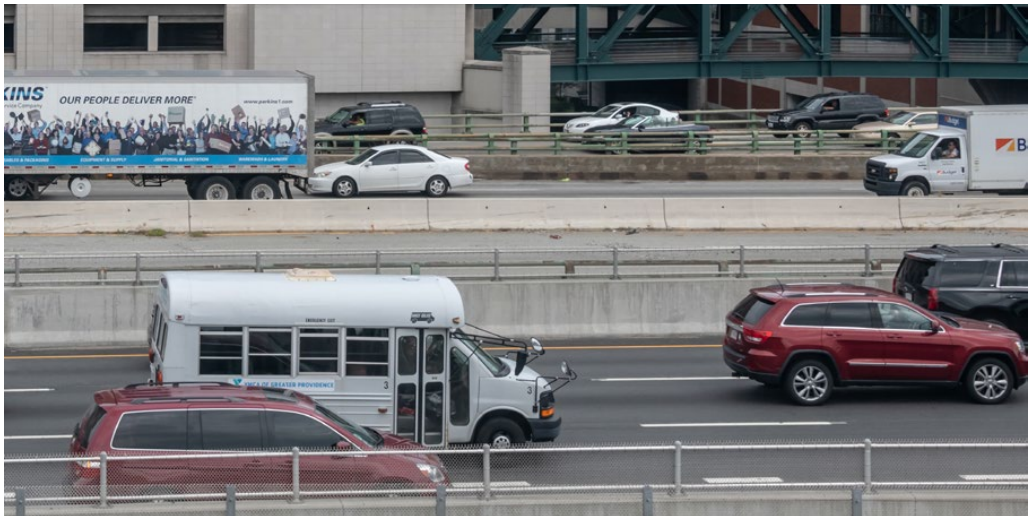
DEM
RHODE ISLAND

OCTOBER 2023



2020 RHODE ISLAND

GREENHOUSE GAS EMISSIONS INVENTORY

AN ASSESSMENT OF RHODE ISLAND'S PROGRESS TOWARDS THE 2021 ACT ON CLIMATE

Introduction

The *2020 Rhode Island Greenhouse Gas Emissions Inventory* marks 30 years of reliable data used to track the state's contribution to global climate change. 2020 also represents the first year the Department of Environmental Management's (DEM) greenhouse gas (GHG) emissions inventory was used to formally assess compliance with the 2021 Act on Climate's GHG emission reduction mandates (R.I. General Laws § 42-6.2-2). Please note, the COVID-19 pandemic significantly reduced emissions in 2020 beyond what would be typically expected and the 2020 inventory should not be interpreted as an indicator of future emission reductions.

KEY FINDINGS

- Rhode Island emitted 9.24 million metric tons of carbon dioxide equivalent ($MMTCO_2e$) in 2020
- The state achieved the Act on Climate's 2020 emission reduction mandate
- Economy-wide emissions decreased by 20.1% (2.32 $MMTCO_2e$) from 1990 levels

Short-Term Trends

TRANSPORTATION

Transportation continues to be the largest source of emissions in Rhode Island. 38.0% of all economy-wide emissions (3.77 $MMTCO_2e$) originated from highway vehicles, aviation, and non-road sources. Gasoline-powered cars and trucks comprised the lion's share (64.7%) of transportation emissions and were responsible for 24.6% of the Rhode Island's total emissions. Pandemic-related social and economic restrictions forced transportation emissions to decline 11.6% from 2019 levels, largely due to reductions in aviation (-79.6%) and highway vehicles (-7.3%). EPA's Motor Vehicle Emissions Simulator (MOVES) was used to estimate emissions from highway vehicles in 2020. This is a small difference of methodology compared to 2019, when EPA's State Inventory Tool (SIT) was employed. Transportation emissions in 2020 are still comparable to 2019 since both estimates are based on total vehicle miles traveled in Rhode Island.

ELECTRICITY CONSUMPTION

Electricity consumption was the state's second largest source in 2020, representing 20.6% of total emissions. The electricity consumption total (2.04 $MMTCO_2e$) represents emissions from Rhode Island's electricity demand from fossil-fueled power plants in New England. Biogenic emissions[1] from electricity consumption were 0.32 $MMTCO_2e$ in 2020 and are reported for informational purposes only, see the Technical Appendix for more details. Electricity consumption emissions increased 16.7% from 2019 levels in 2020. ISO-New England, the regional electric grid operator, likely relied on Rhode Island's efficient and cost-effective natural gas power plants to generate more electricity when Massachusetts' Pilgrim Nuclear Power Station closed in mid-2019. The closure of Pilgrim, along with economic forces and Rhode Island's geographic location within the New England electric grid, may have also increased emissions in 2020. Additionally, Rhode Island retired 6.3% more emissions-free Renewable Energy Certificates (RECs) in 2020 compared to 2019 – an important step towards achieving 100% renewable energy by 2033[2].

RESIDENTIAL, COMMERCIAL, AND INDUSTRIAL HEATING

Emissions from residential heating, sometimes referred to as part of the "buildings" or "thermal" sector, comprised 19.3% of 2020's total (1.91 $MMTCO_2e$). Residential heating emissions originate from household natural gas and oil furnaces and boilers. If combined with the commercial and industrial heating sectors, emissions from heating buildings in Rhode Island were responsible for 3.29 $MMTCO_2e$. Between 2019 and 2020, residential heating emissions declined 8.5%. New England's variable climate played a key role in this decline, as 2020 was a warmer year in Rhode Island compared to 2019.

Heating degree days (HDDs) evaluate the impact of outdoor temperatures on heating fuel use. More HDDs in a year typically correlate to higher emissions. Providence accumulated 4,884 HDDs in 2020, 685 less than 2019[3]. Emissions from combined residential, commercial, and industrial heating declined 9.1% in 2020.

OTHER SECTORS

Methane leaks from Rhode Island's natural gas distribution system emitted 0.26 $MMTCO_2e$ in 2020, 2.7% of the state's total. Emissions from this sector declined 2.2% from 2019 levels, likely attributed to Rhode Island Energy's pipeline replacement program. See the Technical Appendix for details on this sector's methodology. Emissions from industrial processes (4.1% of total) mainly represent the use of ozone-depleting substances and sulfur hexafluoride (SF_6), which is used to insulate electric power lines. The waste sector (1.2% of total) includes municipal solid waste and wastewater treatment. Agricultural emissions (0.3% of total) represent the small amount of methane emissions from livestock and nitrous oxide emissions from applied fertilizers. Carbon sequestered from natural and working lands in Rhode Island offset 7.4% of gross emissions in 2020.

Long-Term Trends

Rhode Island's ambitious climate change mitigation strategies, energy efficiency efforts, and regional economic trends continue to decrease emissions since 1990. In the past 30 years:

LARGEST SECTOR TRENDS

Transportation emissions declined 18.9%

Electricity Consumption emissions declined 27.5%

Residential Heating emissions declined 19.8%

In addition, fugitive methane emissions from natural gas pipeline leaks declined 19.4% since 1990. Emissions from a few of the hardest-to-decarbonize sectors saw small increases since 1990. Non-road source (marine, rail, and construction equipment) emissions increased by 0.03 $MMTCO_2e$ since 1990, while industrial process emissions increased by 0.33 $MMTCO_2e$. Emissions from wastewater treatment slightly increased by 0.01 $MMTCO_2e$ in the last 30 years. Rhode Island also continues to lose natural and working lands to development; the state's carbon sink shrunk by 15.7% from 1990 levels.

Conclusion

The *2020 Rhode Island Greenhouse Gas Emissions Inventory* determined that the state achieved the 2021 Act on Climate's first emission reduction mandate of *"10% below 1990 levels by 2020"*. Rhode Island's emissions in 2020 were 2.32 $MMTCO_2e$, or 20.1% below the 1990 baseline. The COVID-19 pandemic, which seriously impacted society and economic activity, reduced the state's emissions beyond typical expectations. The absence of pandemic-related social and economic restrictions in 2021 will likely translate to a rebound in emissions. DEM will tentatively publish the 2021 inventory no later than fall of 2024 and remains committed to improving the three-year lag time between the current year and the inventory year.

The *Rhode Island 2022 Climate Update* recommended several methodology improvements for the inventory. A public comment period on proposed improvements for the 1990 baseline was held between September 22, 2023 and October 6, 2023. The Technical Appendix details adopted improvements for the 1990 baseline and other adjustments to the inventory's timeseries. All inventory-related announcements, supporting data, and past inventories can be found at https://dem.ri.gov/ghg-inventory. Sign up for climate change-related updates through the Rhode Island Executive Climate Change Coordinating Council's email list here.

HISTORICAL RHODE ISLAND GREENHOUSE GAS EMISSIONS

Sector	1990* Emissions ($MMTCO_2e$)	2010 Emissions ($MMTCO_2e$)	2017 Emissions ($MMTCO_2e$)	2018 Emissions ($MMTCO_2e$)	2019 Emissions ($MMTCO_2e$)	2020 Emissions ($MMTCO_2e$)
Energy	**3.14**	**3.12**	**2.33**	**2.18**	**2.02**	**2.31**
Electricity Consumption	*2.82*	*2.81*	*2.05*	*1.91*	*1.75*	*2.04*
Natural Gas Distribution	*0.33*	*0.31*	*0.28*	*0.27*	*0.27*	*0.26*
Residential Heating	**2.38**	**2.25**	**1.87**	**2.33**	**2.09**	**1.91**
Commercial Heating	**1.13**	**0.92**	**0.87**	**0.98**	**0.94**	**0.80**
Transportation	**4.65**	**4.84**	**4.24**	**4.53**	**4.27**	**3.77**
Aviation	*0.33*	*0.26*	*0.30*	*0.32*	*0.28*	*0.06*
Highway Vehicles	*3.98*	*4.07*	*3.56*	*3.84*	*3.61*	*3.34*
Nonroad Sources	*0.35*	*0.51*	*0.38*	*0.37*	*0.38*	*0.37*
Industry	**0.68**	**0.96**	**0.98**	**1.00**	**0.99**	**0.98**
Industrial Heating	*0.61*	*0.55*	*0.59*	*0.61*	*0.60*	*0.57*
Industrial Processes	*0.07*	*0.41*	*0.39*	*0.39*	*0.40*	*0.40*
Agriculture	**0.05**	**0.06**	**0.06**	**0.05**	**0.03**	**0.03**
Waste	**0.34**	**0.35**	**0.21**	**0.21**	**0.23**	**0.12**
Municipal Solid Waste	*0.24*	*.025*	*0.11*	*0.11*	*0.13*	*0.02*
Wastewater	*0.10*	*0.10*	*0.10*	*0.10*	*0.10*	*0.10*
Land Use, Land Use Change, & Forestry	**-0.81**	**-0.71**	**-0.71**	**-0.72**	**-0.70**	**-0.68**
TOTAL GROSS EMISSIONS	**12.37**	**12.50**	**10.56**	**11.29**	**10.57**	**9.92**
TOTAL NET EMISSIONS	**11.56**	**11.80**	**9.85**	**10.57**	**9.87**	**9.24**

**1990 has been adjusted as done in the 2016 Rhode Island Greenhouse Gas Emissions Reduction Plan*
For the complete dataset, visit: https://dem.ri.gov/ghg-inventory

Technical Appendix

The Department of Environmental Management (DEM) incorporates contemporary climate science and the highest-quality data into the *Rhode Island Greenhouse Gas Emissions Inventory* whenever reasonable. Following consistent stakeholder feedback and recommendations approved by the EC4 in the *Rhode Island 2022 Climate Update*, DEM adopted necessary methodology improvements for consistency across three decades of data. For methodology improvements that affected the inventory's 1990 baseline, DEM held a 14-day public comment period and facilitated a public listening session on October 2, 2023. Read about methodology improvements to the 1990 baseline with submitted public comments here. The complete timeseries of Rhode Island's emissions can be found at https://dem.ri.gov/ghg-inventory.

GLOBAL WARMING POTENTIALS

The global warming potential (GWP) evaluates the climate impact one ton of methane, nitrous oxide, or ozone-depleting substance has compared to one ton of carbon dioxide. GWPs are set and reevaluated by the Intergovernmental Panel on Climate Change (IPCC) every 6-7 years. Since carbon dioxide, the most prevalent GHG, has an atmospheric lifespan greater than 100 years, GWPs are typically expressed on a 100-year-time horizon. Methane traps more heat than carbon dioxide and has a shorter lifespan of only 12.4 years. To demonstrate methane's greater climate impact, GWPs can also alternatively be expressed on a 20-year-time-horizon. The United Nations Framework Convention on Climate Change (UNFCCC) requires 100-year AR5 GWPs, except for fossil methane[4]. The IPCC's GWP for fossil methane assesses total carbon content, which includes methane's oxidation to carbon dioxide in the atmosphere[5]. Since most emission factors used in the inventory already account for total carbon content, the inventory's fossil methane estimates use the same GWP as biospheric methane[6] to avoid double counting carbon dioxide. Examples of 100-year GWPs are listed here:

Type of Greenhouse Gas	IPCC 2nd Assessment Report (SAR)	IPCC 4th Assessment Report (2007)	IPCC 5th Assessment Report (2014)
Carbon dioxide (CO_2)	*1*	*1*	*1*
Methane (CH_4)	*21*	*25*	*28*
Nitrous oxide (N_2O)	*310*	*298*	*265*

To align with UNFCCC requirements and EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks, **DEM updated the inventory's 1990 baseline and entire timeseries to 100-year AR5 GWPs.** This is in response to a recommendation approved by the EC4 on page 32 of the *Rhode Island 2022 Climate Update*:

> ***"We recommend further evaluation and discussion of updating the 1990 baseline if the best science suggests new and reasonable parameters or methods."***

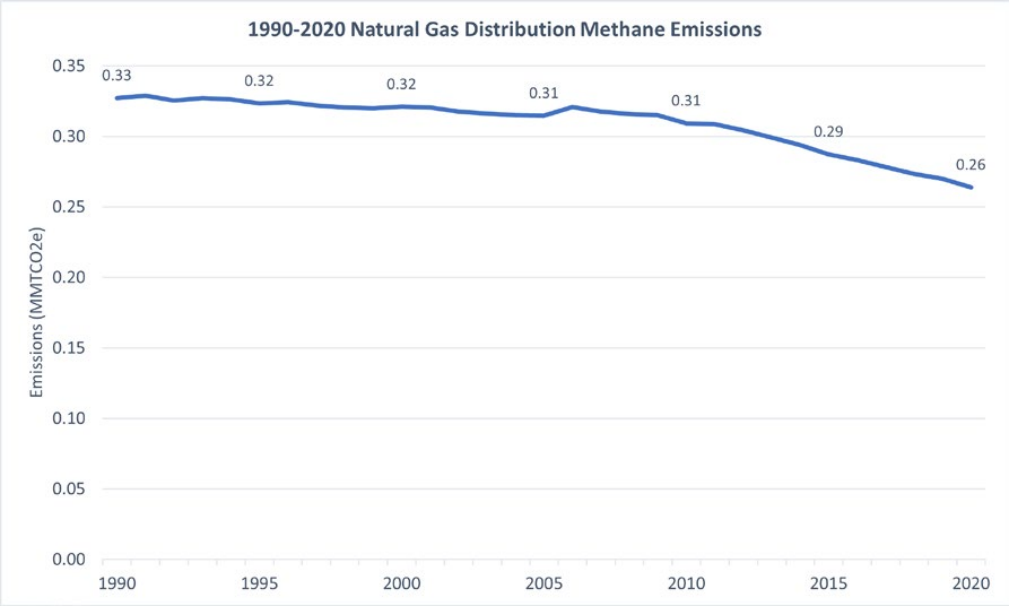
Updating the inventory to 100-year AR5 GWPs incorporates contemporary climate science, follows best practice, and promotes consistency. At DEM's October 2, 2023, public listening session, stakeholders stated methane emissions should be estimated with 20-Year GWPs. In response to comments received, DEM will investigate the possibility of using the 20-year GWP for methane.

The consistent use of a singular GWP across the entire timeseries is also important to demonstrate the effect of programs that reduce emissions over many years. One subsector that highly depends on the GWP for accuracy is natural gas distribution, where fugitive methane leaks from the state's natural gas mains and services are accounted for.

NATURAL GAS DISTRIBUTION DATA

In response to stakeholder feedback regarding the accuracy of the inventory's natural gas distribution estimate, DEM leveraged more robust data and revised this sector's estimate for all inventory years. Methane leaks from natural gas mains and services was formerly obtained from EPA's Facility Level Information on Greenhouse Gases Tool (FLIGHT) for inventories 2010-2019. Alternatively, the 1990 baseline utilized a more robust methodology to estimate methane leaks from natural gas distribution. For the 1990 baseline, the Northeast States for Coordinated Air Use Management (NESCAUM) utilized data from the U.S. Department of Energy's Pipeline & Hazardous Materials Safety Administration (PHMSA) and pipe-line specific emission factors in EPA's State Inventory Tool (SIT) to estimate methane leaks from natural gas distribution[7].

It was brought to DEM's attention that FLIGHT uses an *averaged* emission factor for cast iron, unprotected steel, protected steel, and plastic mains and services. This limitation misrepresented methane leaks from natural gas distribution since pipelines composed of different materials leak at vastly different rates. To remedy this issue, DEM employed PHMSA's natural gas mains and services data in conjunction with EPA's SIT pipeline-specific emission factors. This adjustment aligns with the methodology NESCAUM used for the 1990 baseline. The following graph displays methane leaks from natural gas mains and services, using 100-year AR5 global warming potentials:



SIT's emission factors for cast iron, unprotected steel, protected steel, and plastic mains and services originate from EPA's Methane Emissions from the Natural Gas Industry, Volume 9: Underground Pipelines, published in 1996. DEM has requested EPA align SIT's natural gas distribution emission factors with those used in the *Inventory of U.S. Greenhouse Gas Emissions and Sinks*[8] since those were developed with newer technology.

LAND USE, LAND USE CHANGE, AND FORESTRY REPORTING GUIDELINES

Land Use, Land Use Change, and Forestry (LULUCF) represents the net carbon flux from natural and working lands[9] in Rhode Island. The *2016 Rhode Island Greenhouse Gas Emissions Reduction Plan* estimated LULUCF for the first time and established a net emissions total for the 1990 baseline. The 1990 baseline's LULUCF sector was estimated with data provided by the Rhode Island Geographic Information System, Abt Associates, and trends in carbon dynamics from in EPA's SIT. After the 2021 Act on Climate was enacted, the inventory's net emissions total became increasingly important for assessing progress towards "net-zero emissions by 2050". DEM found the 1990 baseline's methodology to be irreplicable and adopted its own methodology with public input for estimating carbon sequestered from Rhode Island's forests. The *Rhode Island 2022 Climate Update* was receptive to DEM's new methodology and further stated:

> ***"We recommend RIDEM continue to collaborate with its DAFE (Division of Agriculture and Forest Environment) and the U.S. Climate Alliance to continuously improve the LULUCF sector."***

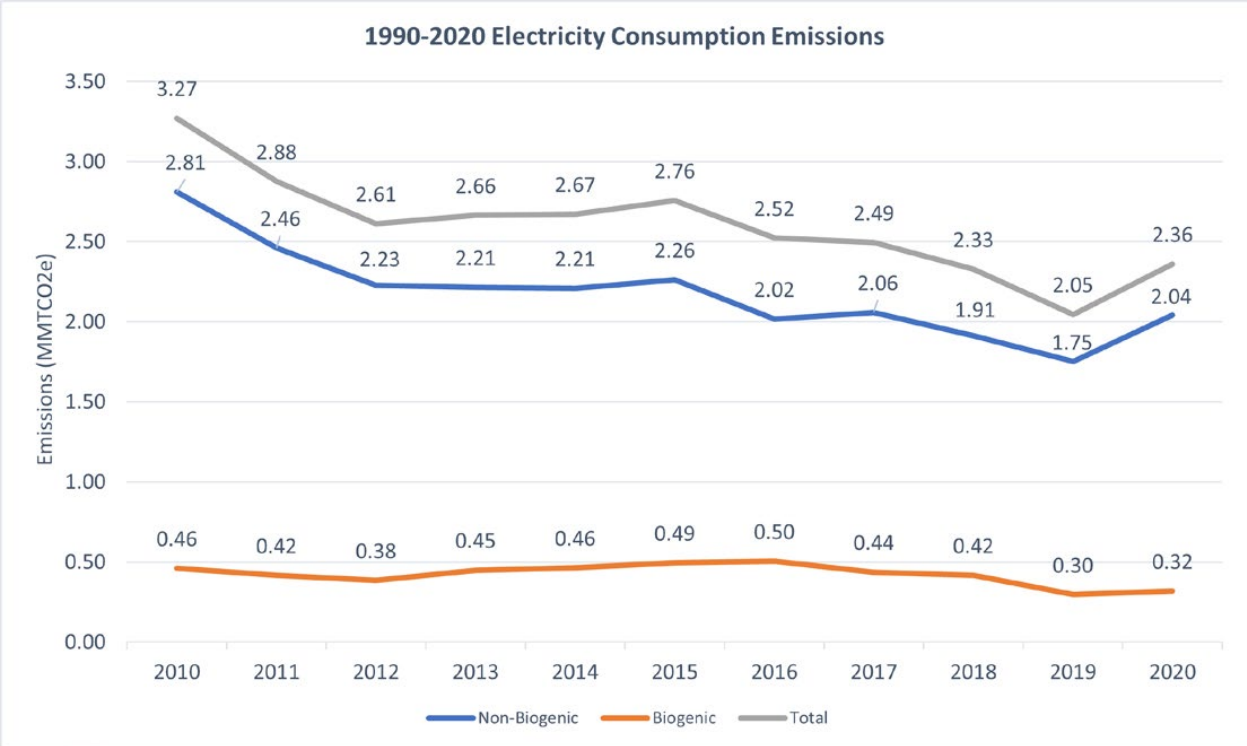
In response to this recommendation, DEM worked with its Division of Agriculture and Forest Environment and the U.S. Climate Alliance at its Natural & Working Lands 2023 National Learning Lab to align the LULUCF sector with the land-use categories defined in the *2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4: Agriculture, Forestry and Other Land Use*[10, 11]. To facilitate this improvement, DEM leveraged state-specific data from EPA's *Inventory of U.S. Greenhouse Gas Emissions and Sinks by States*. Please note, Forest Land Remaining Forest Land (aboveground biomass and forest fires), Croplands, Grasslands, and Settlements Remaining Settlements (urban trees only) continues to follow DEM's methodology adopted last year. EPA's state-specific data was only used to include previously omitted categories, highlighted in **green** below.

Previous LULUCF Categories	Updated LULUCF Categories (NEW)
Forest Land • Forest Land Remaining Forest Land (Aboveground Biomass, Forest Fires)	**Forest Land** • Forest Land Remaining Forest Land (Aboveground Biomass, Forest Fires) • **Land Converted to Forest Land**
Croplands • Agricultural Soil Carbon Flux	**Croplands** • Cropland Remaining Cropland • Land Converted to Cropland
Grasslands • Agricultural Soil Carbon Flux	**Grasslands** • Grassland Remaining Grassland • Land Converted to Grassland
Wetlands • Not Included	**Wetlands** • **Coastal Wetlands Remaining Coastal Wetlands** • **Land Converted to Coastal Wetlands**
Settlements • Settlements Remaining Settlements (Urban Trees, Settlement Soils, Yard Trimmings)	**Settlements** • Settlements Remaining Settlements (Urban Trees, Settlement Soils, Yard Trimmings) • **Land Converted to Settlements**

This methodology improvement was proposed during DEM's 14-day public comment period due to its impact on the 1990 baseline. Alignment with IPCC land-use categories and application of DEM's aboveground biomass methodology adjusted the baseline's LULUCF estimate from -0.29 $MMTCO_2e$ to -0.81 $MMTCO_2e$, an estimate significantly closer to reality. This methodology improvement follows national and international reporting guidelines, creates a net emissions total for each inventory year, and provides a more direct comparison across three decades of data.

TREATMENT OF BIOGENIC EMISSIONS FROM ELECTRICITY CONSUMPTION

The *Rhode Island Greenhouse Gas Emissions Inventory* uses a unique methodology to estimate emissions from electricity consumption[13], which is the only sector to include imported emissions from outside of Rhode Island. DEM's methodology has the ability to differentiate between biogenic emissions[1] and non-biogenic emissions[14]. This is important since the *Rhode Island 2022 Climate Update* and the state's Renewable Energy Standard[2] (RES) both assume biogenically sourced electricity is emissions-free. To reflect these assumptions, biogenic emissions from electricity consumption are now treated as CO_2e-neutral for purposes of assessing compliance with the 2021 Act on Climate. This adjustment was applied to inventories 2010-2020, covering all but one year of the RES's existence. The following graph displays total, non-biogenic, and biogenic emissions from electricity consumption:



Biogenic emissions from electricity consumption are henceforth reported separately from the inventory's official total. This adjustment aligns the inventory with the federal government's convention of reporting biogenic emissions separately from GHG targets[15]. However, DEM recognizes the ongoing international controversy surrounding GHG accounting for energy generated from biogenic sources. To understand the implications of combusting biomass for energy, a detailed lifecycle analysis of the various feedstocks for biogenic emissions would need to occur. Rhode Island, as part of the U.S. Climate Alliance, will continue to collaborate on a more robust framework for reporting biogenic emissions as part of the Alliance's Emissions Working Group.

End Notes

1. Biogenic emissions include electricity generated from biogas, biomass, digester gas, landfill gas, and wood.
2. See R.I. General Laws § 39-26-4.
3. Data courtesy of Northeast Regional Climate Center CLIMOD 2.
4. See paragraphs 1 and 2 of 7/CP.27, "Common metrics used to calculate the carbon dioxide equivalent of anthropogenic greenhouse gas emissions by sources and removals by sinks" at the 27th UNFCCC Conference of Parties (COP27), available online at https://unfccc.int/sites/default/files/resource/cp2022_10a01_adv.pdf.
5. Myhre, G., D. Shindell, F.-M. Bréon, W. Collins, J. Fuglestvedt, J. Huang, D. Koch, J.-F. Lamarque, D. Lee, B. Mendoza, T. Nakajima, A. Robock, G. Stephens, T. Takemura and H. Zhang, 2013: Anthropogenic and Natural Radiative Forcing. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
6. Biospheric methane originates from biogenic emission sources (i.e., biofuels, livestock, etc.).
7. See page 59 of DEM's *2010 Rhode Island Greenhouse Gas Emissions Inventory.*
8. See EPA's *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2014: Revisions to Natural Gas Distribution Emissions.*
9. Natural and working lands include forests and woodlands, grasslands and shrublands, croplands and rangelands, coastal and freshwater wetlands, and urban greenspaces. (U.S. Climate Alliance).
10. IPCC 2006, *2006 IPCC Guidelines for National Greenhouse Gas Inventories*, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan.
11. The IPCC defines a sixth land use category "other land", which is classified as bare soil, rock, and ice. This is assumed to have net carbon flux of 0 $MMTCO_2e$ in Rhode Island and is not included for simplicity.
12. See DEM's *Updates to Electricity Sector GHG Accounting.*
13. The Rhode Island Executive Climate Change Coordinating Council voted to use consumption-based accounting for the electricity sector in 2016. See *Electricity Generation vs. Consumption Accounting*.
14. Non-biogenic emissions include electricity generated from coal, petroleum, natural gas, kerosene, and the non-biogenic component of municipal solid waste.
15. See page 3.1 of the Council on Environmental Quality's *Federal Greenhouse Gas Accounting and Reporting Guidance* as an example.