Locate the table with "Gas Name" = "Carbon Dioxide." The "Gas Quantity" row provides the value for ClearPath input in **metric tons**.

12. **CH_4:** In Subpart C of the aforementioned FLIGHT data page, locate a subheading titled "Gas Information Details." Locate the table with "Gas Name" = "Methane." The "Gas Quantity" row provides the value for ClearPath input in **metric tons**.
13. **N_2O:** In Subpart C of the aforementioned FLIGHT data page, locate a subheading titled "Gas Information Details." Locate the table with "Gas Name" = "Nitrous Oxide." The "Gas Quantity" row provides the value for ClearPath input in **metric tons**.
14.

ClearPath Transportation Inputs

Clearpath_Transp_Inputs__Current.xlsx

ICLEI Has partnered with Google Environmental Insights Explorer (Google EIE) to source transportation data.

This sheet uses transportation data provided by RIDOT to calculate transportation inputs for ClearPath. Enter the average Daily Vehicle Miles Traveled for the City of Providence, provided by RIDOT, into **cell B5**. *(Unable to reach RIDOT, used this data instead: Google EIE, https://insights.sustainability.google/places/ChIJXXN-Q-BE5IkRJ7azSE1832k?hl=en-US.)*

If updates to mode share and fuel source per vehicle type are available/provided, update them in the appropriate sections. RIDOT did not provide these updates with the updated DMVT in summer 2019, so 2018 uses the same percentages as the 2015 inventory.

Water & Wastewater

Miscellaneous

- Boston University Methodology: Up to date as of summer 2019. The current list can be downloaded here.

BU_CMS_NE_emissions_methodology.doc

- ### SCC Full List

Full SCC List.csv

- Plotly graph maker that was used to make graphs for 2018 inventory: https://plot.ly/~chris-sarli/1/#/
- **Note about Manchester Street Power Station:** All the scopes used for the 2018 Inventory were copied directly from the 2015 Inventory. The **Scope 2 Emissions apply to the records for Energy use, not energy production**. Therefore, the Scope 2 figures are the sum of emissions for the records "Residential Electricity" and "Commercial/Industrial Electricity." The Manchester Street records are assigned Scope 1; the facility is seen as a private business/company. While the electrons they produce are the actual product, for the purposes of this inventory, the facility is seen as a business which has associated emissions, not unlike a factory. I was concerned that because we are calculating emissions based on electricity production and use, we were double counting. There is a lot of overlap, but without more precise data, I believe this is the best we can do. **We do not know what percentage of the electricity produced by Manchester Street is used within City limits, and therefore we do not know the relative contribution of renewables etc.** I can't remember if Dino and I brought this specifically up in out call with Mike Steinfeld, but this falls under the (currently) unavoidable error he described. I'm guessing that this double counting is the largest single source of error (overall citywide emissions are likely noticeably lower). However, this method preserves consistency with the previous inventory methodology and gives us an overestimation, which is preferable to an underestimation. Additionally, as renewables become more prominent, this gap will shrink to zero. I wasn't able to find a more granular way to report this information in the GPC docs, although there may be one. This method, however, was used for the 2015 inventory, and feels more honest and complete than the alternative. If you would like to recalculate the Inventory to not count Manchester Street, you'll need to select "Information Only" on each of the three Manchester Street records. This will track the emissions, but not be included in reports generated by ClearPath (and thus not be included in the overall emissions calculations). This will also need to be done for the 2015 inventory in order to obtain comparable figures.
- **Q: Are residential and commercial emissions scope 1 only? Or do they incorporate scope 2 emissions from Man. St. Power station?** For Residential and Commercial/Industrial, electricity use is considered Scope 2. Emissions from the use of other types of fuels (Natural Gas, LPG, Wood, Distillate Oil, Residual Oil, Gasoline) are considered Scope 1. See the above comment on semi-inevitable double-counting with Manchester Street.
- **Note on measuring water and wastewater:** The population/service area for fields point did change slightly between 2015 and 2018, but this is not a significant change. Yes, we are accounting for anaerobic digestion (if I understand the measurements correctly). We are provided with 2018 effluent total nitrogen (TN) load by NBC, which is the daily N load data ClearPath prefers. This is a direct measurement of the nitrogen produced in the process. If this is not available, ClearPath presents another set of options to estimate these emissions based on aerobic/anaerobic characteristics. This is all in the Effluent Discharge record, which maps to the

TN load increase reported by NBC (77kg N/day to 906kg N/day). We don't know what led to the change – this is something NBC might be able to address.

- **Notes on Inventory Parameters:** The parameters used in the 2018 report have been modified for the 2021 report to align with the Greenhouse Gas Global Protocol for Cities (GHG GPC). These parameters