Puerto Rico’s 2019 and 2021 Greenhouse Gas Inventories Report

Puerto Rico Department of Natural and Environmental Resources (DNER)

Applied Economics Clinic
Economic and Policy Analysis of Energy, Environment and Equity

DEPARTMENT OF NATURAL AND ENVIRONMENTAL RESOURCES
DNER

July 2023

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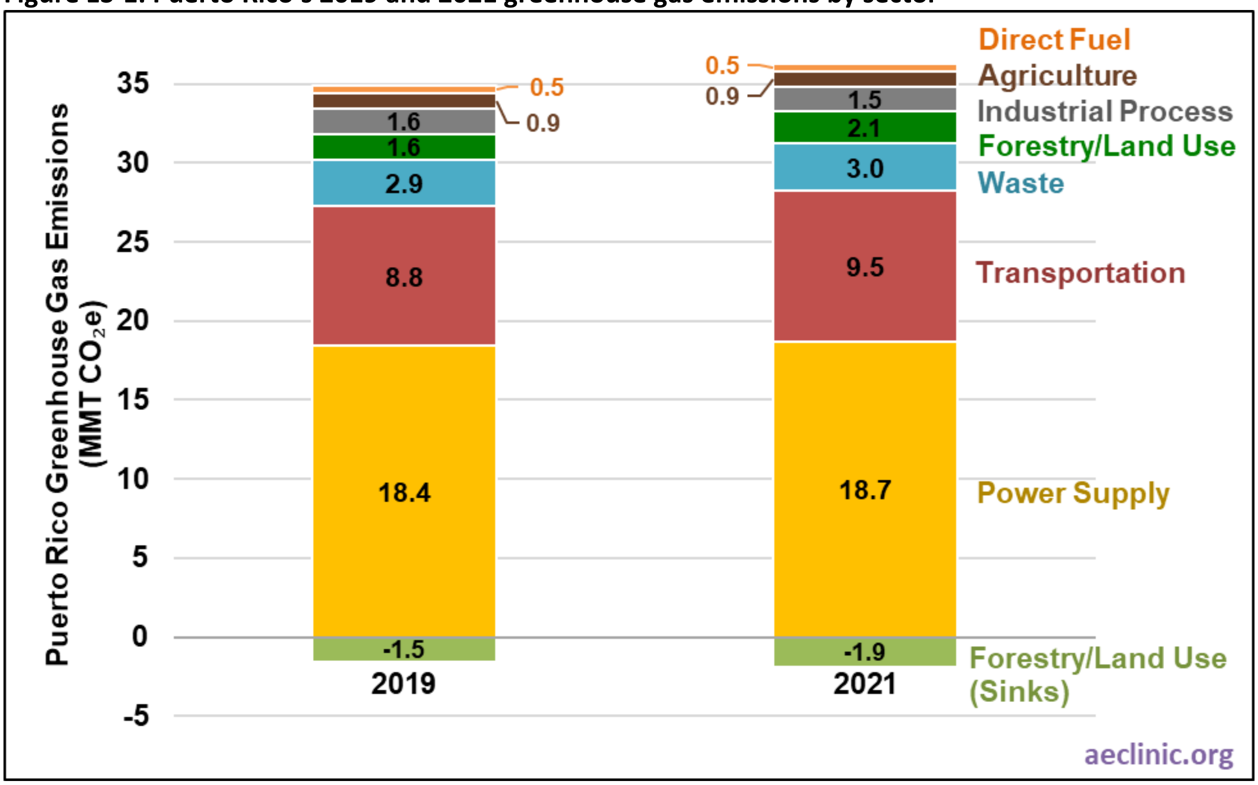
Executive Summary

Puerto Rico's 2019 *Climate Change Mitigation, Adaption, and Resiliency Law* mandates the Department of Natural and Environmental Resources (DNER) to compile and publish an inventory of greenhouse gas emissions by type and source annually and requires that by 2025 island-wide greenhouse gas emissions be no more than 26.7 million metric tons (MMT) of carbon dioxide equivalents (CO_2e) or 50 percent of 2005 levels.

2019/2021 Inventory results

Puerto Rico's greenhouse gas emissions totaled 33.4 MMT CO_2e in 2019 and 34.3 MMT CO_2e in 2021 using the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report's (AR6) global warming potentials (GWPs) and netting out emission sequestration from Forestry and Other Land Use (see Figure ES-1). Emission levels achieved in 2021 represent a 36 percent reduction in emissions from 2005 levels. With 14 percentage points and 4 years left to go, Puerto Rico must find another 7.7 MMT CO_2e to eliminate.

Figure ES-1. Puerto Rico's 2019 and 2021 greenhouse gas emissions by sector

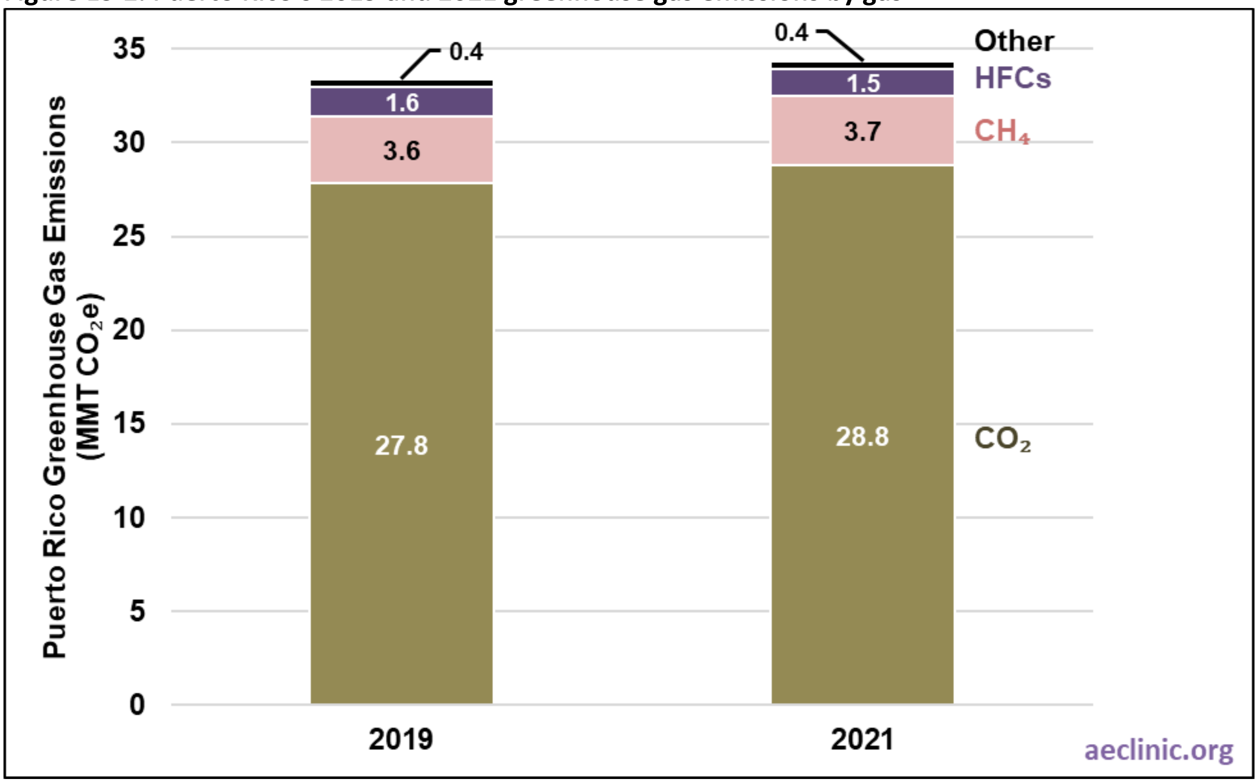


Note: The "Forestry and Other Land Use" category includes both positive (i.e., increased) emissions from carbon releases and wildfires as well as negative (i.e., reduced) emissions from carbon sequestration gains (i.e., emission sinks).

The last Puerto Rico inventory conducted in 2014 used now out-of-date GWPs to present historical emissions for 1990, 1995, 2000, 2005 and 2010, and projected emissions through 2035. The 2014 Inventory reports slightly lower than 2021 power sector emissions and slightly higher than 2021 transportation emissions. Waste Management emissions in this 2019/2021 Inventory are double that presented in the 2014 Inventory, most likely due to difference in data sources rather than any substantial increase in Waste Management sector emissions. Puerto Rico's recent experiences of extreme economic and ecological impacts has included damage from severe weather events, including Hurricanes Irma and María in 2017, and natural disasters, including moderate-to-strong magnitude earthquakes from the closing days of 2019 and early 2020 that had widespread impacts on the infrastructure in the island's southwest. The COVID-19 pandemic hindered Puerto Rico's ability to recover its economy and key infrastructure as has declining population levels. These circumstances affect Puerto Rico's energy and transportation sectors, industrial productivity, farmland and natural ecosystems, and, as a consequence, its greenhouse gas emissions both in the recent past and in the coming decades.

Carbon dioxide (CO_2) accounts for 83 percent of total Puerto Rico greenhouse gas emissions in 2019 and 84 percent of in 2021 (see Figure ES-2). Methane (CH_4) emissions from the Power Supply, Direct Fuel, Transportation, Agriculture, Forestry and Other Land Use, and Waste Management sectors add approximately another 11 percent of emissions; the Waste Management sector produces the greatest share of CH_4 emissions followed by Agriculture. CO_2 emissions from Power Supply and Transportation are the largest source of emissions and have the greatest potential for achieving emission reductions.

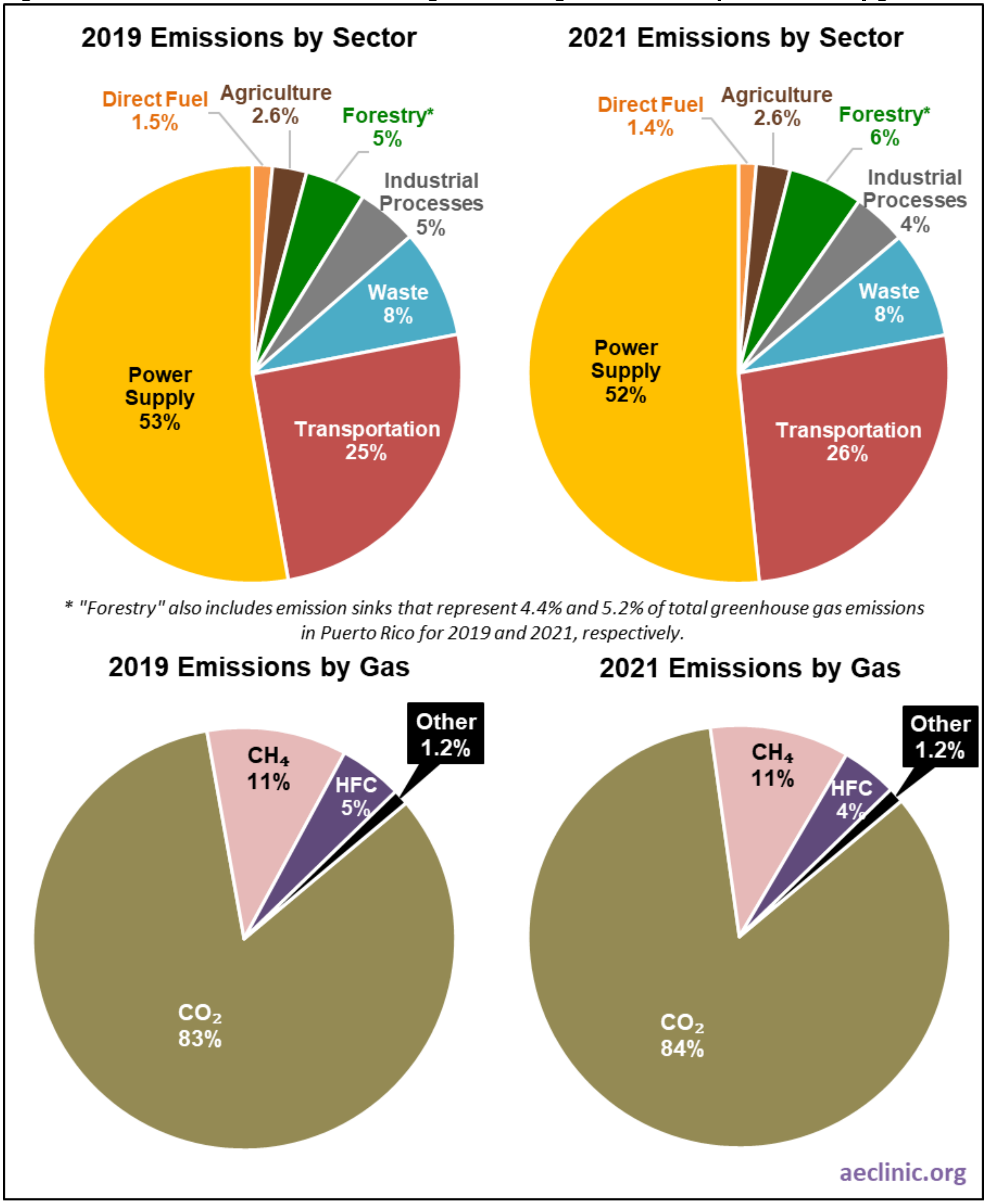
Figure ES-2. Puerto Rico's 2019 and 2021 greenhouse gas emissions by gas



Note: "Other" includes greenhouse gas emissions such as N_2O, SF_6, NF_3, and PFCs.

Power Supply sector emissions account for 53 percent of total emissions in 2019 and 52 percent in 2021 (see Figure ES-3 below). Transportation sector emissions account for an additional 25 and 26 percent of total emissions, respectively. Emission contributions from the remaining sectors are small in comparison indicating that the greatest opportunities for emission reductions exist in the Power Supply and Transportation sectors.

Figure ES-3. Puerto Rico's 2019 and 2021 greenhouse gas emissions by sector and by gas



Note: Totals may not sum to 100 percent due to rounding.

While a far larger share of emissions in the mainland United States and most temperate-climate countries is taken up by direct fuel use for home heating as well as commercial and industrial needs, Puerto Rico's direct fuel use makes up just 1.5 percent of total emissions—roughly consistent with findings in other tropical locations. Hot water and limited building heating needs are largely served by electric-powered equipment. Fuel combustion for back-up generators, however, is an important and growing source of emissions on the island.

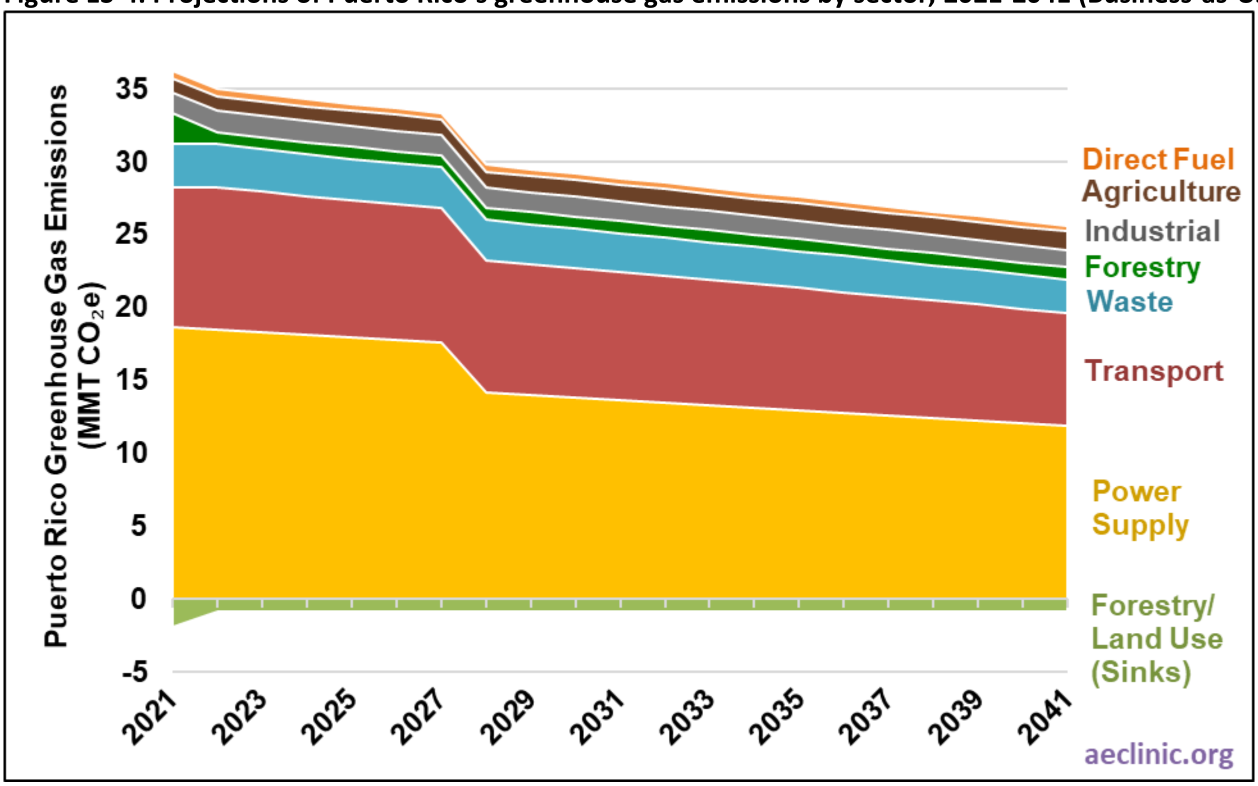
Forestry and Other Land Use emissions peaked at much higher than typical levels in 2018, reflecting a destruction of trees in the 2017 Hurricane María as tree cover change, and therefore emissions, in Puerto Rico's 2018 net emission values. These increased emissions have shrunk each year since 2018 and inventory projections are based on an expectation of slow growth in total tree cover over time.

Emissions projections

Projections of future emission trends—based on expected changes in population, economic growth, and other key forecasts—predict declining emissions over the 2022 to 2041 period, primarily due to emigration and the closure of the AES coal-fired power plant and assumed replacement with renewable electric generation. In a Business-as-Usual scenario, which is based on existing laws, policies and socio-economic expectations without significant change or disruption, emissions fall from 34.3 MMT CO_2e in 2021 down to 24.7 MMT CO_2e in 2041, a reduction of 28 percent over 20 years (see Figure ES-4).

Based on this Business-as-Usual projection, Puerto Rico's greenhouse gas emission levels will reach their mandate levels (50 percent of 2005 levels, or 26.7 MMT CO_2e) in 2035, 10 years later than the required 2025 target.

Figure ES-4. Projections of Puerto Rico's greenhouse gas emissions by sector, 2021-2041 (Business-as-Usual)

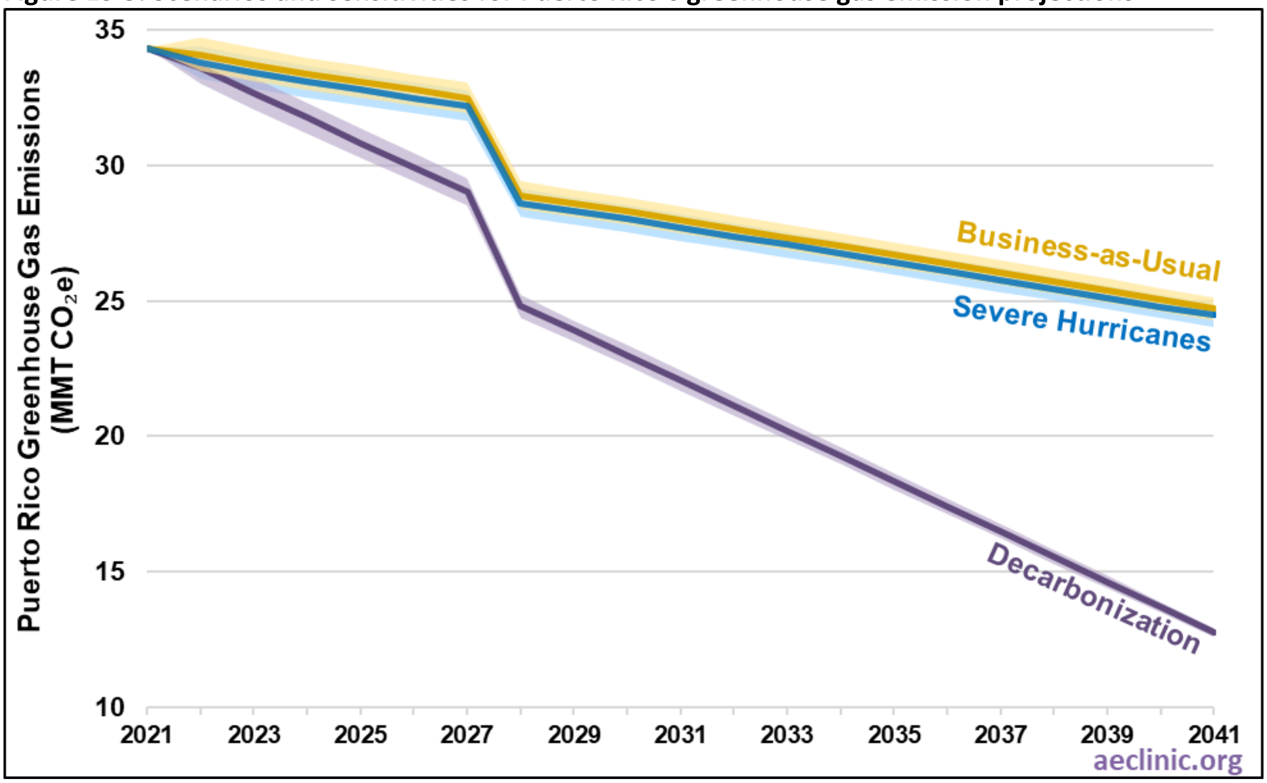


Note: The "Forestry and Other Land Use" category includes both positive (i.e., increased) emissions from carbon releases and wildfires as well as negative (i.e., reduced) emissions from carbon sequestration gains (i.e., emission sinks).

Two other scenarios of future changes in Puerto Rico's greenhouse gas emissions also show lower emissions over time but at a quicker pace than Business-as-Usual. In a Severe Hurricane scenario economic disruption causes lower fuel use and a loss of tree cover causes less carbon sequestration. Overall, 2041 emissions fall to 24.5 MMT CO_2e rather than the 24.7 MMT CO_2e expected in the Business-as-Usual scenario (see Figure ES-5).

A Decarbonization scenario results in a much more rapid reduction of Puerto Rico's emissions. Emissions in the Decarbonization scenario reach 12.8 MMT CO_2e in 2041, falling below the 26.7 MMT CO_2e requirement (50 percent of 2005 emissions) by 2028. Additional sensitivity modeling explored the impact of slower or more rapid economic growth on Puerto Rico's emissions under all 3 scenarios but with minimal effect. Differences due to slower economic growth never exceed a 2 percent emission reduction over the 2022 to 2041 period. Similarly, differences from more rapid economic growth never exceed a 2 percent emission increase over the same period.

Figure ES-5. Scenarios and sensitivities for Puerto Rico's greenhouse gas emission projections



Note: The solid lines depict the reference case for each scenario, while the shaded areas represent the high and low economic growth sensitivities.

Recommendations

Based on the analysis presented in this report, the Applied Economics Clinic has identified several key recommendations to further facilitate Puerto Rico's work towards achieving its ambitious and necessary decarbonization goals set out in Puerto Rico's 2019 *Climate Change Mitigation, Adaption, and Resiliency Law*, including: (1) better data collection, (2) increased climate progress reporting, (3) reprioritization in rebuilding its electric sector, and (4) a new focus in transportation planning. These recommendations are described in detail in the Conclusion section of this report.

1. Data Collection

The production of accurate, timely greenhouse gas emissions inventories in Puerto Rico is greatly hampered by limitations to its data collection and verification processes. The underlying data quality of several sectors presented in this inventory is poor but could be greatly improved in future Puerto Rico inventories if concrete steps are taken immediately to enhance data collection, including: (a) required annual reporting, (b) new data collection, (c) improved data verification, (d) better forecasting credibility, and (e) addressing data and forecasting uncertainty.

2. Lagging behind on 2025 emission reduction targets

Puerto Rico's 2019 climate law mandates greenhouse gas emission reductions of 50 percent by 2025, but has achieved only a 36 percent reduction by 2021. The remaining emission reductions would require careful planning and fast-paced implementation, even if the goal were to achieve them by 2030 or later. Puerto Rico needs a detailed climate plan laying out specific measures, programs, timetables, costs and other impacts necessary to achieve its 2025 emission reduction targets. A multi-sector climate plan–designed with public input and the authorization of elected officials should be published every five years, with progress reports published annually to ensure public accountability.

3. Electric sector reprioritization

Puerto Rican law also requires the elimination of fossil fuels in the energy sector by 2030 and the achievement of 100 percent renewable energy by 2050. In 2022, just 3 percent of Puerto Rico's electric generation was renewable, and the Puerto Rico Electric Power Authority's (PREPA) 2019 integrated resource plan (IRP) called for additions of new natural gas-fired power plants through 2028 with 1.2 GW of new gas planned from 2021 through 2028. PREPA's IRP does not report greenhouse gas emissions from the power sector but rather reports on average emission rates per unit of electricity produced, and offers plans that do not approach the elimination of fossil fuels in its generation mix. A comprehensive planning document—aligned with Puerto Rico's 2019 climate law—is needed to achieve the emissions reductions necessary in the electric sector and to make decarbonization through electrification possible in the transportation and Direct Fuel sectors.

4. New transportation planning

Puerto Rico's 2018 long-term transportation plan is not consistent with its economy-wide emission reduction targets. Electric vehicles are mentioned as a discussion point in the plan's conclusions but are not part of the detailed modeling exercise presented in the report. Island-wide emission reductions will require changes to the transportation sector but, as yet, no plan has been developed to implement that transformation, even on a small or exploratory scale. This important gap in Puerto Rico's emission reduction progress could be closed through the development of a detailed climate plan together with a new long-term transportation plan that includes greenhouse gas emission reductions as one of its primary goals.

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About the Applied Economics Clinic

Based in Arlington, Massachusetts, the Applied Economics Clinic (AEC, www.aeclinic.org) is a mission-based non-profit consulting group that offers expert services in the areas of energy, environment, consumer protection, and equity from seasoned professionals while providing on-the-job training to the next generation of technical experts.

AEC's non-profit status allows us to provide lower-cost services than most consultancies, and when we receive foundation grants, AEC also offers services on a pro bono basis. AEC's clients are primarily public interest organizations—non-profits, government agencies, and green business associations—who work on issues related to AEC's areas of expertise. Our work products include expert testimony, analysis, modeling, policy briefs, and reports, on topics including energy and emissions forecasting, economic assessment of proposed infrastructure plans, and research on cutting-edge, flexible energy system resources.

AEC works proactively to support and promote diversity in our areas of work by providing applied, on-the-job learning experiences to graduate students—and occasionally highly qualified undergraduates—in related fields such as economics, environmental engineering, and political science. Over the past four years, AEC has hosted research assistants from Boston University, Brandeis University, Clark University, Tufts University, University of Denver, University of Massachusetts-Amherst, University of Massachusetts-Boston, University of Southern Maine, and University of Tennessee. AEC is committed to a just workplace that is diverse, pays a living wage, and is responsive to the needs of its full-time and part-time staff.

Founded in 2017 by Director and Senior Economist Elizabeth A. Stanton, PhD, AEC's talented researchers and analysts provide a unique service-minded consulting experience. Dr. Stanton has had more than two decades of professional experience as a political and environmental economist leading numerous studies on environmental regulation, alternatives to fossil fuel infrastructure, and local and upstream emissions analysis. AEC professional staff includes experts in electric, multi-sector and economic systems modeling, climate and emissions analysis, green technologies, and translating technical information for a general audience. AEC's staff are committed to addressing climate change and environmental injustice in all its forms through diligent, transparent, and comprehensible research and analysis.

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List of Acronyms

AES: Applied Energy Services

AEC: Applied Economics Clinic

AEC-EMIT: Applied Economics Clinic's Emissions Measurement Inventory Tool

AR6: IPCC's Sixth Assessment Report

BDE: Puerto Rico's Economic Development Bank

BOD: biological organic demand

CEACC: Committee of Experts and Advisors on Climate Change for the Government of Puerto Rico

CH_4: methane

CHP: combined heat and power

CO_2: carbon dioxide

CO_2e: carbon dioxide equivalent

DCA: Puerto Rico's Department of Consumer Affairs

DEDC: Puerto Rico's Department of Economic Development and Commerce

DF: Puerto Rico's Department of Finance

DNER: Puerto Rico's Department of Natural and Environmental Resources

DTPW: Puerto Rico's Department of Transportation and Public Works

EDGAR: Emissions Database for Global Atmospheric Research

FOMB: Financial Oversight and Management Board

GDP: Gross Domestic Product

GHGRP: U.S. EPA's Greenhouse Gas Reporting Program

GNP: Gross National Product

GPC: Global Protocol for Community-Scale Greenhouse Gas Emission Inventories

GWPs: global warming potentials

HFCs: hydrofluorocarbons

IPCC: Intergovernmental Panel on Climate Change

IRP: integrated resource plan

MMBtu: million British Thermal Units

MMT: million metric tons

MTA: Puerto Rico's Maritime Transit Authority

MWh: megawatt-hours

N_2O: nitrous oxide

NASS: U.S. Department of Agriculture's National Agricultural Statistics Service

NPDES: U.S. EPA's National Pollutant Discharge Elimination System

ODS: ozone-depleting substances

PFCs: perfluorochemicals

PR100: *Puerto Rico Grid Resilience and Transitions to 100% Renewable Energy Study* (2022)

PRASA: Puerto Rico's Aqueducts and Sewers Authority

PR-CCC: Puerto Rico Climate Change Council

PREPA: Puerto Rico Electric Power Authority

PROMESA: Puerto Rico Oversight, Management, and Economic Stability Act

PRSWA: Puerto Rico's Solid Waste Authority

QA/QC: quality assurance/quality control

scf: standard cubic feet

SF_6: sulfur hexafluoride

SUSB: U.S. Census Bureau's Statistics of U.S. Businesses

U.N. FAO: United Nations Food and Agriculture Organization

USDA: U.S. Department of Agriculture

U.S. BTS: U.S. Bureau of Transportation Statistics

U.S. DOE: U.S. Department of Energy

U.S. EIA: U.S. Energy Information Administration

U.S. EPA: U.S. Environmental Protection Agency

U.S. FEMA: U.S. Federal Emergency Management Agency

U.S. HUD: U.S. Department of Housing and Urban Development

I. Introduction

In 2019, Puerto Rico's legislative assembly passed the *Climate Change Mitigation, Adaption, and Resiliency Law* (Act No. 33-2019) to address the impacts of climate change on the island's social and economic well-being, public health, natural resources, and environment. The 2019 climate law aims to reduce, regulate, and monitor greenhouse gas emissions within Puerto Rico's relevant emitting sectors as well as establish specific climate-related goals and targets for Puerto Rico to work towards in the short- and long-term: a 50 percent reduction of 2005 levels in greenhouse gas emissions by 2025 and eliminate the use of fossil fuels in the Power Supply sector by 2050.

As a part of the 2019 climate law, the Puerto Rico Government established the Committee of Experts and Advisors on Climate Change (CEACC) to strategically set Puerto Rico on the right path in implementing Puerto Rico's climate-related policies. One of CEACC's primary duties is to oversee and submit a Climate Change Adaptation, Mitigation, and Resilience Plan for Puerto Rico. The 2019 climate law also requires Puerto Rico's Department of Natural and Environmental Resources (DNER) to compile and submit greenhouse gas emission inventories on an annual basis.

This Applied Economics Clinic (AEC) report, prepared on behalf of DNER, presents the results for Puerto Rico's 2019 and 2021 greenhouse gas emission inventories together with 20-year emissions projections under several scenarios and sensitivities. AEC established a methodology for conducting greenhouse gas emission inventories in Puerto Rico, which went through a comprehensive quality assurance and quality control process by DNER and an Expert Panel (established for this project and composed of experts in greenhouse gas emissions measurement and Puerto Rico climate and energy issues).

The report begins in **Section II** by defining and providing an overview of Puerto Rico's emitting sectors. **Section III** presents the results for Puerto Rico's 2019 and 2021 greenhouse gas emissions inventories. **Section IV** discusses the projected greenhouse gas emissions for Puerto Rico, including the results for each scenario and sensitivity. **Section V** documents the methodology used to conduct the emission calculations in the report as well as the quality assurance and quality control procedures that were employed. **Section VI** concludes the report with key takeaways outlining four critical areas for new efforts that aim to support Puerto Rico's climate goals and targets. **Appendix A** includes biographies for each of the Expert Panel members. **Appendix B** houses detailed data tables for the island-wide and sector-specific results for 2019 and 2021 as well as projected emissions for 2022 through 2041 across three scenarios and accounting for various sensitivities.

II. Overview of Puerto Rico's Emitting Sectors

In Puerto Rico, seven sectors contribute to the island's greenhouse gas emissions: (1) Power Supply, (2) Direct Fuel, (3) Industrial Processes and Product Use, (4) Transportation, (5) Agriculture, (6) Forestry and Other Land Use, and (7) Waste Management. This section provides an overview of Puerto Rico's greenhouse gas emitting activities, organized according to these sectors. Activity data (amounts of fuel consumed, items manufactured, crops and livestock grown, trees grown or removed) and emissions factors (tons of greenhouse gas per unit of activity) is the primary approach to emissions calculation in the 2019/2021 Puerto Rico Inventory.

Power Supply

Puerto Rico's Power Supply sector encompasses the use of fossil fuels and/or renewables to generate electricity for use by residential, commercial, institutional, and industrial customers. Puerto Rican households and businesses use electricity for lighting, electronics, cooling their homes and office spaces, and operating appliances and machinery.

Puerto Rico's electric needs are served by the Puerto Rico Electric Power Authority (PREPA), which is an electric power company owned by the Commonwealth of Puerto Rico under the 1941 Puerto Rico Electric Power Authority Act.[1] Until June 2021, PREPA was responsible for electric generation and served over 1.5 million customers across Puerto Rico; since then, the privately-held corporation LUMA took over PREPA's transmission and distribution operations and customer service relations.[2] Beginning in July 2023, the private corporation General PR will take over operations and maintenance of electric generation in Puerto Rico.[3] While its operations have been contracted out to private entities, PREPA retains ownership of all assets—and all associated debt—and is the only entity legally authorized to conduct energy supply, transmission, and distribution services in Puerto Rico.

Nearly all of Puerto Rico's electricity is derived from fossil fuels, such as natural gas, oil, and coal. In 2022, roughly 97 percent of the island's electricity was generated from fossil fuel-fired power plants (see Figure 1 below).[4] PREPA owns 27 electric generating units across seven power plants, including: six residual oil-fired generation units such as Aguirre Steam and Palo Seco Steam, eleven distillate fuel oil-fired generation units such as Aguirre CCGT and San Juan CCGT, one natural gas-fired generation plant (Costa Sur Steam 5&6), and nine hydroelectric units.[5] PREPA also purchases electricity produced by coal, landfill gas, and natural gas, as well as renewable energy from hydroelectric, wind, and solar photovoltaic sources.[6] Although Puerto Rico currently relies on fossil fuel-based electricity, Puerto Rico's legislature has approved policies to increase renewable energy assets and reduce carbon emissions on the island. The 2019 Puerto Rico Energy Public Policy Act mandates that PREPA obtain 40 percent of its electric supply from renewable resources by 2025, 60 percent by

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[1] Puerto Rico Act No. 83. 1941. *Puerto Rico Electric Power Authority Act.* Available online at: https://bvirtualogp.pr.gov/ogp/Bvirtual/leyesreferencia/PDF/2-ingles/83-1941.pdf

[2] U.S. EIA. 2023. "Puerto Rico Territory Energy Profile." Available at: https://www.eia.gov/state/print.php?sid=RQ..

[3] Acevado, N. January 25, 2023. "Puerto Rico officially privatizes power generation amid protest, doubts." *NBC News.* Available at: https://www.nbcnews.com/news/latino/puerto-rico-officially-privatizes-power-generation-genera-pr-rcna67284

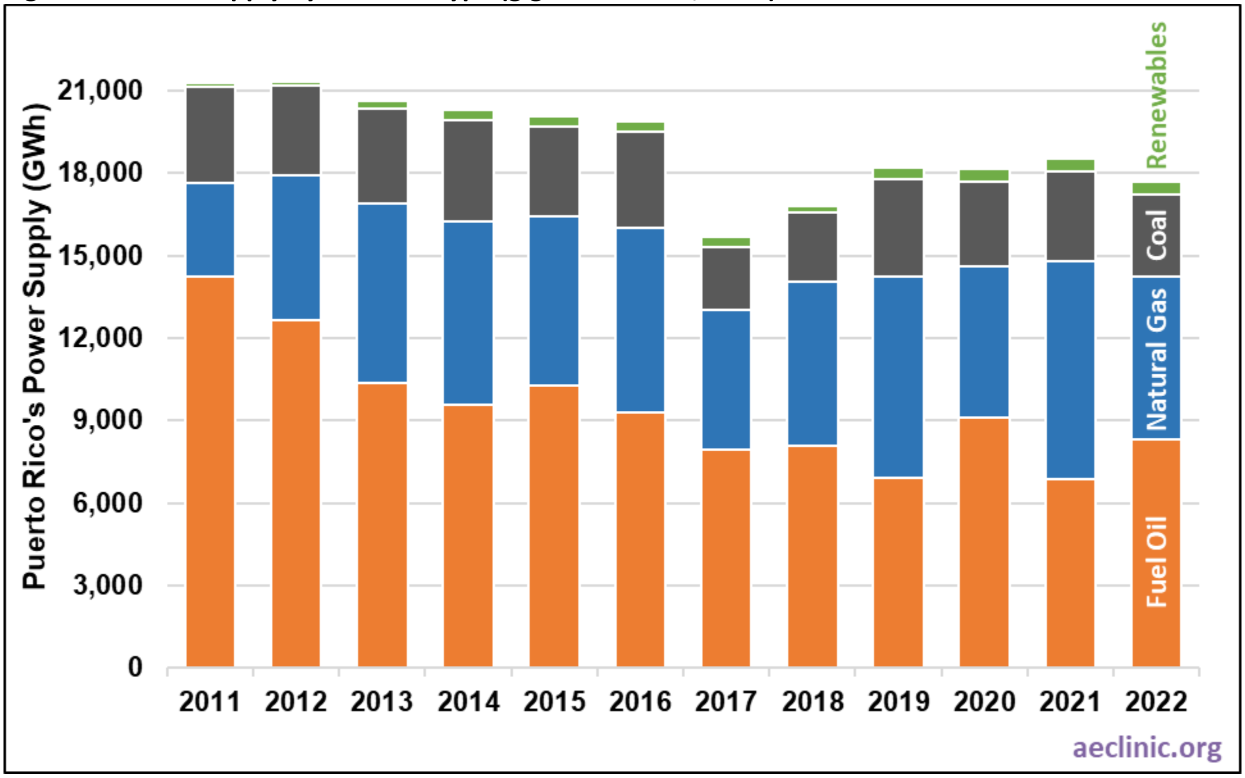
[4] U.S. EIA. 2023. "Puerto Rico Territory Energy Profile." Available at: https://www.eia.gov/state/print.php?sid=RQ.

[5] Siemens Industry. 2019. *Puerto Rico Integrated Resource Plan 2018-2019.* Prepared for Puerto Rico Electric Power Authority. Available at: https://aeepr.com/es-pr/QuienesSomos/Ley57/Plan%20Integrado%20de%20Recursos/IRP2019%20-%20Ex%201.00%20-%20Main%20Report%20%20REV2%2006072019.pdf

[6] Siemens Industry. 2019.

2040, and 100 percent by 2050. As of 2022, approximately 3 percent of Puerto Rico's electric generation came from renewable sources. With three years left before the 2025 deadline, it seems unlikely that the 40 percent target will be achieved on schedule.

Figure 1. Power Supply by resource type (gigawatt-hours, GWh) in Puerto Rico



Data source: PREPA. January 2023. Production and consumption of electric power. Available at: https://estadisticas.pr/en/inventario-de-estadisticas/produccion_consumo_energia_elec

Puerto Rico's power grid is subject to damage by the natural disasters that frequently impact the island. For example, in 2017 Hurricanes Irma and María caused sustained damage to Puerto Rico's electric infrastructure that left the entire island without power in what was—at that point—the longest blackout experienced by the island; it took over two months for approximately 1 million Puerto Rican customers to recover their electricity, and some residents had to go without power for eleven months.[7] This disaster resulted in the longest and largest blackout, in terms of customer-hours of lost electricity service, in U.S. history, and the second largest in the world.[8] In January 2020, a 6.4 magnitude earthquake again damaged Puerto Rico's infrastructure—particularly in southwestern regions of the main island—and led to power outages for several days.[9] Most recently, in September 2022, the entire island of Puerto Rico lost electricity for multiple days following

[7] Castro-Sitiriche, M.J. 2019. *Call to Action: Puerto Rico Energy Policy Brief*. Native Power Research Group. Available at: https://app.box.com/v/CHoLES.

[8] Baggu, M. n.d. *Puerto Rico Grid and Recovery Post Hurricane María* [Powerpoint Slides]. Institute of Electrical and Electronic Engineers. Available at: https://www.nrel.gov/docs/fy22osti/82860.pdf

[9] National Aeronautics and Space Administration. January 15, 2020. "NASA Disasters Program Responds to the 2020 Puerto Rico Earthquakes." *National Aeronautics and Space Administration*. Available at: https://appliedsciences.nasa.gov/our-impact/news/nasa-disasters-program-responds-2020-puerto-rico-earthquakes.

Hurricane Fiona, leaving many residents stranded without access to utilities or medical care.[10]

In Puerto Rico, greenhouse gas emitting subsectors of Power Supply are coal (anthracite and bituminous), oil (distillate fuel oil and residual fuel oil), natural gas, landfill gas, and electricity transmission and distribution. PREPA's greenhouse gas emissions come from its owned generation assets that use fuel oils and natural gas, as well as purchased electricity from the EcoEléctrica natural gas-power plant in Peñuelas, the Applied Energy Services (AES) coal-fired plant in Guayama, and Landfill Gas Technologies' landfill gas units in Fajardo and Toa Baja.

Direct Fuel

Puerto Rico's Direct Fuel sector encompasses the direct combustion of fuels in homes, businesses, industrial facilities, and other buildings for end-uses such as cooking, space and water heating, and heating for industrial processes, among others. In Puerto Rico, direct fuel combustion includes fuels such as liquefied petroleum gases (such as propane), fuel oils, and kerosene by residential, commercial, institutional, and industrial end-users, but excludes fuel used for electric power generation and transportation.

Due to its tropical climate, only one in ten households in Puerto Rico have heating systems, primarily powered by electricity or solar thermal energy (92 percent).[11] Residential use accounts for 55 percent of propane combustion in Puerto Rico.[12] About half a million Puerto Rican homes use propane gas as their primary cooking fuel.[13] Propane is also used widely in Puerto Rico's industrial sector to provide energy for manufacturing processes, heating and cooling, and as a source of back-up generation for homes and businesses.

Back-up generators are a commonly used source of reliable energy in Puerto Rico, especially during power outages.[14] Hurricane María caused a historic blackout[15] leaving a great many residents and most commercial and service providers to depend on generators for their energy needs.[16] Hurricane María's destruction of Puerto Rico's energy transmission and distribution system accelerated the demand for back-up generators; as many as 250-to-300 back-up generators were sold per day on the island after Hurricane María 2017.[17] PREPA's bankruptcy in early 2017 slowed the island's ability to recover after Hurricane María and, years later, blackouts

[10] Sullivan, B. October 2, 2022. "More than 100,000 clients in Puerto Rico are still without power 2 weeks after Fiona." *NPR.* Available at: https://www.npr.org/2022/10/02/1126462352/puerto-rico-hurricane-fiona-luma-energy-power-outages

[11] U.S. Census Bureau. 2021. "B25040: House Heating Fuel." *American Community Survey 5-Year Estimates.* Available at: https://data.census.gov/table?q=B25040:+HOUSE+HEATING+FUEL&g=040XX00US72&tid=ACSDT5Y2021.B25040

[12] Craig, G. 2019. "Building Puerto Rican Resiliency with LPG-Fueled Engines". *Power Mag*. Available at: https://www.powermag.com/building-puerto-rican-resiliency-with-lpg-fueled-engines/

[13] Ibid.

[14] (1) Institute for Energy Research. 2023. "Biden Sends Natural Gas Generators to Puerto Rico for Resiliency." *Institute for Energy Research.* Available at: https://www.instituteforenergyresearch.org/fossil-fuels/gas-and-oil/biden-sends-natural-gas-generators-to-puerto-rico-for-resiliency/; (2) Direct Relief. 2020. "Families in Puerto Rico Find a New Source of Power." *Direct Relief.* Available at: https://www.directrelief.org/2020/08/families-in-puerto-rico-find-a-new-source-of-power/

[15] Zhan, M. 2022. "Puerto Rico's Power Grid is struggling 5 years after Hurricane María. Here's Why." *ABC News.* Available at: https://abcnews.go.com/Technology/puerto-ricos-power-grid-struggling-years-hurricane-María/story?id=90151141

[16] Dickson, C. 2017. "Powerless Puerto Ricans huddle around their generators." *Yahoo News.* Available at: https://news.yahoo.com/powerless-puerto-ricans-huddle-around-generators-215900088.html?guccounter=1&guce_referrer=aHR0cHM6Ly93d3cuYmluZy5jb20v&guce_referrer_sig=AQAAAGQA2pVRXmjuF1xQsRbpwd7fgMNbY3UwGyrXhPZm2ahamFA6Tl_gvr7XaGz2LWzRVeJ8H3Z8adO3Po5VY3dEGXrbm91kRbdBbADFXTa74RZOIeDj5S1Ex9_6ngcxLPkIaOEsV23xbXDu1SQHlNGlkr1Q1gKq4zuRtoJNQZVPLlh0

[17] Fausset, R., F. Robles, D. Acosta. 2017. "Minus Electrical Grid, Puerto Rico Becomes Generator Island". *New York Times.* Available at: https://www.nytimes.com/2017/10/07/us/puerto-rico-power-generators.html

are common and residents face uncertainty concerning their electric service.[18] The tropical nature of the island and lack of reliable energy infrastructure moves residents and businesses to prioritize access to back-up generators.[19] Increased reliance on fossil-fuel based back-up generators on a regular basis has significant implications for greenhouse gas emissions and Puerto Rico's ability to meet its decarbonization targets.

Industrial Processes

Puerto Rico's Industrial Processes and Product Use sector accounts for greenhouse gas emissions that result from the manufacturing of various materials from processes other than energy use or generation. Based on the most recent *Inventory of U.S. Greenhouse Gas Emissions and Sinks*,[20] industrial process emissions come from sectors that include the manufacturing of metals, cement and lime, petrochemicals, substitutes to ozone-depleting substances (ODS) for cooling and refrigeration, glass, semiconductors, ammonia, nitric and adipic acid, and urea.[21] In Puerto Rico, these industrial process emissions are limited to (1) cement production; (2) semiconductor manufacturing; and (3) production and consumption of ODS substitutes (perfluorochemicals (PFCs), hydrofluorocarbons (HFCs), and halons) (see Figure 2 below for the workforce size of each of these industries in Puerto Rico). The lime and glass production industries ceased operations in Puerto Rico in 1994 and 2008, respectively.[22]

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[18] Zhan, M. 2022. "Puerto Rico's Power Grid is struggling 5 years after Hurricane María. Here's Why." *ABC News.* Available at: https://abcnews.go.com/Technology/puerto-ricos-power-grid-struggling-years-hurricane-María/story?id=90151141

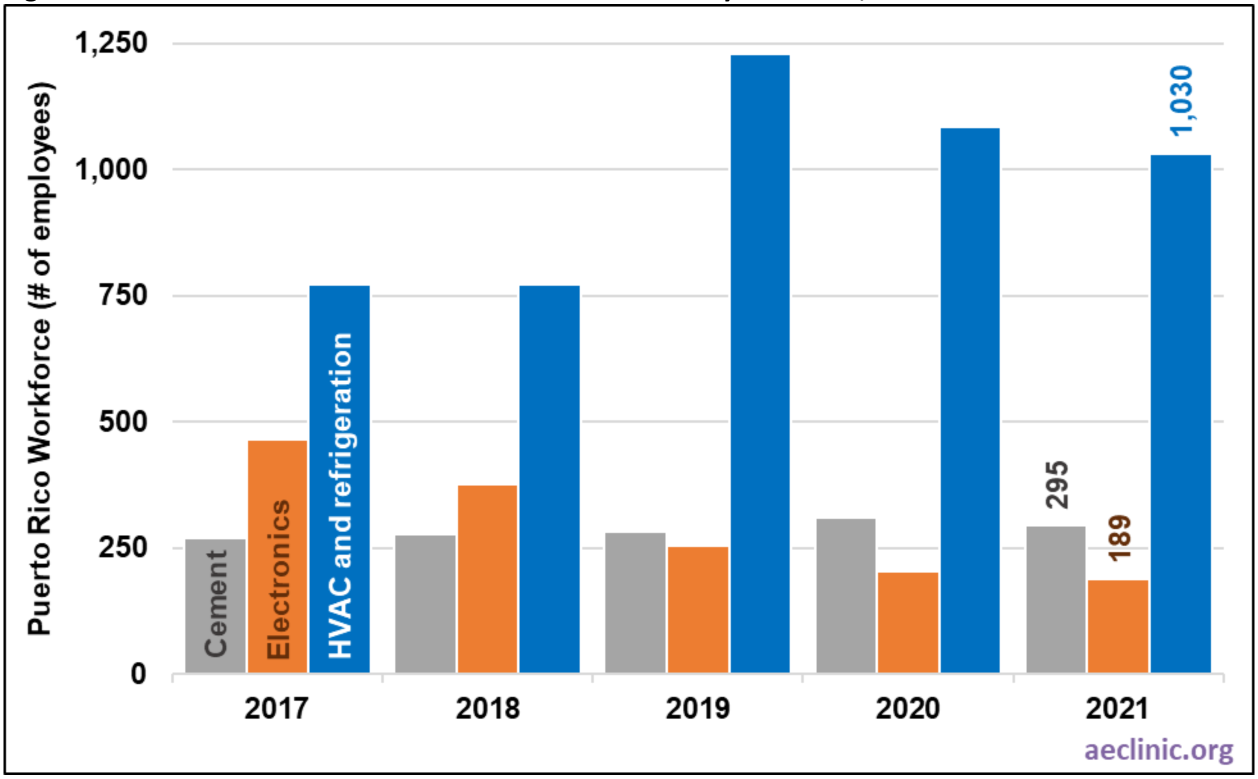
[19] Gay, H.A., Santiago, R., Gil, B., Remedios, C., Montes, P.J., López-Araujo, J., Chévere, C.M., Imbert, W.S., White, J., Arthur, D.W. Horton, J.K., 2019. "Lessons learned from Hurricane María in Puerto Rico: practical measures to mitigate the impact of a catastrophic natural disaster on radiation oncology patients." *Practical Radiation Oncology*, *9*(5), pp.305-321. DOI: https://doi.org/10.1016/j.prro.2019.03.007 p. 319

[20] U.S EPA. 2023. *Inventory of U.S. Greenhouse Gas Emissions Sinks: 1990-2021.* U.S EPA. Available at: https://www.epa.gov/system/files/documents/2023-04/US-GHG-Inventory-2023-Main-Text.pdf.

[21] U.S. EPA. 2023. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2021 – Industrial Processes and Product Use.* U.S EPA. Available at: https://www.epa.gov/system/files/documents/2023-02/US-GHG-Inventory-2023-Chapter-4-Industrial-Processes-and-Product-Use.pdf

[22] Center for Climate Strategies, Inc, 2014, p.64

Figure 2. Puerto Rico Industrial Processes workforce sizes by subsector, 2017-2021

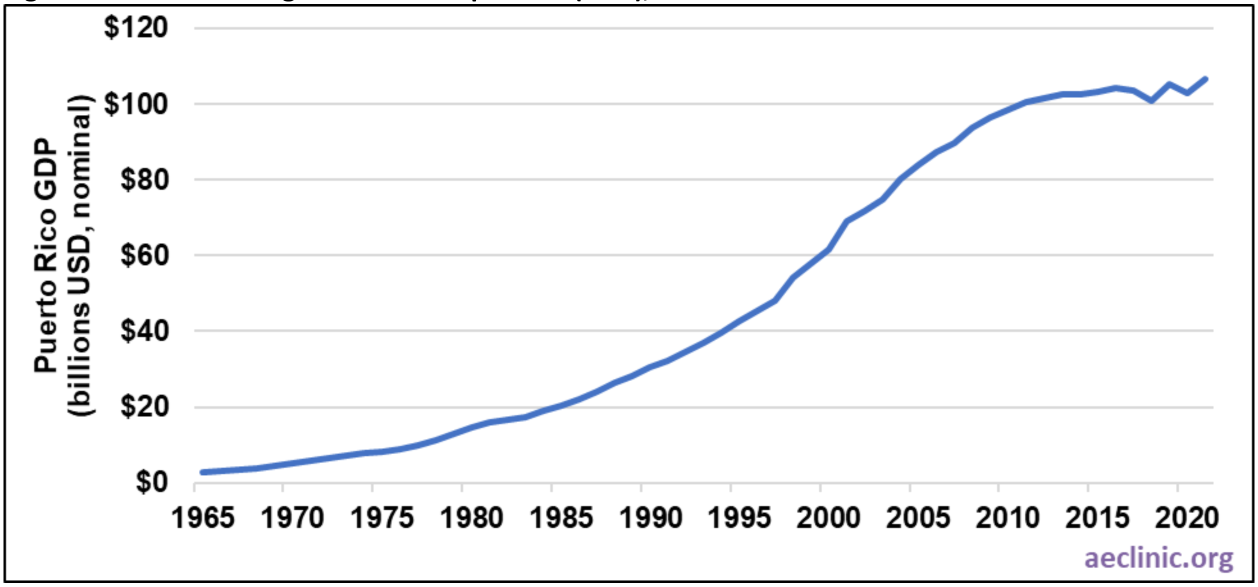


Source: U.S. Census Bureau. 2017-2021. County Business Patterns [Table IDs: CB2100CBP, CB2000CBP, CB1900CBP, CB1800CBP, CB1700CBP]. Available at: https://data.census.gov/

During the second half of the twentieth century the U.S. federal "Operation Bootstrap" program rapidly industrialized the Puerto Rican economy. From 1960 to 2000, Puerto Rico's gross domestic product (GDP) swelled from $1.7 billion USD to $61.7 billion, an average 9 percent annual growth rate.[23] Since then, however, economic growth in Puerto Rico has slowed: Average GDP growth from 2012 to 2021 was less than 0.5 percent per year (see Figure 3 below).[24] Industry's share of overall GDP in Puerto Rico has followed a similar trend, rising from 28 percent in 1960 to 48 percent in 2001, with very little growth thereafter.[25] As of 2021, industry's share of GDP in Puerto Rico remained stagnant at 51 percent (see Figure 4 below).[26]

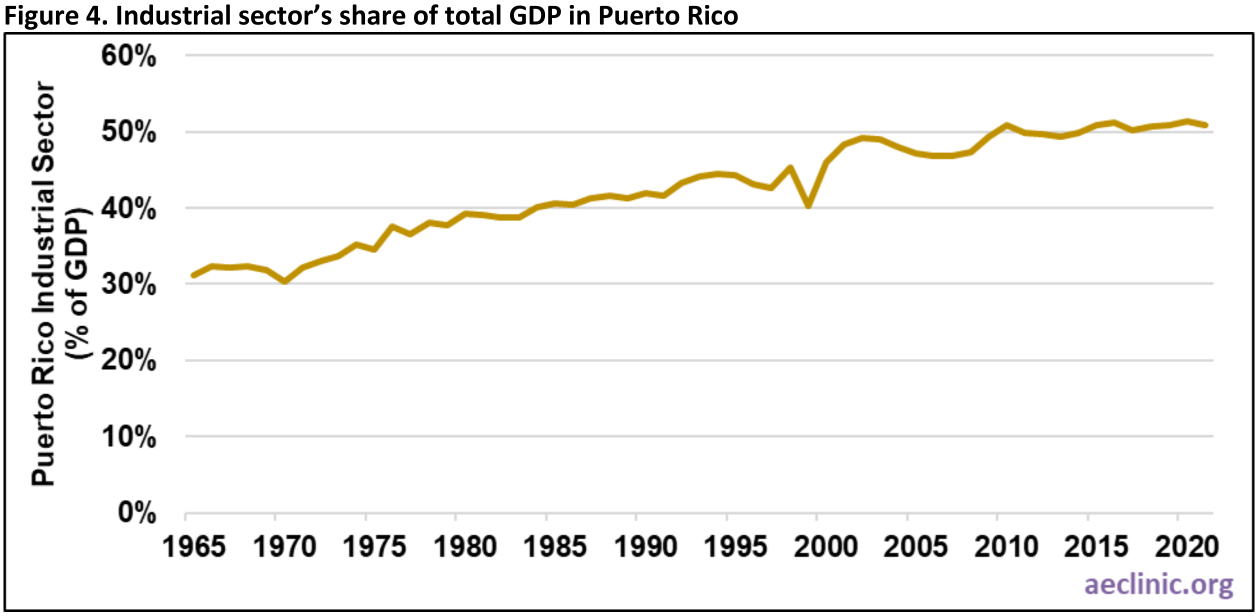
[23] The World Bank. 2021. *GDP (current US$) – Puerto Rico*. The World Bank. Available at: https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=PR
[24] The World Bank, 2021.
[25] The World Bank. 2021. *Industry (including construction), value added (% of GDP) – Puerto Rico*. The World Bank. Available at: https://data.worldbank.org/indicator/NV.IND.TOTL.ZS?locations=PR
[26] The World Bank, 2021.

Figure 3. Puerto Rico's gross domestic product (GDP), nominal



Source: World Bank. 2021. GDP (current US$) – Puerto Rico. Available at: https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=PR

Figure 4. Industrial sector's share of total GDP in Puerto Rico



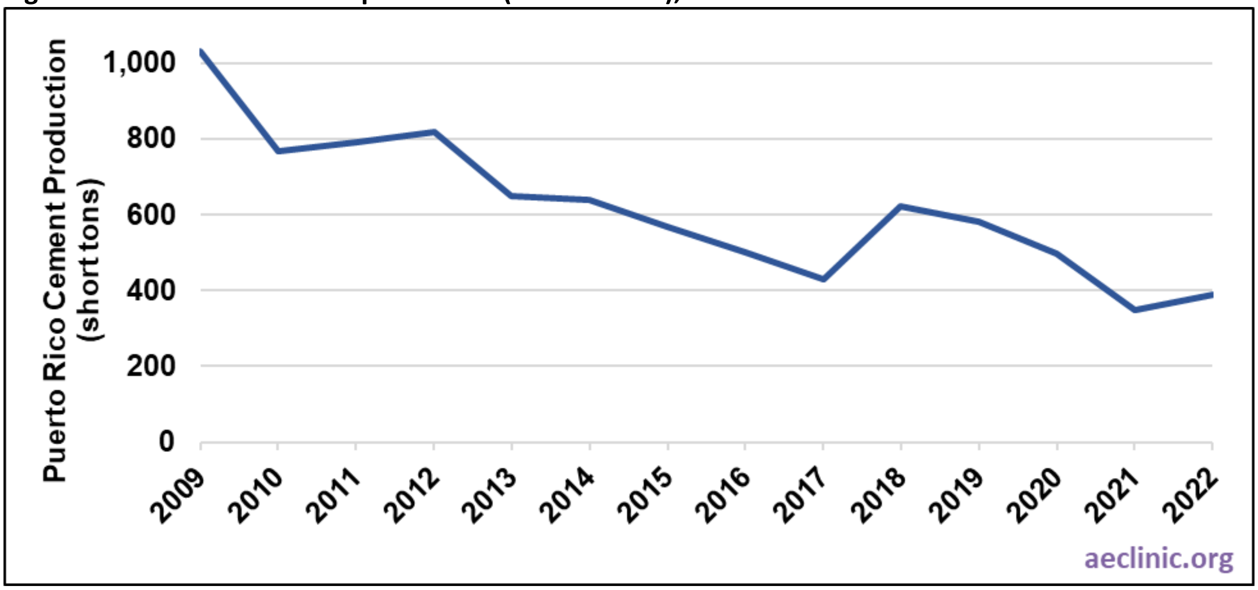
Source: The World Bank. 2021. Industry (including construction), value added (% of GDP) – Puerto Rico. Available at: https://data.worldbank.org/indicator/NV.IND.TOTL.ZS?locations=PR

The industrial sectors responsible for process and product-use emissions play an important role in the Puerto Rican economy. Puerto Rico's climate vulnerability has created a frequent need to construct and reconstruct buildings in the wake of adverse climate events like hurricanes.[27] The cement industry is essential to building

[27] Larnerd, N.J., Ballard, S., and Kurtzer, J. December 7, 2022. "Humanitarian Response and Climate Resilience in Puerto Rico." *Center for Strategic and International Studies.* Available at: https://www.csis.org/analysis/humanitarian-response-and-climate-resilience-puerto-rico.

and rebuilding infrastructure. By 2006, Puerto Rico used 1.9 million tons of cement annually, or 500 kg per capita; worldwide, average annual per capita cement use is 300 kg per capita.[28] Cement production was a major contributor to the industrial sector but has been declining over the past decade due to slower demand from construction contractors and developers.[29] Nonetheless, as demonstrated by the upticks in cement production in 2018 and 2022 following Hurricanes Irma, María, and Fiona, the escalation of climate change events can be expected to cause an increase in cement production in Puerto Rico to rebuild structures destroyed by natural disasters (see Figure 5).

Figure 5. Puerto Rico cement production (in short tons), 2009-2022



Source: Institute of Statistics of Puerto Rico. January 2023. Production and sales of cement. Available at: https://estadisticas.pr/en/estadisticas-mas-recientes?type=produccion_y_ventas_de_cemento

The 2022 passage of the CHIPS+ and Science Act is projected to boost manufacturing activity in Puerto Rico.[30] As of 2021, there were only four semiconductor manufacturing facilities in Puerto Rico, employing a total of 189 workers.[31] With the increase in manufacturing activity expected from the legislation, emissions from semiconductor manufacturing will need to be monitored.

[28] (1) Martín, C. October 12, 2017. "How Hurricane María exposed Puerto Rico's "colonial boom and bust." *Urban Institute*. Available at: https://www.urban.org/urban-wire/how-hurricane-María-exposed-puerto-ricos-colonial-boom-and-bust; (2) Monteiro, P.J.M, Miller, S.A., Horvath, A. 2017. Towards sustainable concrete. *Nature Materials*, 16, 698-699. https://doi.org/10.1038/nmat4930

[29] Economist Intelligence. May 13, 2016. "Planning Board estimates a deeper recession in 2016/17." *Economist Intelligence*. Available at: https://country.eiu.com/article.aspx?articleid=364212220&Country=Puerto%20Rico&topic=Economy&subto_9

[30] Rival Times. July 29, 2022. "Industriales and InvestPR anticipate that the CHIPS+ Act will benefit the economy of Puerto Rico." *Rival Times*. Available at: https://rivaltimes.com/industriales-and-investpr-anticipate-that-the-chips-act-will-benefit-the-economy-of-puerto-rico/

[31] U.S. Census Bureau. 2021. *County Business Patterns [Table ID: CB2100CBP]*. Available at: https://data.census.gov/table?q=puerto+rico&n=3344&tid=CBP2021.CB2100CBP

Rapid introduction of ODS substitutes into Puerto Rico in the 1990s generated a relatively large increase in this sector's emissions for Puerto Rico.[32] ODS substitutes were once widely used in the manufacture of refrigeration and air conditioning systems.[33] However, the 1963 Clean Air Act and the 1989 Montreal Protocol required phaseouts of ODS due to their high ozone depletion potential. By 2000, 54 percent of greenhouse gas emissions from the Industrial Processes and Product Use sector in Puerto Rico came from ODS substitute use, increasing to around 80 percent in 2010.[34] Today, the production and consumption of ODS substitutes is responsible for 99.5 percent of emissions in Puerto Rico's Industrial Processes and Product Use sector. ODS substitutes are used for refrigeration and cooling purposes, making it essential to find lower-emitting refrigerant alternatives especially in tropical locations like Puerto Rico.

Transportation

Puerto Rico's Transportation sector creates emissions from on-road, off-road, marine, and air transport supported by a system of roads/highways, railways, ports, harbors, and airports. On-road transport refers to the use of various motor vehicles (cars, trucks, buses, motorcycles) powered by either gasoline or diesel; off-road transport includes tractors, forklifts, cranes, backhoes, bulldozers, and golf carts.

Puerto Rico has among the world's highest number of cars per square mile and per capita, in part due to the absence of extensive public transportation services.[35] Limited bus transportation is available throughout the San Juan metropolitan areas, a light rail line (Tren Urbano) that connects three municipalities (San Juan, Guaynabo, and Bayamón), and *públicos* (public-use minibuses and passenger cars) that connect towns throughout the island. Most Puerto Ricans, however, rely on personal vehicles to get to home, school, and shopping. As of 2022, Puerto Rico was home to 4,300 vehicles per square mile and 2.13 million vehicles overall (or 666 vehicles per 1,000 people).[36] (In comparison, the mainland United States has about 800 vehicles per 1,000 people.[37]) In 2021, Puerto Ricans traveled less than half of the distance (4,188 vehicle miles traveled per capita each year on average) than their counterparts in the mainland United States (9,500 vehicle miles traveled per capita) (see Figure 6 below).[38]

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[32] Center for Climate Strategies, Inc. 2014. p.64 and 67.

[33] U.S. EPA. November 21, 2022. "Managing Refrigerant Emissions." U.S. EPA. Available at: https://www.epa.gov/ozone-layer-protection/managing-refrigerant-emissions#:~:text=Many%20refrigerants%20that%20are%20commonly,%2C%20chlorobromomethane%2C%20and%20methyl%20chloroform.

[34] Center for Climate Strategies, Inc. 2014. p.64

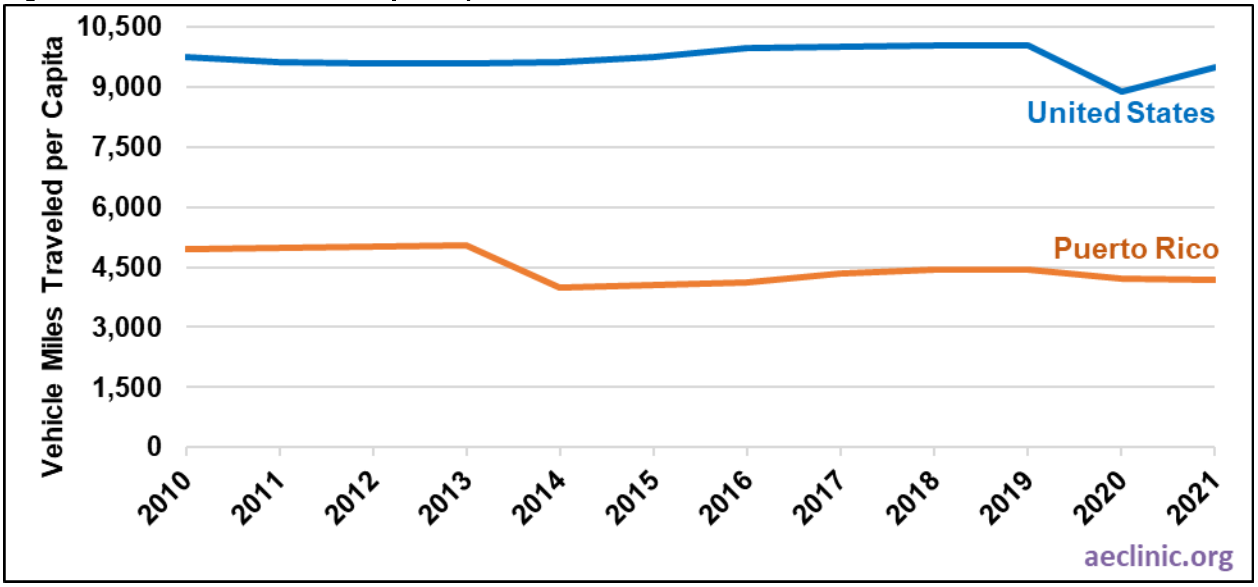
[35] Kantrow-Vázquez, M, May 16, 2023. "'Above average' public transit spending fuels private vehicle use." *New is My Business.* Available at: https://newsismybusiness.com/govts-above-average-public-transit-spending-still-fuels-private-vehicle-use/

[36] GlobalFleet. 2023. "Puerto Rico." GlobalFleet. Available at: https://www.globalfleet.com/en/wikifleet/puerto-rico

[37] GlobalFleet. 2023. "Puerto Rico." GlobalFleet. Available at: https://www.globalfleet.com/en/wikifleet/united-states-america

[38] U.S. DOT. 2010-2021. "Highway Statistics Series". U.S. DOT. Available at: https://www.fhwa.dot.gov/policyinformation/statistics/2010/vm2.cfm

Figure 6. Vehicle miles traveled per capita in Puerto Rico and the United States, 2010-2021



Puerto Rico imports approximately 85 percent of its food and all of its fuel (other than biomass).[39] Cargo shipping is highly centralized to the Port of San Juan; 79 percent of all off-island shipments are handled there. All freight within Puerto Rico is moved via truck; the island's long-distance railroad system was closed in the 1950s.[40] Air transportation is essential to Puerto Rico's tourism industry: In the year 2021, the San Juan Luis Muñoz Marín International Airport—Puerto Rico's largest airport—received a total of 46,894 incoming flights, including 40,604 flights from origins within the United States and 6,290 international flights, containing a total of more than 4.7 million passengers (1.4 times the size of Puerto Rico's 2021 population).[41]

Puerto Rico is heavily reliant on fossil fuels for its transportation needs, including motor gasoline, diesel, and jet fuel. According to the U.S. Energy Information Administration (U.S. EIA), the island consumes around 76 thousand barrels per day of imported petroleum products, and more than half of those barrels (38 thousand) are motor gasoline. Puerto Rico also consumes 8 thousand barrels per day of diesel fuel and 9 thousand barrels per day of jet fuel.[42]

Reliance on truck-delivered fossil fuels made fulfilling energy needs impossible at times after tropical storms María in 2017 and Fiona in 2022.[43] The hurricanes washed out roads and destroyed traffic signals leading to $647 million in repair costs to roads and bridges, not including the cost of debris removal.[44] In total, hurricane

[39] Ecola, L. Davenport, A.C., Kuhn, K., Rothenberg, A.D., Cooper, E., Barret, M., Atkin, T.F., Kendall, J. 2020. *Rebuilding Surface, Maritime, and Air Transportation in Puerto Rico After Hurricanes Irma and María.* Prepared for Homeland Security Operational Analysis Center. Available at: https://www.rand.org/pubs/research_reports/RR2607.html

[40] Ecola, L. Davenport, A.C., Kuhn, K., Rothenberg, A.D., Cooper, E., Barret, M., Atkin, T.F., Kendall, J. 2020.

[41] (1) Inteligencia Económica. 2016. *Tourism: A Driver for Economic Growth.* Prepared for Puerto Rico Hotel & Tourism Association. Available at: https://www.finance.senate.gov/imo/media/doc/Puerto%20Rico%20Hotel%20&%20Tourism%20Association%20(Submission%202).pdf; (2) United States Department of Transportation (U.S. DOT). N.d. *Flights: All Carriers – San Juan, PR: Luis Munoz Marin International (Destination Airport)*. Bureau of Transportation Statistics. Available at: https://www.transtats.bts.gov/Data_Elements.aspx?Data=1

[42] U.S. EIA. 2023. "Puerto Rico Territory Energy Profile." Available at: https://www.eia.gov/state/print.php?sid=RQ

[43] Ecola, L. Davenport, A.C., Kuhn, K., Rothenberg, A.D., Cooper, E., Barret, M., Atkin, T.F., Kendall, J. 2020.

[44] Ibid.

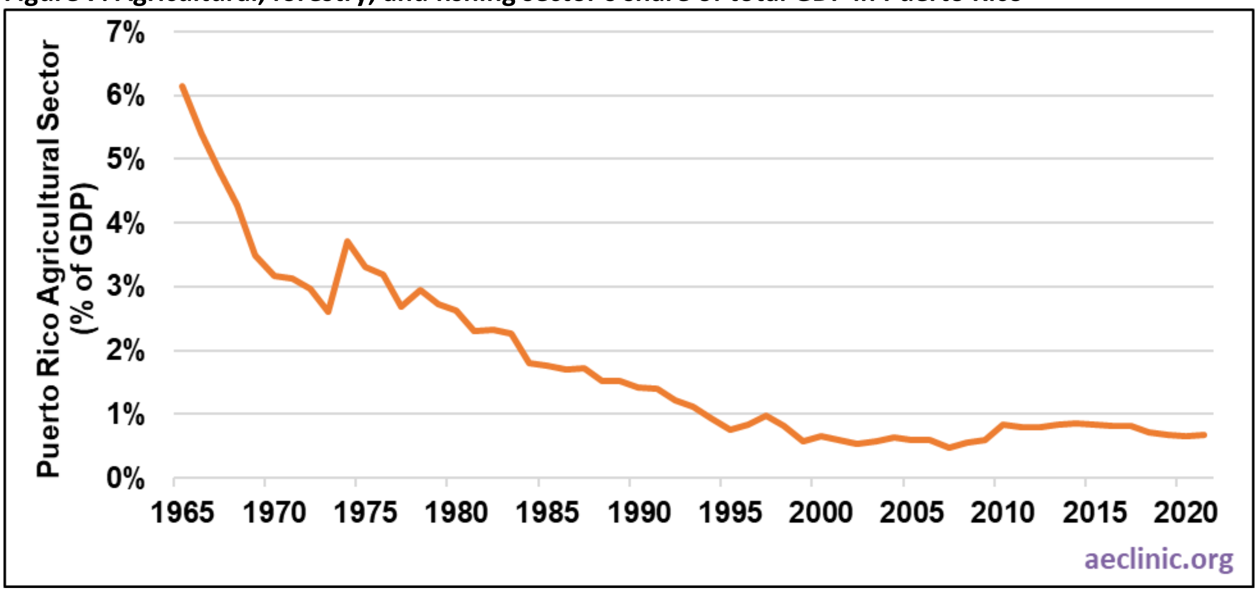
damage led to $1.8 billion in repair costs and another $1.1 billion in recommended resilience upgrades.[45]

Passed in 2022, the U.S. Bipartisan Infrastructure Law allocates more than $1.1 billion over the next five years to invest in Puerto Rico's roads and bridges. The Law also makes the largest investment in public transit in U.S. history, offering more than $470 million to Puerto Rico over the course of five years to improve its public transit.[46]

Agriculture

Puerto Rico's Agricultural sector generates greenhouse gas emissions from livestock (cattle, swine, poultry, etc.) and crop production (woody perennial crops, coffee, grains, etc.) with four key emission subcategories: cropland soil, cropland carbon, enteric fermentation from livestock management, and manure management from livestock.[47] Agriculture, forestry and fishing combined accounted for only 0.7 percent of the island's GDP in 2021 (see Figure 7), with only 15 percent of the island's total food needs produced internally.[48]

Figure 7. Agricultural, forestry, and fishing sector's share of total GDP in Puerto Rico



Source: The World Bank. 2021. Agriculture, forestry, and fishing, value added (% of GDP) – Puerto Rico. Available at: https://data.worldbank.org/indicator/NV.IND.TOTL.ZS?locations=PR

In the 1930s, agriculture alone contributed over 40 percent of Puerto Rico's GDP. The decline in the number of farms over the past three decades (from 19,951 in 1998 down to 8,230 in 2018) greatly reduced agriculture's significance in the Puerto Rican economy.[49] Damages from Hurricanes Irma and María in 2017 contributed to

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[45] Ecola, L. Davenport, A.C., Kuhn, K., Rothenberg, A.D., Cooper, E., Barret, M., Atkin, T.F., Kendall, J. 2020.

[46] United States White House. 2022. *Building a Better America.* Available at: https://www.whitehouse.gov/wp-content/uploads/2022/11/Puerto-Rico-BIL-State-Fact-Sheet-Nov-22.pdf

[47] Center for Climate Strategies, 2014.

[48] Kenner, B., Russell, D., Valdes, C., Sowell, A., Pham, X., Terán, A., Kaufman, J. 2023. *Puerto Rico's Agricultural Economy in the Aftermath of Hurricanes Irma and María: A Brief Overview*. United States Department of Agriculture. Available at: https://www.ers.usda.gov/webdocs/publications/106261/ap-114.pdf?v=9256.7

[49] United States Department of Agriculture. 2020. *Puerto Rico Agriculture Results from the 2018 Census of Agriculture*. Available at: https://www.nass.usda.gov/Publications/Highlights/2020/census_puertorico.pdf

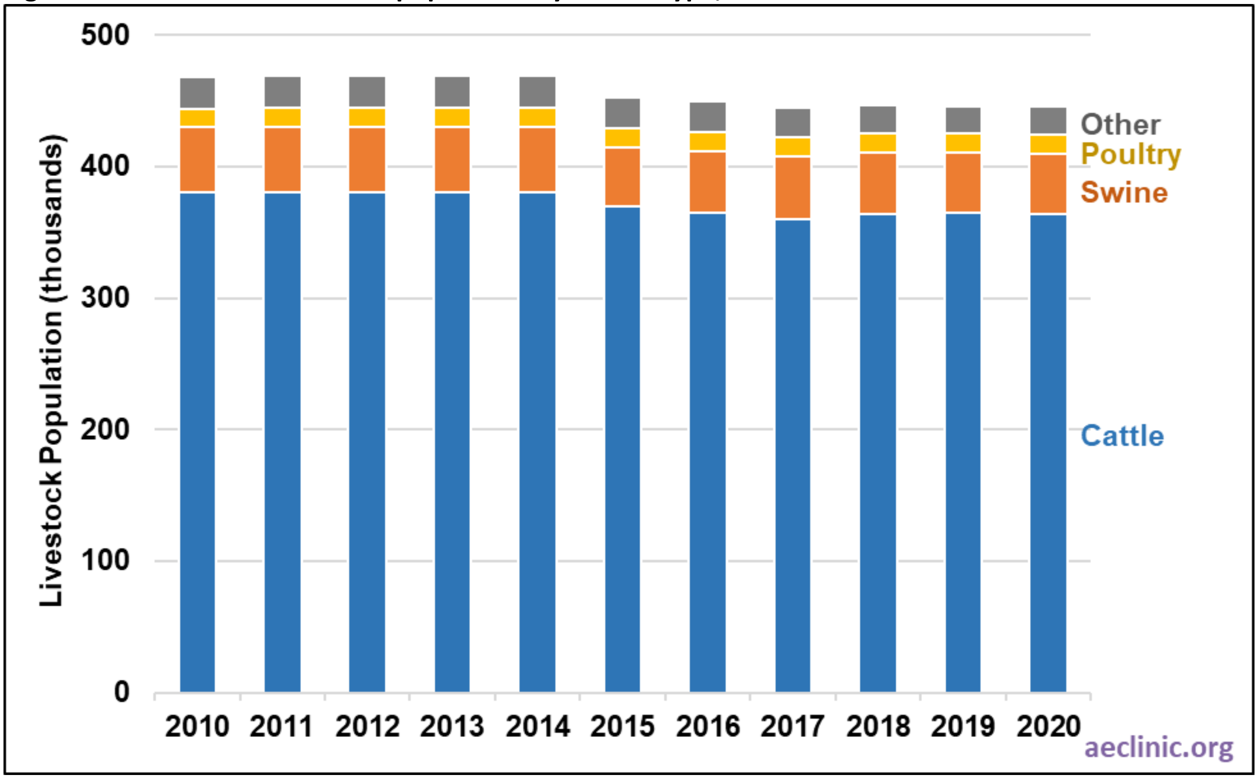
the decline in the number of farms, with farmers leaving the sector after crop and infrastructure damage.[50] As the number of farms and amount of farmland declined, farm size has increased mostly due to a sharp reduction in farms less than 10 cuerdas in size (a cuerda is a little less than an acre).[51]

The region of Utuado, in western-central Puerto Rico, is home to the largest number of farms (19 percent), followed by Lares (16 percent), and Caguas (14 percent), together accounting for nearly half of all Puerto Rican farms.[52] Farmers in Puerto Rico produce a variety of commodities for sale, including livestock such as cattle, swine, and poultry (see Figure 8), livestock products such as milk, other dairy products and eggs, as well as coffee, bananas, plantains, pigeon peas, rice and other crops.[53] In 2018, agricultural sales totaled $485 million, including $172 million from milk sales alone;[54] over half of all agriculture production occurred in the regions of Arecibo ($139.1 million) and Ponce ($120 million).[55]

Of farmers surveyed in the 2018 Census of Agriculture, half reported their primary occupation was farming. At the same time, 60 percent of farmers reported less than 25 percent of income came from farming and more than three-quarters reported a net household income below $40,000.[56] Net household income for farming families varies across the eight regions of the island, with 87 percent of farms in Utuado reporting income below $40,000 compared to 68 percent in Mayaguez.[57]

[50] Kenner, B., Russell, D., Valdes, C., Sowell, A., Pham, X., Terán, A., Kaufman, J. 2023.
[51] United States Department of Agriculture, 2020. *Puerto Rico Agriculture Results from the 2018 Census of Agriculture*. Available at: https://www.nass.usda.gov/Publications/Highlights/2020/census_puertorico.pdf
[52] United States Department of Agriculture. 2020. *Puerto Rico (2018) Island and Regional Data Volume 1- Geographic Area Series- Part 52.* Available at: https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Outlying_Areas/Puerto_Rico/prv1.pdf
[53] Ibid.
[54] United States Department of Agriculture. 2020. "Puerto Rico Agriculture Results from the 2018 Census of Agriculture. Available at: https://www.nass.usda.gov/Publications/Highlights/2020/census_puertorico.pdf
[55] Ibid.
[56] United States Department of Agriculture.2 020. *Puerto Rico (2018) Island and Regional Data Volume 1- Geographic Area Series- Part 52.* Available at: https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Outlying_Areas/Puerto_Rico/prv1.pdf
[57] Ibid.

Figure 8. Puerto Rico's livestock population by animal type, 2010-2020



Note: "Other" includes goats, sheeps, horses, donkeys, mules, rabbits, and bees. Source: U.N. FAO. 2011-2020. "Crops and livestock products". Live Animals. Available at: https://www.fao.org/faostat/en/#data/QCL

Forestry and Other Land Use

Puerto Rico's Forestry and Other Land Use sector results in both greenhouse gas emissions and the sequestration of emissions taken from the atmosphere. Emissions from this sector can include the change in net CO_2 from forestland, cropland, grassland, wetland, settlements, and other land that includes bare soil, rock, and all land areas that do not fall into any of the other land-use categories; net CO_2 flux is the sum of CO_2 absorption by photosynthesis and CO_2 emissions from respiration from vegetation, decomposition of organic matter, forest fires, or land-use changes such as deforestation. Fires are a natural and critical ecological function for the maintenance of healthy and resilient forests, facilitating the germination of seeds, replenishment of soil nutrients, and stimulation of tree growth. However, wildfires release greenhouse gas emissions (such as CO_2, CH_4, and nitrous oxides (N_2O)) that contribute to climate change.[58]

Until the onset of colonization in 1493, the island now called Puerto Rico was almost completely forested. As a colony of Spain, Puerto Rico's economy was initially based on timber and gold extraction, but as control over the island was transferred to the United States, its land and economy was transitioned into large-scale sugarcane and shade-grown coffee plantations.[59] A growing population and the expansion of agriculture led to

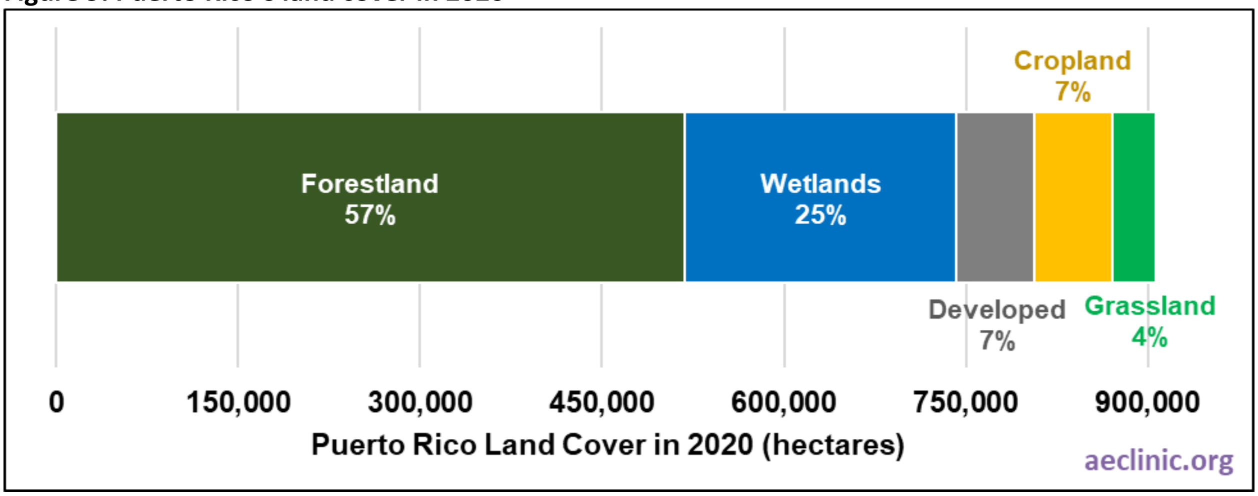
[58] U.S EPA. N.d. *Climate Change Indicators: Wildfires.* Available at: https://www.epa.gov/sites/default/files/2021-04/documents/wildfires_td.pdf

[59] Commonwealth of Puerto Rico Department of Natural and Environmental Resources. 2015. *Puerto Rico Forest Action Plan.* Available at: https://www.drna.pr.gov/wp-content/uploads/2015/11/Puerto-Rico-Forest-State-Action-Plan.compressed.pdf

deforestation.[60] By 1940, there was a 45 percent reduction in mangrove forest due to urbanization and the negative effects of human activity.[61] The Post-World War II surge in industrialization precipitated a migration of Puerto Rico's population to urban centers and an abandonment of agricultural lands. The result was an island-wide regeneration of secondary forests.[62]

Today, Puerto Rico's landcover is dominated by forests (57 percent), followed by wetlands (25 percent), with small shares of developed land (7 percent), cropland (7 percent), and grassland (4 percent) (see Figure 9 below).[63]

Figure 9. Puerto Rico's land cover in 2020



Data source: U.N. FAO. 2023. Land Cover. Available at: https://www.fao.org/faostat/en/#data/LC

Home to various types of forests including, dry forests, rainforests, and mangrove stands, Puerto Rico has all four mangrove species native to the Caribbean: red mangrove (*Rhizophora mangle*), white mangrove (*Laguncularia racemosa*), black mangrove (*Avicennia germinans*), and the button mangrove (*Conocarpus erectus*).[64] Mangroves stabilize shorelines, prevent erosion, filter water, and sequester carbon comparable to that of tropical forests,[65] among other benefits. Currently Puerto Rico's forests store approximately 7.6 million tons of carbon in their above- and below-ground live tree biomass.[66]

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[60] (1) Commonwealth of Puerto Rico Department of Natural and Environmental Resources. 2015.; (2) Mather, A.S. and Needle, C.L. 1998. "The Forest Transition: A Theoretical Basis." *Area*, 30, 117-124. http://dx.doi.org/10.1111/j.1475-4762.1998.tb00055.x

[61] Martinuzzi, S., W. Gould, A. Lugo, E. Medina. 2009. "Conversion and recovery of Puerto Rico mangroves: 200 years of change." *Forest Ecology and Management,* 257:75-84. https://doi.org/10.1016/j.foreco.2008.08.037

[62] Grau, H. R., M. Aide, Zimmerman, J.K., Thomlinson, J.R., Helmer, E., and Zou, X. 2003. "The ecological consequences of socioeconomic and land-use changes in postagriculture Puerto Rico." *BioScience*, 53(12):1159- 1168. https://doi.org/10.1641/0006-3568(2003)053[1159:TECOSA]2.0.CO;2

[63] U.N. FAO. 2023. *Land Cover*. Available at: https://www.fao.org/faostat/en/#data/LC

[64] Huertas, L. March 17, 2022. "In Puerto Rico, a marathon effort builds to restore mangroves and dunes." *Mongabay*. Available at: https://news.mongabay.com/2022/03/in-puerto-rico-a-marathon-effort-builds-to-restore-mangroves-and-dunes/#:~:text=Puerto%20Rico%20is%20home%20to,button%20mangrove%20(Conocarpus%20erectus).

[65] Alongi, D. 2012. Carbon sequestration in mangrove forests. *Carbon Management,* 3(3), 313-322. https://doi.org/10.4155/cmt.12.20

[66] U.S. Department of Agriculture. Revised 2023. EVALIDator 2.0.6. Available at: https://apps.fs.usda.gov/fiadb-api/evalidator

About six-sevenths of Puerto Rico's forests are privately owned with the remaining forests publicly administered by the Commonwealth of Puerto Rico (11 percent) or the U.S. Federal Government (3 percent).[67] There are 1.3 billion cubic feet of merchantable wood in Puerto Rico's forests of which 86 percent is on unreserved (i.e. the harvest of trees is not restricted by law or statute), private lands.[68] From 2001 to 2021, Puerto Rico lost 75.5 thousand hectares (nearly 14 percent) of its tree cover due to deforestation from the expansion of agriculture and urbanization, and wild fires.[69] Puerto Rico experienced a substantial amount of tree loss in 2017 due to the impacts of Hurricane María; 40 to 60 percent of the tall trees that form the canopy of the forest lost large branches, were snapped in half, or were uprooted.[70] Fires also contribute substantially to forest loss and greenhouse gas emissions. In Puerto Rico, peak fire season typically begins in early January and lasts around 18 weeks.[71] From 2001 to 2021, Puerto Rico lost 3.5 thousand hectares of tree cover from fires,[72] which release N_2O and CH_4, along with CO_2.

Waste Management

Puerto Rico's Waste Management sector produces greenhouse gas emissions from the treatment of solid waste and wastewater produced by residential, commercial, institutional, and industrial entities. Solid waste management includes the collection, transportation, and treatment of solid waste products such as plastics, paper, metal, food waste, and other miscellaneous items that have been thrown away. Solid waste is subjected to a variety of treatment pathways, including reuse, recycling, composting, landfill disposal and incineration; each pathway has a different emissions intensity for CO_2 and CH_4 depending on the type of waste that is treated and how it is treated.

Wastewater management consists of the physical, biological, chemical, or sludge treatment of sewage and other wastewater products from activities such as bathing, dishwashing, toilet flushing, and manufacturing. Physical treatment methods include processes like screening, sedimentation and skimming to remove solids. Biological water treatment uses microorganisms to metabolize organic matter in the wastewater. Chemical water treatment uses chemicals to kill bacteria in the water, and chemicals may be added to purify the wastewater afterwards. Finally, in sludge treatment wastewater is thickened (reducing volume of sludge), digested (reducing total mass of solids and destroying pathogens), and dewatered (drying sludge). Dried sludge is added to landfills, applied to agricultural cropland as fertilizer, or combined with other materials and marketed as "biosolid" compost for use in agriculture and landscaping. The operation of wastewater treatment plants results in direct emissions from the biological processes of greenhouse gases including CO_2, CH_4, and N_2O.

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[67] Brandeis, T., Turner, J.A. 2009. *Puerto Rico's Forests.* Prepared for the United States Department of Agriculture and Forest Service. Available at: https://foresthistory.org/wp-content/uploads/2017/01/Puerto-Ricos-Forests-2009.pdf
[68] Ibid.
[69] Global Forest Watch. 2022. *Puerto Rico.* Available at: https://www.globalforestwatch.org/
[70] Kekesi, A. September 17, 2019. "NASA Surveys Hurricane Damage to Puerto Rico's Forests." *U.S. National Aeronautics and Space Administration*. Available at: https://svs.gsfc.nasa.gov/4735#:~:text=Almost%2060%25%20of%20the%20canopy,on%20average%2C%20after%20Hurricane%20María.
[71] Global Forest Watch. 2022. *Puerto Rico.* Available at: https://www.globalforestwatch.org/
[72] Global Forest Watch. 2022. *Puerto Rico.* Available at: https://www.globalforestwatch.org/

The American Society of Civil Engineers' *2019 Report Card for Puerto Rico's Infrastructure* reports that Puerto Rican residents generate an average of 5.6 pounds of waste per person per day, compared to 4.4 pounds per day for the average mainland U.S. resident.[73] Puerto Rico's recycling system diverts 9 to 14 percent of solid waste; the Puerto Rico Solid Waste Reduction and Recycling Act of 1992 had called for an increase of recycling rates up to 35 percent.[74] In comparison, the mainland United States currently diverts 32 percent of its solid waste to recycling and compost facilities.[75] Analysis from U.S. FEMA and U.S. EPA indicates that Puerto Rico could run out of landfill space in 2 to 4 years.[76]

Puerto Rico lacks a centralized waste management system. Instead, municipalities own the majority of landfills and provide collection services for their own residents. In the 20th century, Puerto Rican municipalities managed 61 different unlined landfills for their residents' solid waste; in 1994, 32 of these landfills were closed.[77] The American Society of Civil Engineers' gave Puerto Rico a "D-" grade for its solid waste management performance and noted that post-closure activities to bring facilities back into compliance have not been conducted at the landfills closed in the 1990s.[78] As of 2019, of the 29 landfills currently active in Puerto Rico only 11 were compliant with the U.S. Solid Waste Disposal Act of 1965 and the 1976 Resource Conservation and Recovery Act.[79] These standards govern the disposal of solid and hazardous ways to protect human health and the environment, to conserve energy and natural resources, and to reduce the amount of waste generated.

In the wake of Hurricane María, Puerto Rican landfills received additional debris and wreckage equivalent to 2.5 years' worth of solid waste.[80] The rapid accumulation of waste in Puerto Rico is causing its landfills to quickly fill up, creating a waste crisis on the island that has lasted for decades and spurring demand for new waste treatment facilities.[81] The economic costs to Puerto Rico's municipalities, coupled with the high cost of closure for landfills that are noncompliant, add up to over $100 million to close Puerto Rico's existing landfills.[82] These costs include clay and cover soil for the capping and covering of the closed landfill, the treatment and disposal of leachate extracted from the landfill during post-closure, and environmental monitoring of the landfill post-closure.[83] According to the American Society for Civil Engineers' *2019 Report Card*, it would cost at least another $11.5 million to open a new federally compliant municipal solid waste facility.[84]

The Puerto Rico Solid Waste Authority (PRSWA) tracks the total capacity of all active landfills as well as annual

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73 American Society for Civil Engineers (ASCE). 2021. *2019 Report Card for Puerto Rico's Infrastructure*. Available at: https://infrastructurereportcard.org/wp-content/uploads/2021/07/2019-Puerto-Rico-Report-Card-Final.pdf. p.50

74 Ibid.

75 U.S. EPA. December 3, 2022. "National Overview: Facts and Figures on Materials, Wastes,and Recycling." U.S. EPA. Available at: https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/national-overview-facts-and-figures-materials#:~:text=These%20Facts%20and%20Figures%20are,25%20million%20tons%20were%20composted.

76 U.S. FEMA and U.S. EPA. 2020. *Municipalities Mitigating for Future Disasters TODAY* [PowerPoint slides]. FEMA and EPA. Available at: https://www.epa.gov/system/files/documents/2021-09/gfx-solid-waste-management-in-puerto-rico.pdf

77 McAdams, C.L. 1996. "Recycling in Puerto Rico." *U.S. Department of Energy Office of Scientific and Technical Information (OSTI).* Available at: https://www.osti.gov/biblio/234110

78 ASCE 2021. p.50

79 Ibid.

80 ASCE 2021. p.51

81 Cruz Mejías, C. February 16, 2021. "Trash Crisis leaves Puerto Rico Near 'the Brink.'" *Global Press Journal*. Available at: https://globalpressjournal.com/americas/puerto-rico/trash-crisis-leaves-puerto-rico-brink/

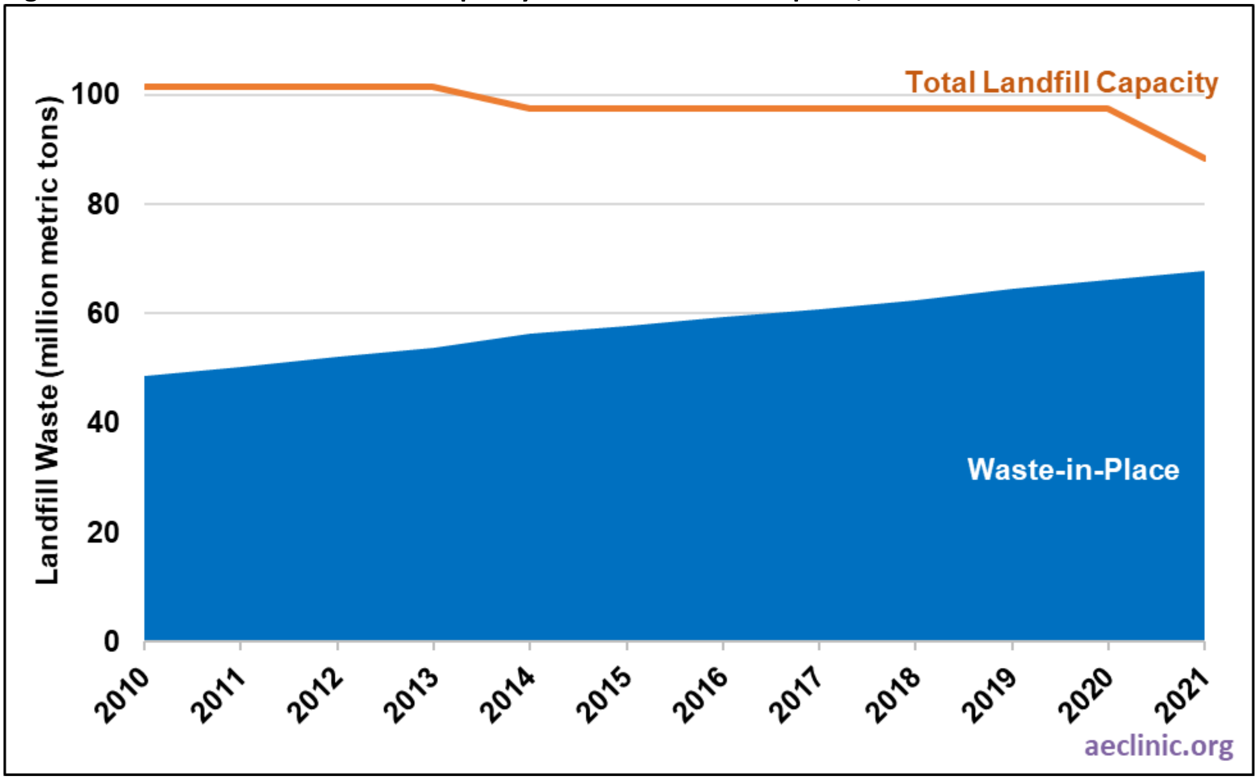
82 ASCE 2021. p.52

83 Duffy, D.P. September 1, 2005. "Landfill Economics Part 3: Closing Up Shop." *MSW Management*. Available at: https://www.mswmanagement.com/landfills/article/13003375/landfill-economics-part-3-closing-up-shop

84 ASCE 2021. p.52

data on the total amount of municipal solid waste accepted and stored in place at each landfill (see Figure 10 below). Landfill facilities are filling up. In 2010, approximately 48 percent of active landfills were filled; by 2021, the percentage filled had risen to 78 percent.[85] The treatment of solid waste in landfills generates emissions of carbon dioxide (CO_2) and methane (CH_4). Greenhouse gas emissions from solid waste are calculated based on the total amount of waste accumulated at a landfill; however, CO_2 emissions from solid waste management are considered biogenic and therefore excluded from emissions inventory calculations.

Figure 10. Puerto Rico total landfill capacity and landfill waste in place, 2010-2021



Source: Direct communication with V.I. Marrero, Puerto Rico Department of Natural and Environmental Resources.

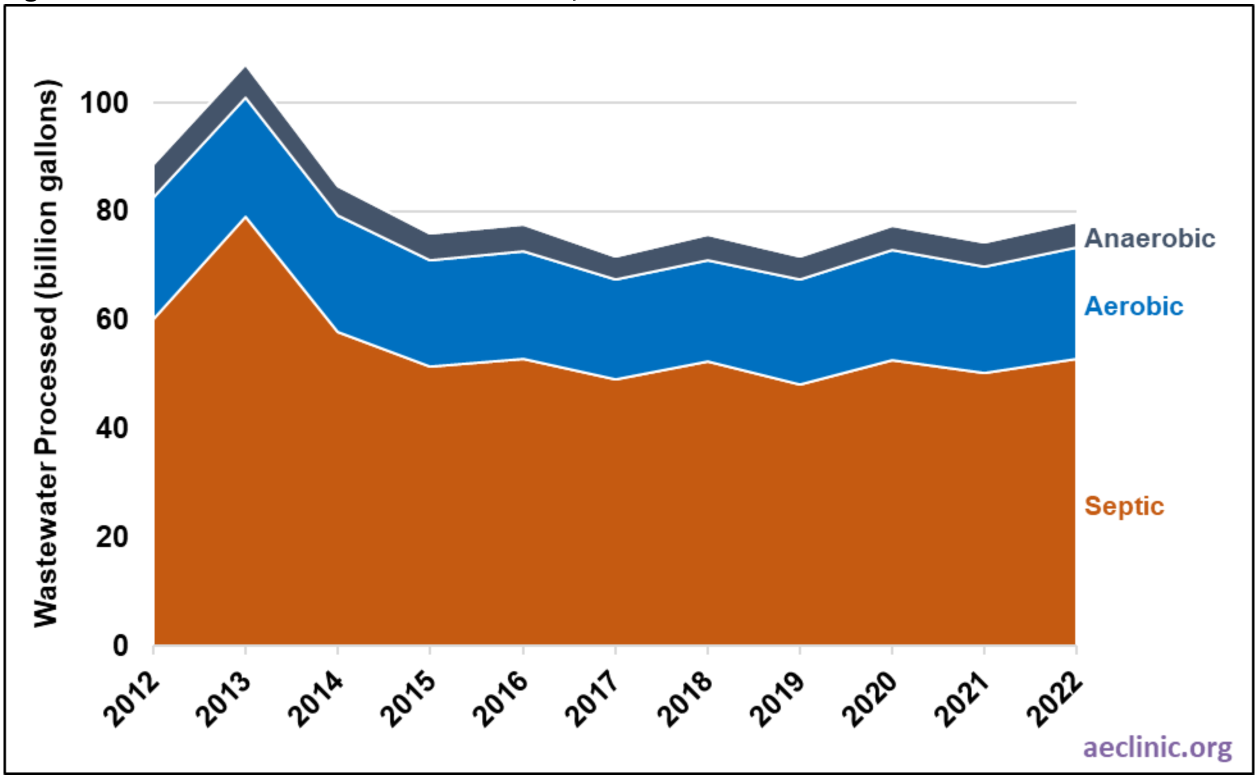
Island-wide, 44 percent of the material that ends up in Puerto Rico's landfills is compostable, of which 22 percent is vegetative material such as trees, grass clippings, and bushes.[86] However, only two publicly owned compost facilities are in operation on the island.[87] To fill this gap, nonprofit organizations such as Isla Nena Compost are working to establish composting facilities and make these services more accessible to residents and commercial facilities. Composting results in CO_2 emissions (also considered biogenic) and CH_4 emissions.

Wastewater treatment is largely managed by the Puerto Rico Aqueducts and Sewers Authority (PRASA), which own and operates 51 wastewater treatment plants on the island, providing sewage removal service to approximately 59 percent the island's residents as of 2019.[88] The wastewater of the remaining 1.2 million residents is disposed of through septic systems or open waterways. In total, Puerto Rico's wastewater

[85] Direct communication with M. V. Rodriguez, Director of Puerto Rico Land Pollution Control Area.
[86] Dalmau, C.A.P. and Torres, M.E.O. October 21, 2022. "Disaster debris is pushing Puerto Rico's landfills to the brink." *Grist*. Available at: https://grist.org/extreme-weather/disaster-debris-is-pushing-puerto-ricos-landfills-to-the-brink/
[87] U.S. FEMA and U.S. EPA. 2020.
[88] ASCE 2021. p.56

treatment plants process about 220 million gallons of wastewater per day—116 million gallons of which are treated and reused for agricultural irrigation and aquifer recharge activities.[89] In 2022, nearly 80 billion gallons of wastewater was processed in Puerto Rico by septic, aerobic, anaerobic, or reactor treatment methods (see Figure 11 below). PRASA estimates that over the six-year period from 2022 to 2027, it will need $551 million to update its aging infrastructure to remain compliant with federal requirements.[90]

Figure 11. Puerto Rico's wastewater treatment, 2012-2022



Data source: Direct communication with H. Perez, Puerto Rico Aqueducts and Sewers Authority.

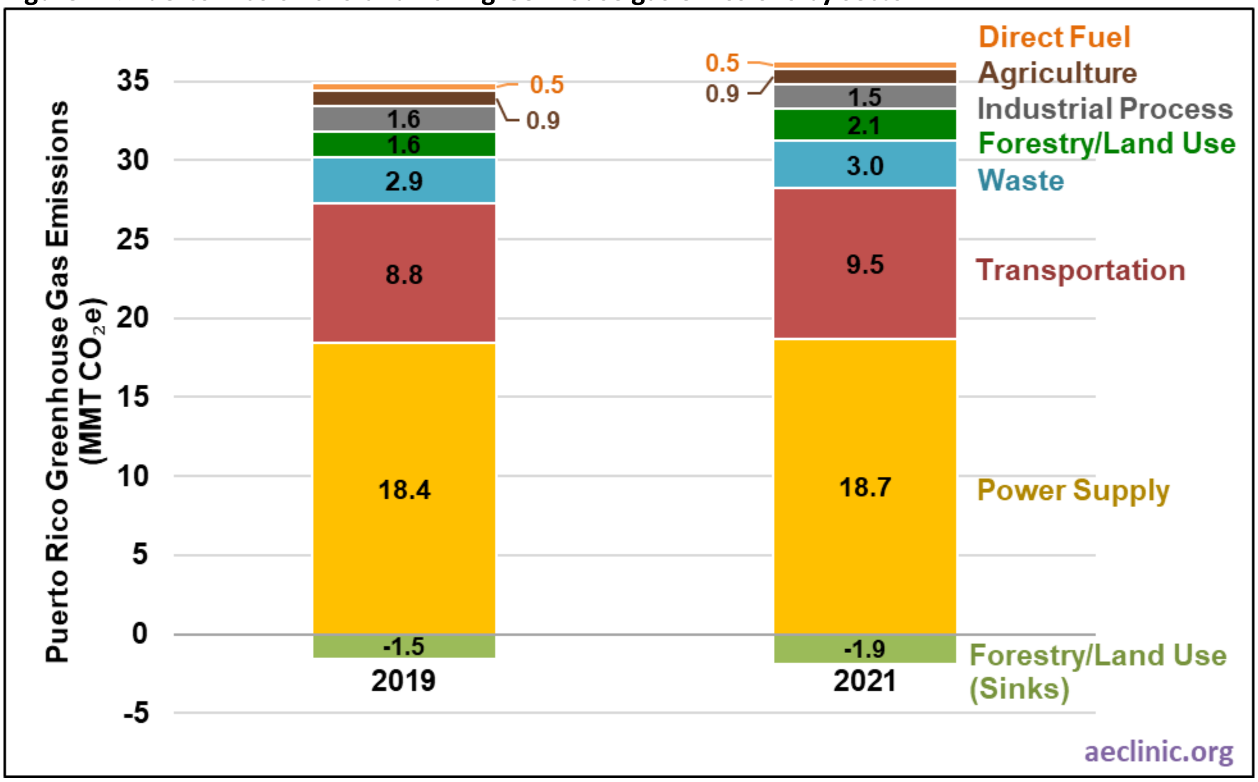
[89] Ibid.

[90] ASCE 2021. p.57

III. 2019 and 2021 Greenhouse Gas Emissions in Puerto Rico

Puerto Rico's greenhouse gas emissions totaled 33.4 MMT CO_2e in 2019 and 34.3 MMT CO_2e in 2021 (see Figure 12). These estimates are based on the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report's (AR6) global warming potentials (GWPs) (used to convert CH_4 and other non-CO_2 greenhouse gases into CO_2 equivalents) and are net of emission sequestration from Forestry and Other Land Use. Puerto Rico's 2019 *Climate Change Mitigation, Adaption, and Resiliency Law* measures mandated emission reductions against an estimated 2005 emissions level of 53.3 MMT CO_2e (calculated in the 2014 Inventory using IPCC's Fourth Assessment Report's (AR4) GWPs, which would tend to underestimate total greenhouse gas emissions) and calls for a 50 percent reduction relative to 2005 emissions by 2025.

Figure 12. Puerto Rico's 2019 and 2021 greenhouse gas emissions by sector



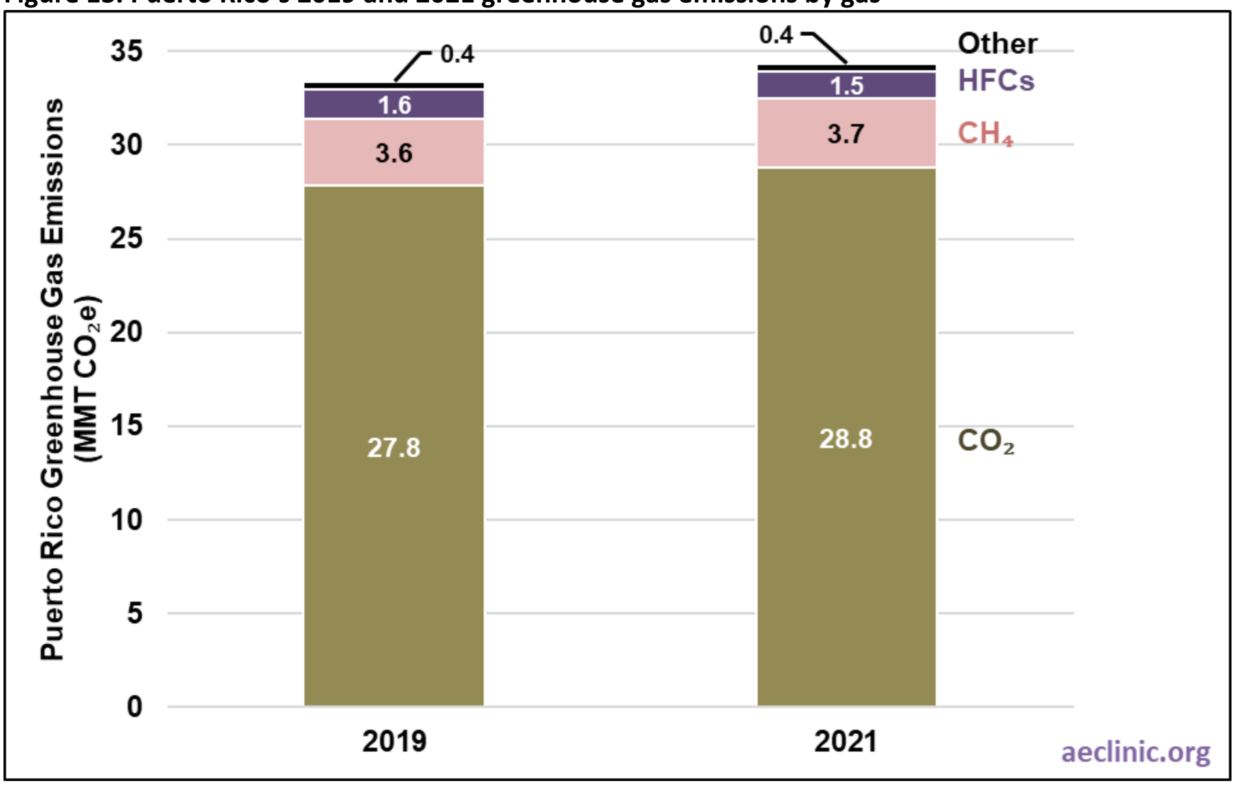
Note: The "Forestry and Other Land Use" category includes both positive (i.e., increased) emissions from carbon releases and wildfires as well as negative (i.e., reduced) emissions from carbon sequestration gains (i.e., emission sinks).

Island-wide total greenhouse gas emissions are required, therefore, to be no higher than 26.7 MMT CO_2e in 2025. Emission levels achieved in 2021 (34.3 MMT CO_2e) represent a 36 percent reduction in emissions from 2005 levels. With 14 percentage points and 4 years left to go, Puerto Rico must find another 7.7 MMT CO_2e to eliminate. The last Puerto Rico inventory—conducted in 2014 with historical emissions for 1990, 1995, 2000, 2005 and 2010, and projected emissions through 2035—reports slightly lower than 2021 power sector emissions and slightly higher than 2021 transportation emissions. Waste emissions in this 2019/2021 Inventory are double that presented in the 2014 Inventory, most likely due to difference in data sources rather than any substantial increase in waste sector emissions.

In comparing past and present inventories, it should be noted that the 2014 Inventory used different GWPs for non-CO_2 gases and assigned some emissions from power generation to an "industrial sector" whereas the current inventory presents an "industrial process emissions" sector composed exclusively of manufacturing emissions unrelated to fuel combustion. The allocation of emissions from power production to Puerto Rico's residential, commercial and industrial electric customers cannot be discerned from available data.

Measured in AR6 CO_2e-terms, CO_2 accounts for 83 percent of total Puerto Rico greenhouse gas emissions in 2019 and 84 percent of in 2021 (see Figure 13). CH_4 emissions from the Power Supply, Direct Fuel, Transportation, Agriculture, Forestry and Land Use, and Waste Management sectors add approximately another 11 percent of emissions; the Waste Management sector produces the greatest share of CH_4 emissions followed by agriculture. CO_2 emissions from Power Supply and Transportation are the largest source of emissions and have the greatest potential for achieving emission reductions.

Figure 13. Puerto Rico's 2019 and 2021 greenhouse gas emissions by gas

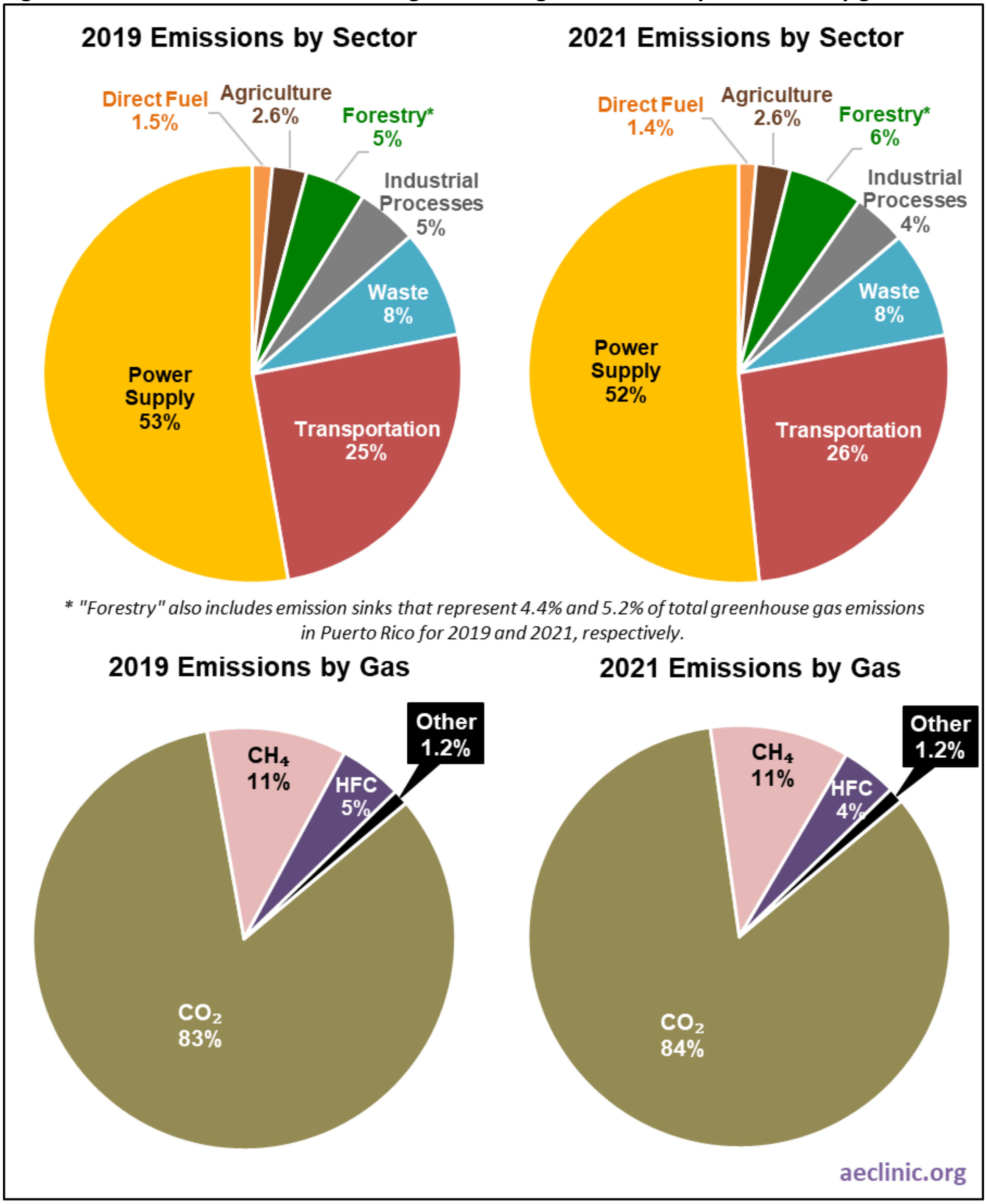


Note: "Other" includes greenhouse gas emissions such as N_2O, SF_6, NF_3, and PFCs.

Power Supply sector emissions account for 53 percent of total emissions is 2019 and 52 percent in 2021 (see Figure 14 below). Transportation emissions account for an additional 25 and 26 percent of total emissions, respectively. Emission contributions from the remaining sectors are small in comparison indicating that the greatest opportunities for emission reductions exist in the Power Supply and Transportation sectors.

While a far larger share of emissions in the mainland United States and most temperate-climate countries is taken up by direct fuel use for home heating as well as commercial and industrial needs, Puerto Rico's direct fuel use makes up just 1.5 percent of total emissions—roughly consistent with findings in other tropical locations. Hot water and limited building heating needs are largely served by electric-power equipment. Fuel combustion for back-up generators, however, is an important and growing source of emissions on the island. Forestry and Other Land Use emissions peaked at much higher than typical levels in 2018, reflecting a destruction of trees in the 2017 Hurricane María as tree cover change, and therefore emissions, in Puerto Rico's 2018 net emission values. These increased Forestry and Other Land Use emissions have shrunk each year since 2018 and inventory projections (presented in Section IV below) are based on an expectation of slow growth in total tree cover over time.

Figure 14. Puerto Rico's 2019 and 2021 greenhouse gas emissions by sector and by gas

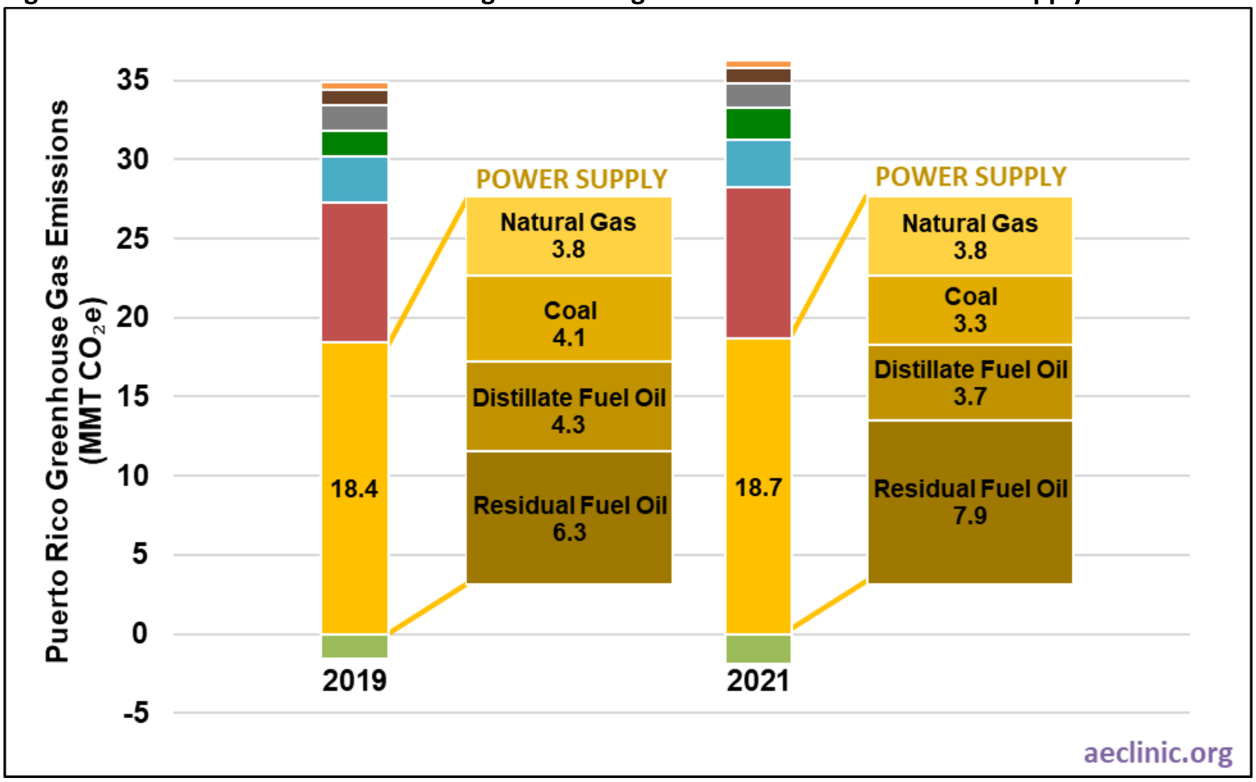


Note: Totals may not sum to 100 percent due to rounding.

Power Supply

Providing Puerto Rico's households and businesses with electricity, the Power Supply sector results in more than half of all economy-wide greenhouse gas emissions: 18.4 MMT CO_2e in 2019 and 18.7 MMT CO_2e in 2021 (see Figure 15). Renewable generation is zero-carbon and does not contribute to greenhouse gas emissions. Eighty percent of Puerto Rico's total 2021 Power Supply sector emissions came from the combustion of coal, distillate fuel oil (sometimes also called diesel)[91] and residual fuel oil; the remaining 20 percent came from natural gas combustion.

Figure 15. Puerto Rico's 2019 and 2021 greenhouse gas emissions from the Power Supply sector



Note: The "Power Supply" sector also includes greenhouse gas emissions from landfill gas (of which CO_2 emissions are considered biogenic and not accounted for in the emissions inventory) and electric transmission and distribution.

Direct Fuel

Emissions from the Direct Fuel sector—used for back-up generation, cooking, and some industrial processes (not run on electricity)—contributed 0.5 MMT CO_2e to total Puerto Rico greenhouse gas emissions in both 2019 and 2021 (see Figure 16 below). The majority of these Direct Fuel emissions came from combustion of propane and other related liquid petroleum gases; the remainder came from the combustion of kerosene.

[91] "Distillate fuel oil" is the term used to describe fuel oils distilled from crude oil, of which diesel is one type. In this report, all distillate fuel oils used in stationary combustion processes (i.e., in the Power Supply and Direct Fuel sectors) are referred to as "distillate fuel oil"; diesel used for mobile combustion in the Transportation sector is referred to as "diesel."

Figure 16. Puerto Rico's 2019 and 2021 greenhouse gas emissions from the Direct Fuel sector

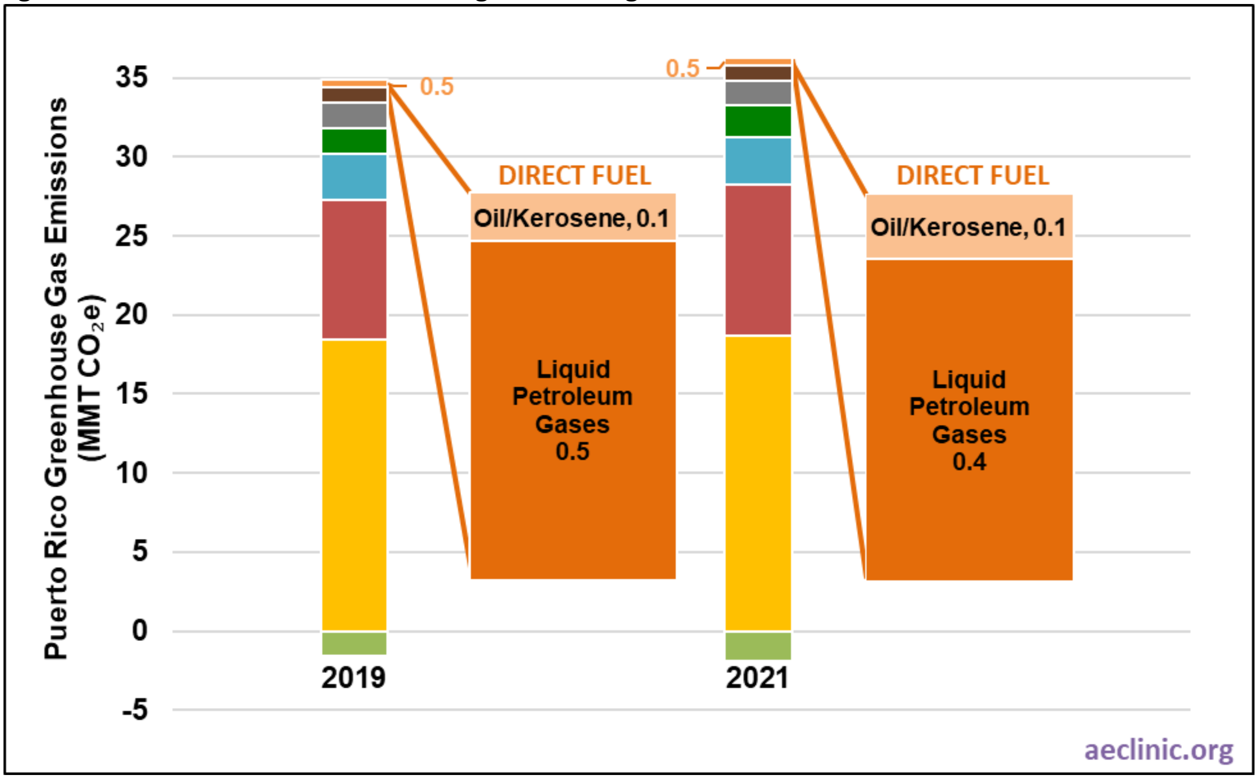
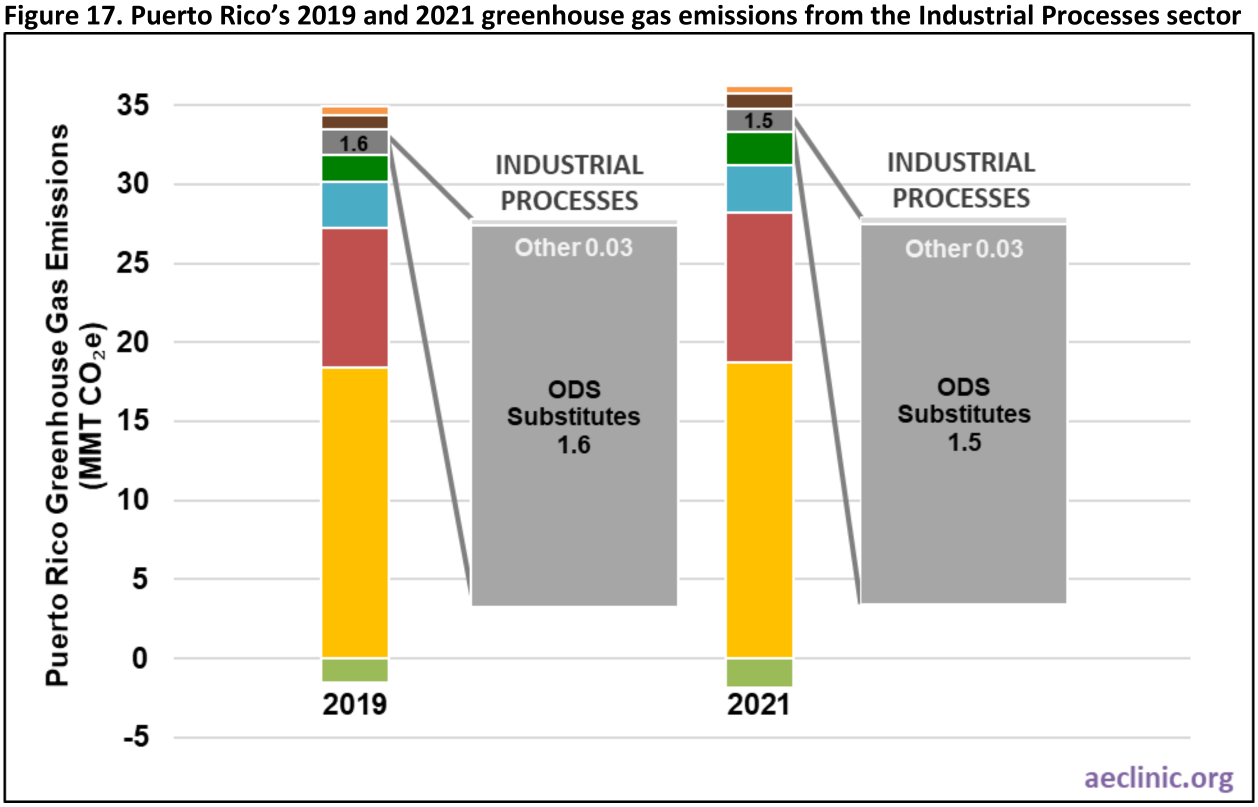


Figure 17. Puerto Rico's 2019 and 2021 greenhouse gas emissions from the Industrial Processes sector



Note: The "Other" category includes greenhouse gas emissions from the cement and semiconductor industries.

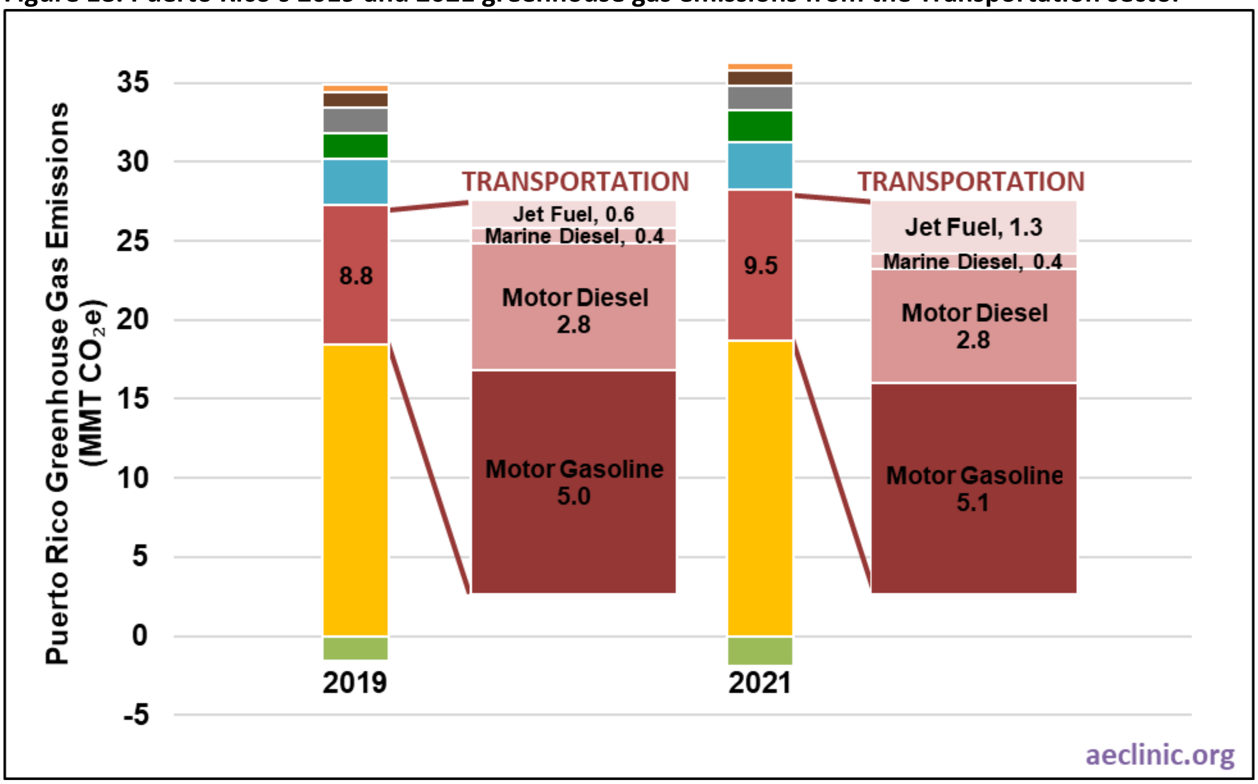
Industrial Processes

Industrial Processes and Product Use sector emissions come from manufacturing processes and not from the combustion of fuels for energy in industrial settings. Puerto Rico's industrial process emissions are generated from the production of ODS substitutes (1.6 MMT CO_2e in 2019 and 1.5 MMT CO_2e in 2021), with cement and semiconductor manufacturing contributing small shares of emissions (see Figure 17 above).

Transportation

Puerto Rico's Transportation sector—responsible for one-quarter of all emissions—is the second largest contributor to economy-wide emissions. Transportation activities resulted in 8.8 MMT CO_2e in 2019 and 9.5 MMT CO_2e in 2021 (see Figure 18). Most transportation emissions are the result of on- and off-road gasoline and diesel fuel use (89 percent in 2019 and 83 percent in 2021). Smaller shares of emissions come from fuel combustion by boats and planes; these emissions do not include international "bunker fuels", that is, fuel used to travel to another country.

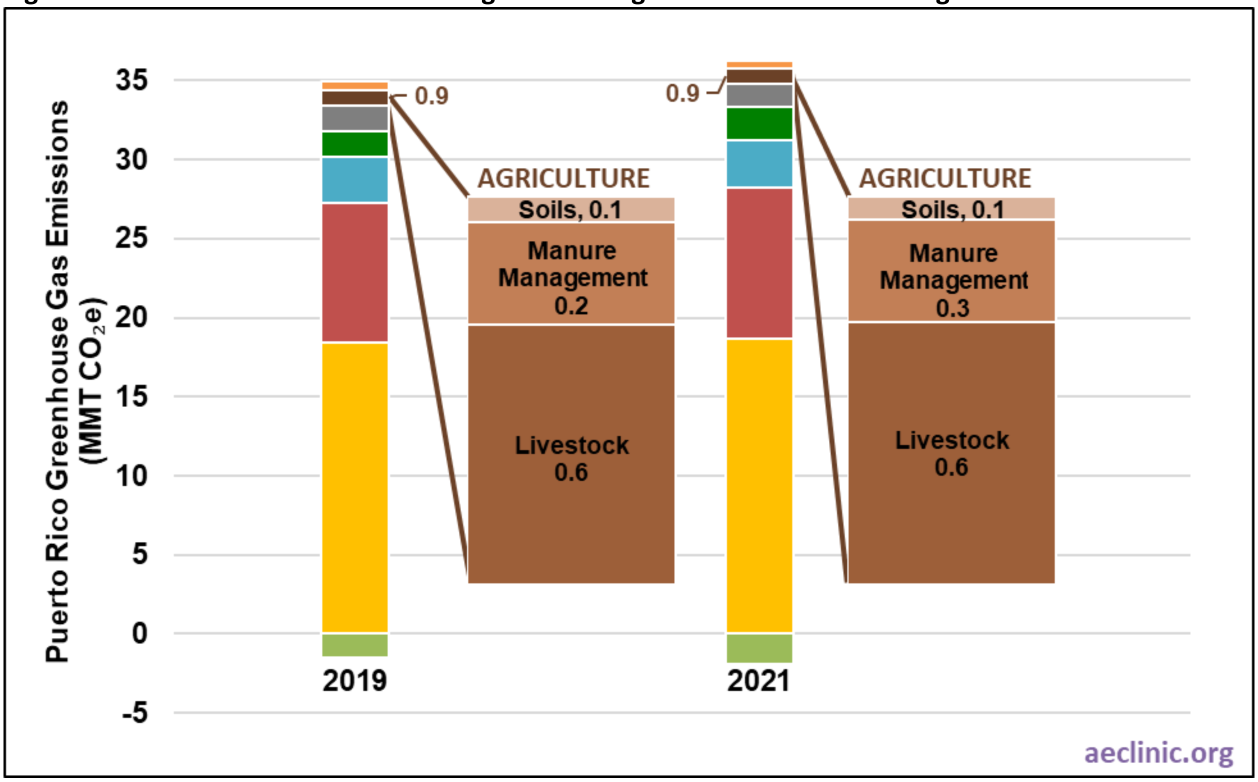
Figure 18. Puerto Rico's 2019 and 2021 greenhouse gas emissions from the Transportation sector



Agriculture

Puerto Rico's Agriculture sector added just 0.9 MMT CO_2e to total economy-wide emissions in both 2019 and 2021 (see Figure 19). Two-thirds of these emissions (in carbon-equivalent terms) are CH_4 emissions from livestock, drained organic soils, manure applications and soil management, such as tillage practices, also contribute small shares of emissions.

Figure 19. Puerto Rico's 2019 and 2021 greenhouse gas emissions from the Agriculture sector

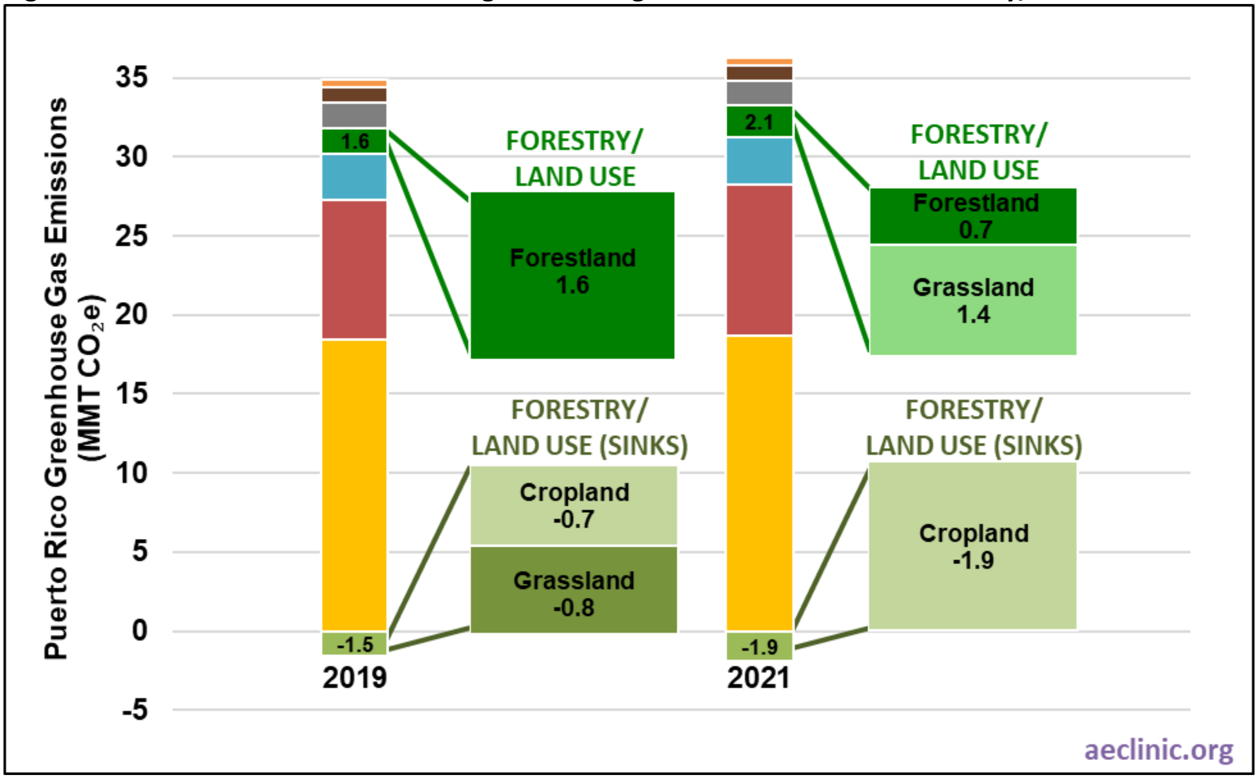


Note: The "Livestock" category includes greenhouse gas emissions from enteric fermenation. The "Agricultural" sector also includes emissions from croplands, such as crop residues, rice cultivation, and burning activities.

Forestry and Other Land Use

Forestry and Other Land Use in Puerto Rico contributes both greenhouse gas emissions—from reductions in tree biomass and land use change (for example, from forest to grassland)—and greenhouse gas sequestration from forests and other ecosystems' absorption of atmospheric CO_2. Net Forestry and Other Land Use emissions were 0.1 MMT CO_2e in 2019 and 0.2 MMT CO_2e in 2021 (see Figure 20 below); carbon emissions were 1.6 MMT CO_2e in 2019 and 2.1 MMT CO_2e in 2021, and carbon sequestration was 1.5 MMT CO_2e in 2019 and 1.9 MMT CO_2e in 2021.

Figure 20. Puerto Rico's 2019 and 2021 greenhouse gas emissions from the Forestry/Other Land Use sector

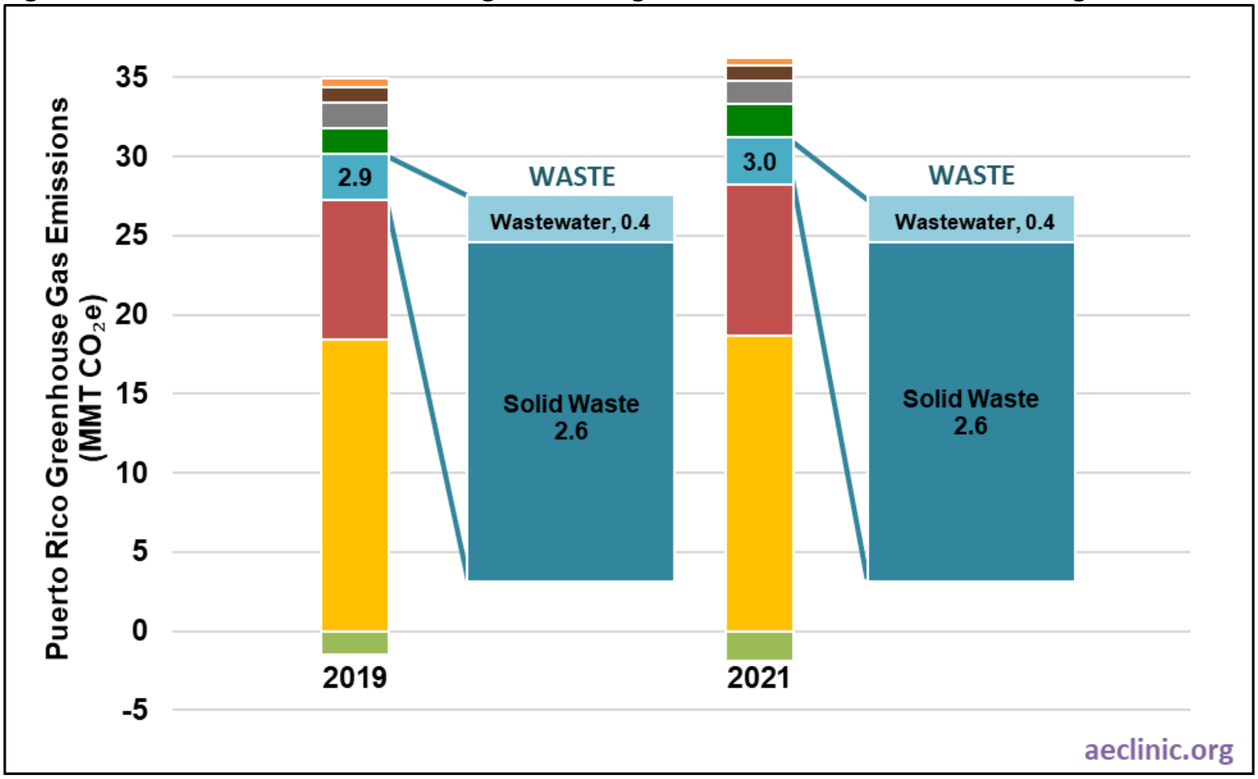


Note: The "Forestry and Other Land Use" includes both positive (i.e., increased) emissions from carbon releases and wildfires as well as negative (i.e., reduced) emissions from carbon sequestration gains (i.e., emission sinks).

Waste Management

Puerto Rico's Waste Management sector includes emissions from solid waste and wastewater, totaling 2.9 MMT CO_2e in 2019 and 3.0 MMT CO_2e in 2021 (see Figure 21 below). Municipal solid waste and more informal solid waste disposal accounts for 88 percent of total Waste Management sector emissions in both years. No data were available for industrial solid waste and industrial wastewater, and these emissions are therefore omitted from this inventory.

Figure 21. Puerto Rico's 2019 and 2021 greenhouse gas emissions from the Waste Management sector



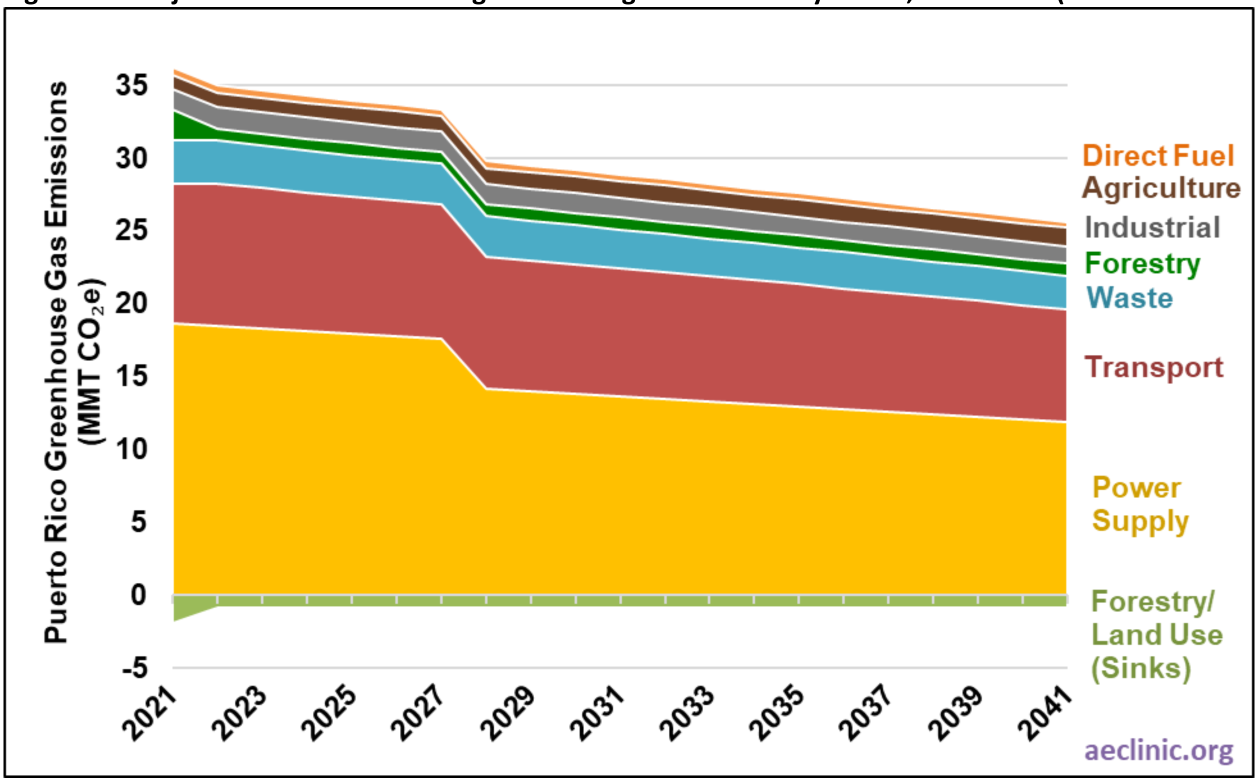
Note: The "Solid Waste" category includes greenhouse gas emissions from landfills and composting activities, while the "Wastewater" category consists of greenhouse gas emissions from the following wastewater treatment processes: septic, aerobic, anaerobic, and reactor.

IV. Projections: Scenarios and Sensitivities

Projections of future emission trends—based on expected changes in population, economic growth, and other key forecasts—predict declining emissions over the 2022 to 2041 period, primarily due to emigration and the closure of the AES coal-fired power plant and assumed replacement with renewable electric generation. In a Business-as-Usual scenario, which is based on existing laws, policies and socio-economic expectations without significant change or disruption, emissions fall from 34.3 MMT CO_2e in 2021 down to 24.7 MMT CO_2e in 2041, a reduction of 28 percent over 20 years (see Figure 22).

Based on this Business-as-Usual projection, Puerto Rico's greenhouse gas emission levels will reach their mandated levels (50 percent of 2005 levels, or 26.7 MMT CO_2e) in 2035, 10 years later than the required 2025 target.

Figure 22. Projections of Puerto Rico's greenhouse gas emissions by sector, 2021-2041 (Business-as-Usual)

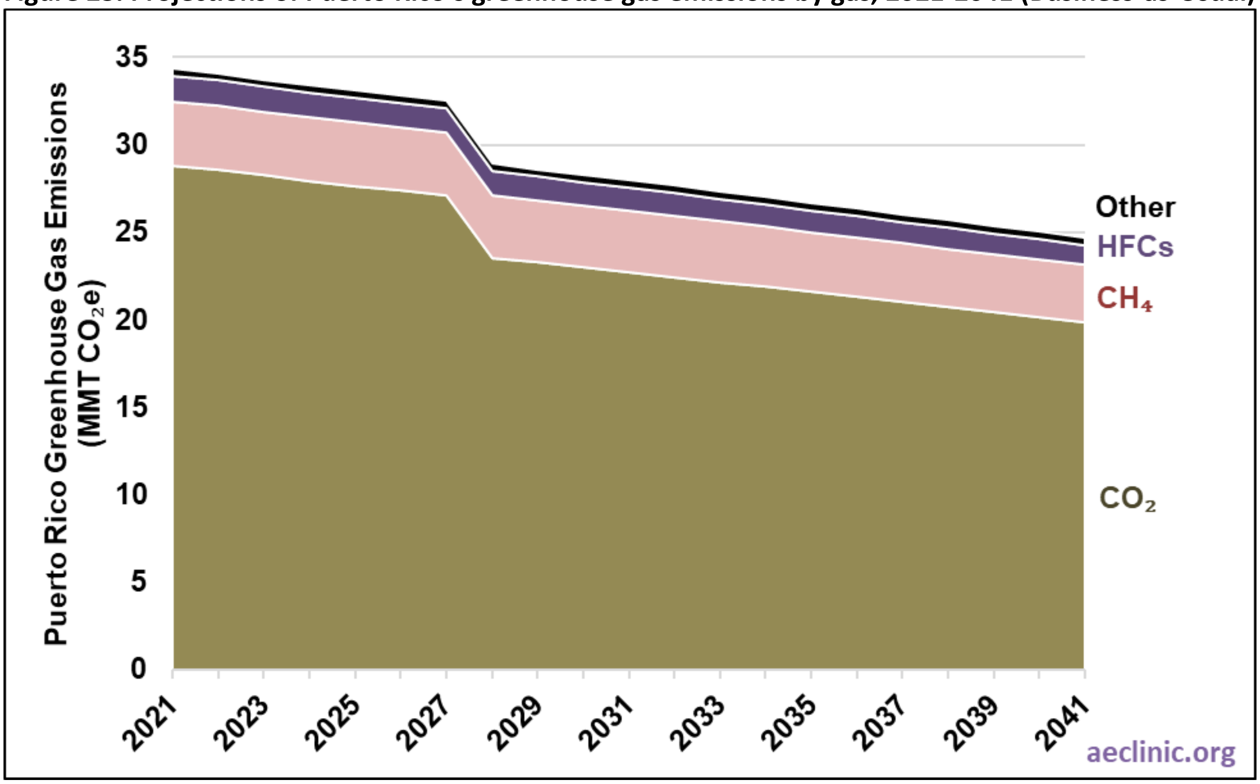


Note: The "Forestry and Other Land Use" category includes both positive (i.e., increased) emissions from carbon releases and wildfires as well as negative (i.e., reduced) emissions from carbon sequestration gains (i.e., emission sinks).

The Business-as-Usual scenario assumes that fuel use and emissions in the Power Supply, Direct Fuel, Transportation, and Waste Management sectors will fall in proportion to Puerto Rico's declining population, at an average annual rate of reduction of 1.3 percent from 2022 through 2041. In addition, Power Supply sector emission projections assume that operations of the AES coal plant will remain constant through the year 2027 and then cease with the retirement of the plant in 2028. Industrial Processes sector emissions grow at 2 percent per year in the Business-as-Usual scenario, consistent with projections of economic growth in Puerto Rico over this same period. In compliance with the Kigali Amendment to the Montreal Protocol, the consumption of HFC emissions is phased out, reaching 85 percent of current levels by 2035.[92]

Agriculture emissions grow over the next two decades, based on forecasts produced by the U.N. Food and Agriculture Organization. We assume an increase in tree cover over time, at the same pace of growth that occurred in the pre-María 2011-2017 period, approximately 0.7 percent per year; forest-based emission sequestration increases together with tree cover growth. (Detailed assumptions and data used in constructing these projections are presented below in Section 0: Inventory Methodology.) Overall, Puerto Rico's CO_2 emission fall, CH_4 emissions remain roughly the same, and HFC emissions fall over time (see Figure 23).

Figure 23. Projections of Puerto Rico's greenhouse gas emissions by gas, 2021-2041 (Business-as-Usual)

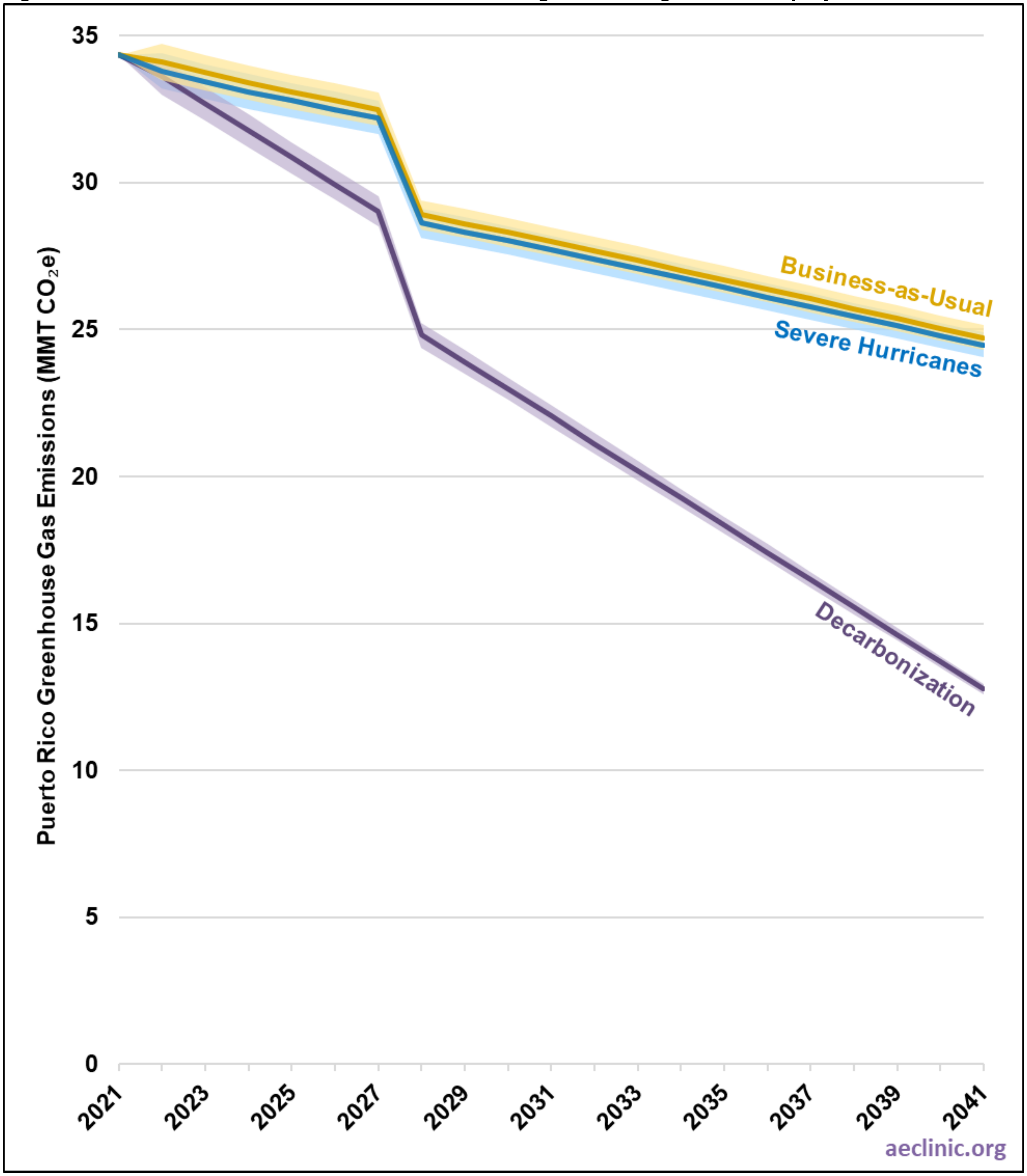


Note: "Other" includes greenhouse gas emissions such as N_2O, SF_6, NF_3, and PFCs.

Two other scenarios of future changes in Puerto Rico's greenhouse gas emission also show lower emissions over time but at a quicker pace than in the Business-as-Usual scenario. A Severe Hurricanes scenario projects serious economic and environmental impacts from Category 5 hurricanes on average once every three years (these impacts are smoothed out over time such that one-fifth of the full impact occurs in every year). Economic disruption causes lower fuel use and a loss of tree cover causes less carbon sequestration. Overall, 2041 emissions fall to 24.5 MMT CO_2e rather than the 24.7 MMT CO_2e expected in the Business-as-Usual scenario (see Figure 24 below).

[92] United Nations. 2016. *Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer.* Available at: https://treaties.un.org/Pages/ViewDetails.aspx?src=IND&mtdsg_no=XXVII-2-f&chapter=27&clang=_en

Figure 24. Scenarios and sensitivities for Puerto Rico's greenhouse gas emission projections



Note: The solid lines depict the reference case for each scenario, while the shaded areas represent the high and low economic growth sensitivities.

A Decarbonization scenario results in a much more rapid reduction of Puerto Rico's emissions. Power Supply, Direct Fuel, and Transportation sector emissions are reduced to zero by 2050. Tree coverage and forest-based sequestration grow at double the pace of the Business-as-Usual scenario. Industrial Processes, Agriculture, and

Waste Management emissions change at the same rates as in the Business-as-Usual scenario. Emissions in the Decarbonization scenario reach 12.8 MMT CO_2e in 2041, falling below the 26.7 MMT CO_2e requirement (50 percent of 2005 emissions) by 2028, only three years later than required.

Additional sensitivity modeling explored the impact of slower or more rapid economic growth on Puerto Rico's emissions under all 3 scenarios but with minimal effect. Differences due to slower economic growth never exceed a 2 percent emission reduction over the 2022 to 2041 period. Similarly, differences from more rapid economic growth never exceed a 2 percent emission increase over the same period.

V. Inventory Methodology

Using AEC's Emissions Measurement Inventory Tool (AEC-EMIT), the Puerto Rico 2019/2021 Inventory calculates the net greenhouse gas emissions released in Puerto Rico in the years 2019 and 2021 and provides a 20-year projection of greenhouse gas emissions beginning in 2022. This is the first inventory released on behalf of the Puerto Rican government since the 2014 Puerto Rico Greenhouse Gases Baseline Report (2014 Inventory).[93] The 2019/2021 Inventory is designed with reference to the 2014 Inventory, the 2006 IPCC Guidelines for National Greenhouse Gas Inventories,[94] and the 2019 Refinement to the 2006 IPCC Guidelines for National *Greenhouse Gas Inventories.*[95] The 2019/2021 Inventory identifies specific sectors and subsectors (see Table 1 below) most relevant to Puerto Rico's economy, conducts greenhouse gas emissions calculations and projections for each sector, and provides a summary of those results by sector and greenhouse gas.

AEC-EMIT

AEC's Emissions Measurement Inventory Tool

AEC-EMIT is a spreadsheet-based tool that provides users with an interface to build a greenhouse gas emissions inventory (and 20-year emissions projections) for a specific geographic region. Users can customize the tool by selecting greenhouse gases, sectors, subsectors, scenarios, sensitivities, and other information specific to their inventory. Users are also provided a dashboard to toggle select assumptions and parameters (e.g., global warming potentials, scenarios, and sensitivities, etc.). Summary tabs aggregate results across sectors and can be used to provide disaggregated sub-sector-specific results.

[93] Estado Libre Asociado de Puerto Rico. 2014. *Puerto Rico Greenhouse Gases Baseline Report.* Available at: https://drna.pr.gov/wp-content/uploads/2017/05/Puerto-Rico-GHG-2014.pdf.

[94] IPCC. 2006. *2006 IPCC Guidelines for National Greenhouse Gas Inventories.* Task Force on National Greenhouse Gas Inventories. Available at: https://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html.

[95] IPCC. 2019. *2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.* Task Force on National Greenhouse Gas Inventories. Available at: https://www.ipcc.ch/report/2019-refinement-to-the-2006-ipcc-guidelines-for-national-greenhouse-gas-inventories/.

Table 1. Description of sectors and subsectors in the 2019/2021 Inventory

Sector	Subsectors	Greenhouse Gases	Description of Emissions
Power supply	Coal-, gas-, and oil-fired generation	CO_2, CH_4, N_2O, SF_6	Fossil fuel combustion for power generation.
Direct fuel use	Residential, commercial, industrial, and institutional fuel use	CO_2, CH_4, N_2O	Fossil fuel combustion for uses other than power generation or transportation.
Industrial processes and product use	Cement production, semi-conductor manufacturing, and ozone-depleting substitutes use	CO_2, N_2O, HFCs, PFCs, SF_6	Emissions from manufacturing processes Excludes emissions from industrial fuel combustion.
Transportation	On-road gasoline, on-road and off-road diesel, and jet fuel consumption	CO_2, CH_4, N_2O	Fossil fuel combustion from mobile combustion.
Agriculture	Cropland soil management, cropland carbon, livestock management via enteric ferementation, livestock management via manure management	CO_2, CH_4, N_2O	Emissions from cropland use, changes in crop soils, and livestock management.
Forestry and other land use	Above-ground carbon in live trees, below-ground carbon in live trees, forest fires, soil sequestration emissions	CO_2	Emissions from the change in biomass carbon stocks in forests and other non-agricultural lands.
Waste management	Solid waste management and wastewater management	CO_2, CH_4, N_2O	Emissions from solid and liquid waste management systems.

Greenhouse gas emissions are calculated for each sector and subsector. The greenhouse gases considered in the emission calculations are as follows: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6).[96]

- CO_2 is emitted through burning of fossil fuels, solid waste, biogenic materials, and through various industrial or chemical processes.
- CH_4 is emitted during the production, combustion, and transportation of fossil fuels. As well as from livestock, agricultural, and waste management practices.
- N_2O is emitted during agricultural, land-use, and waste management activities as well as combustion of fossil fuels.
- Fluorinated gases (SF_6, HFCs, PFCs) are emitted from household, commercial, and industrial applications and processes and are also used as substitutes for refrigerants made of ozone-depleting substances.

[96] U.S. EPA. "Overview of Greenhouse Gases." *Overview of Greenhouse Gases.* Available at: https://www.epa.gov/ghgemissions/overview-greenhouse-gases#f-gases.

Greenhouse gases absorb varying amounts of heat in the atmosphere.[97] Global warming potentials (GWPs) allow the radiative impacts of different greenhouse gases to be compared and summed together into a common unit: CO_2 equivalents (CO_2e).

GWP values differ depending on:

(1) the time period over which greenhouse gases are examined (e.g., 20 years or 100 years), and

(2) the IPCC *Assessment Reports* in which they are published (see Table 2; note that IPCC's guidance on GWP values has changed over time).[98]

The Puerto Rico 2019/2021 Inventory evaluates Puerto Rico's emissions using the AR6 GWP values at the suggestion of the Expert Panel. While the U.S. EPA recommends the use of AR4 GWPs, the wider international community tends to use more recent GWP guidance for conducting greenhouse gas inventories. The AEC-EMIT tool allows for the user to switch between AR6, AR5, and AR4 values to facilitate comparison with other jurisdictions that have yet to adopt IPCC's latest AR6 GWP values.

Using AR6 guidance, the 100-year GWP of N_2O, for example, is 273, which means that one metric ton of N_2O absorbs 273 times more heat (i.e., global warming impact) than the same amount of CO_2 over 100 years: this means that 1 metric ton of N_2O is equivalent to 273 metric tons of CO_2e.

Table 2. Greenhouse gases and GWPs

Greenhouse gas	6th Assessment Report (AR6)	
	100-Year GWP	20-Year GWP
CO_2	1	1
CH_4	27.9	81.2
N_2O	273	273
SF_6	25,200	18,300
NF_3	17,400	13,400
HFCs*	14,600	12,400
PFCs*	12,400	8,940

** The GWP potentials for HFCs and PFCs refer to their maximum values.*
Source: Smith, C., Z.R.J. Nicholls, K, Armour, W. Collins, P. Forster, M. Meinshausen, M.D. Palmer, and M. Watanabe. August 2021. AR6 WGI Report, Chapter 7. Available at: https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Chapter_07_Supplementary_Material.pdf. Table 7.SM.7. p. 27

[97] EPA. "Understanding Global Warming Potentials." *Understanding Global Warming Potentials.* Available at: https://www.epa.gov/ghgemissions/understanding-global-warming-potentials.
[98] Ibid.

The 2019/2021 Inventory follows the IPCC's recommended approach to compiling a greenhouse gas inventory.[99]

1. **Gather data from public and private datasets:** To collect and organize data from public datasets for the 2019/2021 Inventory, the same data and data sources utilized in the 2014 Inventory[100] were listed and collected if: 1) the data were publicly available; 2) the data were provided for 2018 or later years; and 3) the data were specific to Puerto Rico. Additional data were also collected according to the same criteria listed above. Data for the same seven sectors used in the 2014 Inventory, with updated names and definitions. were collected: Power Supply; Direct Fuel; Industrial Processes and Product Use; Transportation; Agriculture; Forestry and Other Land Use; and Waste Management.
2. **Gather data from emission reporting forms:** Data requests were sent out to a total of eleven government agencies, the University of Puerto Rico at Mayagüez, and the Puerto Rico Electric Power Authority (PREPA) for data in several of Puerto Rico's economic sectors; additional contact was made with nine Puerto Rico agricultural experts and three representatives of manufacturing organizations who could provide data on industries expected to produce industrial process emissions. Of the agencies and officials contacted, responses were received from four government agencies and PREPA, six agricultural experts, and two representatives of the Puerto Rico Manufacturers Association. Only the four agencies and PREPA provided data.
3. **Construct methodologies for the sectoral emissions calculations and projections:** Methodologies for each sector have been reviewed by by the Expert Panel assembled to review the 2019/2021 Inventories methods and findings (see Appendix A for short bios of each Expert Panel member).
4. **Subject emissions calculations to quality assurance or quality control (QA/QC) two separate times to confirm the validity of the results.** AEC's QA/QC methods are described in detail below and include multiple rounds of both internal and external review of the 2019/2021 Inventory methodology and findings.

IPCC procedures for a greenhouse gas emissions inventory:

1. Identify the key categories that focus effort and resources on the sectors that contribute most to the inventory or its uncertainty. These can be based off the previous inventory.
2. Identify the methods of estimation for each category that are particular to country-specific requirements.
3. Collect data and maintain verification, documentation, and checking procedures (QA/QC procedures). Simultaneously collect data on uncertainties and refine methods as data are collected.
4. Ensure time series consistency.
5. Perform uncertainty analysis and key category analysis.
6. Perform QA/QC procedures.

Source: IPCC. 2006. IPCC Guidelines, Volume 1, Chapter 1.6 "Introduction to the 2006 Guidelines" IPCC. Available at: https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/1_Volume1/V1_1_Ch1_Introduction.pdf, p. 1.9 – 1.10.

[99] IPCC. 2006. *IPCC Guidelines, Volume 1, Chapter 1.6 "Introduction to the 2006 Guidelines."* IPCC. Available at: https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/1_Volume1/V1_1_Ch1_Introduction.pdf. p. 1.9 – 1.10.

[100] Center for Climate Strategies, Inc., 2014.; Wherever possible, multiple data sources were cross-checked against one another.

The independent Expert Panel evaluated the methodology and proposed data sources. Available data from public and private datasets have been reviewed and cross-checked against data from multiple sources. Completed calculations underwent two internal QA/QC checks before final 2019/2021 Inventory emissions and projections are presented.

Methodology overview

The 2019/2021 Inventory follows Puerto Rico's 2014 Greenhouse Gas Inventory in its overall organization. The 2014 Inventory (released September 2014) presented the island's greenhouse gas emissions from 1990 to 2013 together with projections of 2014 to 2035 emissions.[101] For each sector in the 2019/2021 Inventory, AEC based its detailed emission calculation methodology on (1) available data and (2) IPCC guidelines.[102] Where applicable, the 2019/2021 Inventory draws best practices from other greenhouse gas emissions inventories and the available literature on emissions accounting.[103]

Emissions calculations and the IPCC tier system

IPCC guidelines recommend that greenhouse gas emissions be calculated by multiplying together two components: ***activity data*** and ***emission factors***.

Activity data measure the extent to which emissions-generating activities occur. These data are available from a variety of sources: directly from businesses or other institutions, collected in publicly available databases, or estimated from other types of available data. For example, the activity data for using natural gas to generate electricity would be the number of standard cubic feet (scf) of natural gas burned.[104]

Emission factors are measurements of the emissions released from a set amount of activity data. Emission factors are available from a variety of sources, such as the U.S. EPA. For example, the CO_2 emissions factor for burning natural gas in a power plant is 0.05444 kg of CO_2 per scf.[105]

To calculate greenhouse gas emissions, activity data are multiplied by a corresponding emissions factor.[106] For example, burning 100 scf of natural gas results in emissions of 5.444 kg of CO_2.

IPCC classifies emissions calculation methods according to three tiers based on their level of complexity. Tier 1 represents the most basic method; Tier 2 is the intermediate method; and Tier 3 is the most complex method.[107]

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[101] Estado Libre Asociado de Puerto Rico. 2014. *Puerto Rico Greenhouse Gases Baseline Report.* Available at: https://drna.pr.gov/wp-content/uploads/2017/05/Puerto-Rico-GHG-2014.pdf. p. 1.

[102] IPCC. 2006. *2006 IPCC Guidelines for National Greenhouse Gas Inventories.* Task Force on National Greenhouse Gas Inventories. Available at: https://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html.

[103] (1) Wartmann, S., Sheldon, D., Watterson, J. 2021. Projections of Greenhouse Gas Emissions and Removals: An Introductory Guide for Practitioners. GIZ. Prepared for the Federal Ministry for the Environmental, nature Conservation and Nuclear Safety. Available at: https://unfccc.int/documents/358238. (2) ICF. 2023. *User's Guide for States Using the Greenhouse Gas Projection Tool.* Prepared for the State Energy and Environment Program, U.S. EPA. Available at: https://www.epa.gov/statelocalenergy/download-state-inventory-and-projection-tool?token=1lMB9dPZeyhYruS4fTOcJ9qPVUNbewZFtpFWcSlvaQI. (3) IPCC. 2006. *2006 IPCC Guidelines for National Greenhouse Gas Inventories.* Task Force on National Greenhouse Gas Inventories. Available at: https://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html.

[104] U.S. EPA Center for Corporate Climate Leadership. 2022. *Emission Factors for Greenhouse Gas Inventories.* Available at: https://www.epa.gov/system/files/documents/2022-04/ghg_emission_factors_hub.pdf. p. 1.

[105] U.S. EPA Center for Corporate Climate Leadership, 2022, p. 1.

[106] IPCC. 2006. *IPCC Guidelines, Volume 1, Chapter 1.6 "Introduction to the 2006 Guidelines."* IPCC. Available at: https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/1_Volume1/V1_1_Ch1_Introduction.pdf, p. 1.6.

[107] IPCC, 2006, p. 1.6.

Tier 2 and Tier 3 are considered more accurate.[108] Typically, Tier 1 methods rely on the least-disaggregated activity data (more disaggregated data are split up into more specific sub-activities and can be sorted based on geography, type of activity, production process, or some other criteria) and emissions factors that are not country-specific. Tier 2 methods typically use country-specific emissions factors, and Tier 3 methods use more disaggregated activity data. In a few cases, where none of IPCC's designated methods are possible for a specific sector or subsector, AEC has developed an alternative methodology following IPCC guidelines to the greatest extent possible. IPCC tiers and divergences used in the 2019/2021 Inventory are described for each sector below.

It is important to note that data quality impacts the accuracy of all emission inventory estimates. In the case of Puerto Rico, several serious concerns with data quality may have a significant impact on these results. Data quality issues are discussed in the sector-specific sections of this methodology and in the Conclusion section of this report.

Emission Factors

Emission factors (or emissions intensities) are estimated ratios of greenhouse gas emissions produced per unit of activity data; multiplying the emissions factor by the amount of corresponding activity data results in an estimate of emissions released. The use of activity data and emissions factors is the primary approach to emissions calculation in the 2019/2021 Puerto Rico Inventory. The quality of emissions factors determines the complexity of emissions calculations, as designated by the IPCC tier system. (More complex emissions factors make it more likely that an emissions calculation receives a higher rating—Tier 2 or 3—rather than a lower rating—Tier 1.) The quality of emissions factor data depends on the degree to which the factors are specific to a particular geography, a specific technology, or the manner by which the technology is utilized.

The U.S. EPA and IPCC publish emissions factors for different greenhouse gases and activities deemed acceptable for use in state and national emissions inventories. In Puerto Rico's 2019/2021 Inventory, U.S. EPA and IPCC estimates were supplemented—when necessary—by data published in emissions inventory guidelines followed in British Columbia, Canada, industry estimates of emission factors for specific activities, and with the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC) published by the World Resources Institute.

Stationary combustion emission factors

Activity data for the Power Supply and Direct Fuel sectors is the quantity of fuel combusted in these activities: power generation, cooking, back-up generation, or industrial energy use. For each fuel, emission factors for CO_2, CH_4, and N_2O were obtained from the EPA's dataset of emission factors for greenhouse gas inventories, published in April 2023 (see Table 3 below).

108 IPCC, 2006, p. 1.6.

Table 3. Stationary combustion emission factors in original units

	CO_2 Factors	CH_4 Factors	N_2O Factors
Coal	**kg per short ton**	**g per short ton**	**g per short ton**
Anthracite Coal	2,602	276	40
Bituminous Coal	2,325	274	40
Gaseous Fuels	**kg per scf**	**g per scf**	**g per scf**
Natural Gas	0.05444	0.0010	0.0001
Landfill Gas*	0.02525	0.0016	0.0003
Petroleum Products	**kg per gallon**	**g per gallon**	**g per gallon**
Distillate Fuel Oil	10.21	0.41	0.08
Residual Fuel Oil	11.27	0.45	0.09
Kerosene	10.15	0.41	0.08
Liquefied Petroleum Gases	5.68	0.28	0.06

*Note: * CO_2 emissions from landfill gas are considered biogenic, meaning that they are excluded from greenhouse gas emissions inventory calculations per IPCC guidelines.*
Source: U.S. EPA. April 2023. Emission Factors for Greenhouse Gas Inventories. Available at: https://www.epa.gov/climateleadership/ghg-emission-factors-hub. Table 1.

Mobile combustion emission factors

Activity data for the Transportation sector is the consumption of fuels such as motor gasoline, motor diesel, marine diesel, and jet fuel. Emissions factors for different transportation fuels were obtained from the EPA's dataset on emission factors for greenhouse gas inventories (see Table 4 below). Since the EPA's emissions factors for CH_4 and N_2O from on-road travel are only provided in a grams per mile unit and activity data was only available as fuel quantities, per-gallon emission factors were obtained from the greenhouse gas inventory best practices set forth by the British Columbia Ministry of Environment and Climate Change Strategy in April 2021.

Table 4. Mobile combustion emission factors in original units

	CO_2 Factors	CH_4 Factors	N_2O Factors
On-road travel	**kg per gallon**	**kg per gallon**	**kg per gallon**
Motor Diesel	10.21	0.00041	0.00008
Motor Gasoline	8.78	0.00038	0.00008
Off-road travel	**kg per gallon**	**g per gallon**	**g per gallon**
Marine Diesel	10.21	6.41	0.17
Jet Fuel	9.75	0.00	0.30

Sources: (1) U.S. EPA. April 2023. Emissions Factors for Greenhouse Gas Inventories. Available at: https://www.epa.gov/climateleadership/ghg-emission-factors-hub. Table 2, 5. (2) British Columbia Ministry of Environment and Climate Change Strategy. April 2021. 2020 B.C. Best Practices Methodology for Quantifying Greenhouse Gas Emissions. Available at: https://www2.gov.bc.ca/assets/gov/environment/climate-change/cng/methodology/2020-pso-methodology.pdf. Table 8.

Other emission factors: Forestry and Other Land Use, Waste Management, and Electric Transmission

Emissions factors for other sectors were procured from a variety of public and private sources (see Table 5 below). Activity data for Forestry and Other Land Use included changes to biomass, biomass combustion, and changes to land cover. Emissions factors for biomass combustion and change in land cover were taken from the U.S. EPA and IPCC. In the Waste Management sector, compost-related emission factors were obtained from the World Resources Institute's Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (in turn derived from IPCC guidelines). Wastewater emission factors were obtained from IPCC 2006 Guidelines. Finally, two additional subsectors required emission factors: CO_2 emissions from cement production were calculated using emission factors from EPA, and SF_6 emissions from electricity transmission and distribution were calculated using emission factors provided by U.S. EPA through its Greenhouse Gas Reporting Program.

Table 5. Emission factors for other sectors in original units

Sector	Subsector	Emission Factors
Power Supply	Transmission and distribution emissions	• 0.52 kg of SF_6 per mile of transmission
Industrial Processes	Cement	• 0.776 of CO_2 per MT of cement produced
Forestry and Other Land Use	Tree mortality from fires	• 1,640 kg CO_2 per short tons of biomass • 126 g CH_4 per short tons of biomass • 63 g N_2O per short tons of biomass
	Forestland changes	• -238.3 MT CO_2 per hectare
	Grassland changes	• -250.3 MT CO_2 per hectare
	Cropland changes	• -219.3 MT CO_2 per hectare
Waste Management	Wastewater (septic)	• 0.124 g CH_4 per gallons of wastewater • 0.0014 g N_2O per gallon of wastewater
	Wastewater (aerobic)	• 0.022 g CH_4 per gallons of wastewater • 0.0002 g N_2O per gallon of wastewater
	Wastewater (anaerobic)	• 0.059 g CH_4 per gallons of wastewater • 0.0005 g N_2O per gallon of wastewater
	Wastewater (reactor)	• 0.055 g CH_4 per gallons of wastewater • 0.0001 g N_2O per gallon of wastewater

Sources: (1) U.S. EPA. 2023. Emissions Factors for Greenhouse Gas Inventories. Available at: https://www.epa.gov/climateleadership/ghg-emission-factors-hub. Table 1. (2) IPCC. 2006. IPCC Guidelines, Volume 4, Chapter 4: "General Methodologies Applicable to Multiple Land Use Categories." IPCC. Available at: https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_02_Ch2_Generic.pdf. p. 2.11. (3) IPCC. 2006. IPCC Guidelines, Volume 4, Chapter 4: "Agriculture, Forestry and Other Land Use." IPCC. Available at: https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_04_Ch4_Forest_Land.pdf. p. 4.12. (4) IPCC. 2006 Guidelines for National Greenhouse Gas Inventories, Volume 4, Chapter 2. Available at: https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_02_Ch2_Generic.pdf, Equation 2.27, Tables 2.3, 2.5, and 2.6. Equation 11.2, Table 11.1 (5) World Resources Institute. 2014. Global Protocol for Community-Scale Greenhouse Gas Emission Inventories. Available at: https://ghgprotocol.org/sites/default/files/ghgp/standards/GHGP_GPC_0.pdf. Table 8.3. (6) IPCC. 2006. IPCC Guidelines, Volume 5, Chapter 6.10: "Wastewater Treatment and Discharge" IPCC. Available at: https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_6_Ch6_Wastewater.pdf. Equations 6.2 and 6.7, Tables 6.2 and 6.3. (7) U.S. EPA. 2019. U.S. Cement Industry Carbon Intensities. EPA. Available at: https://www.epa.gov/system/files/documents/2021-10/cement-carbon-intensities-fact-sheet.pdf. p.1. (8) U.S. EPA. 2023. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2021. Available at: https://www.epa.gov/system/files/documents/2023-04/US-GHG-Inventory-2023-Main-Text.pdf. p.4-153. (9) British Columbia Ministry of Environment and Climate Change Strategy. April 2021. 2020 B.C. Best Practices Methodology for Quantifying Greenhouse Gas Emissions [Table 8]. Available at: https://www2.gov.bc.ca/assets/gov/environment/climate-change/cng/methodology/2020-pso-methodology.pdf. p.21. (10) U.S. EPA. 2023. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2021. Available at: https://www.epa.gov/system/files/documents/2023-04/US-GHG-Inventory-2023-Main-Text.pdf. p.4-153.

2019/2021 Inventory

Sectors and subsectors represent key categories for methods and analysis in an emissions inventory and its projections—i.e., their estimates have a significant influence on a country or region's emissions with regard to the absolute level, trend, or uncertainty of those emissions.[109] They also facilitate the organization of calculation methodologies, data collection, emissions calculations, and projections.[110]

For each sector, AEC carried out the following steps for estimating emissions, then summing across sectors to estimate Puerto Rico's total emissions:

1. Determine emissions sectors and subsectors in accordance with IPCC guidelines on the selection of key categories and subcategories.
2. Gather activity data and emissions factors for each sector and subsector.
3. Make determinations regarding the highest possible complexity (or IPCC tier) of calculations given available data.
4. Enter activity data and emissions factors into the AEC-EMIT tool.
5. Adjust assumptions and parameters for emissions calculations in the AEC-EMIT tool.
6. Modify calculations and data sources as needed to account for natural disasters or other data abnormalities.
7. Multiply activity data by the respective greenhouse gas emissions factors.
8. Consolidate final emissions calculations by sector and total in CO_2e.

Projections and sensitivity analysis

AEC-EMIT projects several scenarios and sensitivities for Puerto Rico by sector for the years 2022 to 2041:

- **A "Business-as-Usual" scenario**, (or baseline), projects emissions over chosen years assuming the most likely economic outcomes under current regulations and statutes; specific forecasting assumptions for each sector are provided below. This Business-as-Usual scenario assumes no impacts from severe storms.
- Alternative scenarios differ from the Business-as-Usual scenario based either on the data used or assumptions made about the future. The 2019/2021 Inventory provides two scenarios in addition to the Business-as-Usual scenario:
    - **Severe Hurricanes:** A scenario in which Puerto Rico experiences a severe hurricane (assumed to have damaged consistent with a Category 5 hurricane, such as Hurricane María) at a high-paced frequency (three times per decade). Note that Hurricane Fiona in 2022 occurred so recently that data regarding its emission impacts are not available.
    - **Decarbonization:** A strict climate policy scenario in which Puerto Rico dramatically accelerates efforts to decarbonize by electrifying the end-use consumption of energy, particularly in the Direct Fuel and Transportation sectors, and by retiring all greenhouse-gas emitting power

[109] IPCC. 2006. *Chapter 4: Methodological Choice and Identification of Key Categories.* IPCC. Available at: https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/1_Volume1/V1_4_Ch4_MethodChoice.pdf. p. 4.5.
[110] Ibid, p. 4.5.

generation.

- **Sensitivity analyses** examine changes in emission projections that result from variations to underlying assumptions or key parameters of the projection—baseline forecast data, specific assumptions, or calculation parameters—to ensure that projections do not have large differences based on small changes to calculation methods. The 2019/2021 Inventory conducts sensitivity analysis on each of its three scenarios (Business-as-Usual, Severe Hurricanes, and Decarbonization) by assuming variations in Puerto Rico's economic activity, both high and low.

AEC's method of emissions projections is as follows: (1) project changes in underlying activity data for each subsector; (2) forecast emissions using the assumption that emission factors remain unchanged over time. To project changes in activity data, we associate each data point with an existing forecast for which we have data over the relevant period (GDP, population, land use changes, etc.). We assume that activity data follow the same rate of change as the associated existing forecast.

AEC reviewed forecasts and other assessments from the U.S. HUD's Climate Action Plan[111], Guía Rápida al Plan de Uso de Terrenos de Puerto Rico[112], 2045 Puerto Rico Long Range Multimodal Transportation Plan[113], data from the U.S. Census Bureau[114], International Monetary Fund[115], Federal Reserve Economic Data[116], and Global Forest Watch[117], State Data Center PR[118], The Causes and Consequences of Puerto Rico's Declining Population[119]; the U.S. Bureau of Economic Analysis Puerto Rico[120]; Economic Census of Puerto Rico[121]; and the Puerto Rico Energy Public Policy Act of 2019 (Act No. 17-2019).[122]

Forecast data are limited to population, employment, GDP, GDP per capita, and Gross National Product (GNP) specific to Puerto Rico, and U.S.-wide fuel prices; many of those projections have been estimated by non-Puerto Rican institutions and often extend only until 2027. Given better access to additional forecasts of demographic and economic data, future Puerto Rico inventories may benefit from emissions scenarios or sensitivities related

[111] United States Housing and Urban Development. 2021. *Climate Action Plan.* Available at: https://www.hud.gov/sites/dfiles/Main/documents/HUD-Climate-Action-Plan.pdf

[112] Junta de Plantificacion de Puerto Rico. 2016. *Guía Rápida al Plan de Uso de Terrenos de Puerto Rico*. Available at: https://gis.jp.pr.gov/PUT2015/Gu%C3%ADa%20Plan%20de%20Uso%20de%20Terrenos%202016.pdf

[113] Steer. 2018. *2045 Puerto Rico Long Range Multimodal Transportation Plan.* Steer. Prepared for Puerto Rico Highways and Transportation Authority (PRHTA). Available at: http://lrtp.steergroup.com.co/wp-content/uploads/2018/12/PR-Island-wide_FINAL.pdf.

[114] United States Census Bureau. 2023. International Database Tool. Available at: https://www.census.gov/data-tools/demo/idb/#/country?YR_ANIM=2020&COUNTRY_YEAR=2023&COUNTRY_YR_ANIM=2023

[115] International Monetary Fund. 2022. *World Economic Outlook Database*. Available at: https://www.imf.org/en/Publications/WEO/weo-database/2022/October.

[116] Federal Reserve Economic Data. 2022. *Gross National Income for Puerto Rico*. Available at: https://fred.stlouisfed.org/series/NYGNPMKTPCDPRI

[117] Global Forest Watch. 2022. *Puerto Rico*. Available at: https://www.globalforestwatch.org/

[118] State Data Center, Puerto Rico. 2022. Available at: https://censo.estadisticas.pr/.

[119] Abel, J.R. and Deitz, R. 2014. "The Causes and Consequences of Puerto Rico's Declining Population." *Current Issues in Economics and Finance, 20 (4).* Available at: https://www.newyorkfed.org/research/current_issues/ci20-4.html

[120] Bureau of Economic Analysis. 2022. *Gross Domestic Product for Puerto Rico, 2020.* Available at: https://www.bea.gov/data/gdp/gdp-puerto-rico.

[121] United States Census Bureau. 2017. *Economic Census of Puerto Rico*. Available at: https://www.census.gov/data/tables/2017/econ/economic-census/puerto-rico.html.

[122] Puerto Rico Laws Act 17. 2019. *An Act Establishing the Puerto Rico Energy Public Policy Act*. Available at: https://bvirtualogp.pr.gov/ogp/Bvirtual/leyesreferencia/PDF/2-ingles/17-2019.pdf.

to emissions limits, a carbon tax or emissions markets, renewable energy goals, microgrids, electric vehicles, energy efficiency, impacts from electric outages, severe drought, wildfires, land use changes, protection of Puerto Rico's natural heritage, an aging population, emigration, or urban and rural growth patterns.

The most dependable emissions projections come from high-quality forecasts of activity data and of related socioeconomic data. Typically, socioeconomic forecasts for states and localities are developed by local agencies, research institutions, and academics, with in-depth knowledge of social and economic drivers, impacts, and interconnections. We were not able to identify any such local sources of socioeconomic forecasting for Puerto Rico and instead relied on inferior forecasting created by U.S. and/or international agencies and organizations.

To create scenarios, forecast data are used to adjust the activity data on which emissions are based. This projection method is used in greenhouse gas emissions inventories for several U.S. states, and by the U.S. EPA's State Inventory and Projection Tool.[123] For each sector, AEC used the following steps to estimate projections:

1. Determine the data necessary to make the Business-as-Usual scenario, alternative scenarios, and sensitivity projections.
2. Gather the necessary forecast data.
3. Enter forecast data into the AEC-EMIT tool.
4. Create the Business-as-Usual and other alternative scenarios and sensitivities using forecast data as a basis to project activity data out for 20 years.
5. Adjust assumptions, parameters, scenarios, and sensitivities in the AEC-EMIT tool.
6. Multiply projected activity data by their respective emissions factors.
7. Consolidate final projections by sector and total in CO_2e.

The 2019/2021 Inventory accounts for the effect of natural disasters on emissions projections in three ways:

1. The 2019/2021 Inventory accounts for severe storm impacts by using historical data and information on relevant storm impacts to extrapolate or interpolate 2019 and 2021 data.
2. Business-as-Usual activity projections accounts for the more common-place impacts of Category 1-3 storms on the Puerto Rican economy through forecasted activity data.
3. Future projections account for the possibility of Category 5 severe hurricanes are represented as an alternative, Severe Hurricanes, scenario.

Quality Assurance and Quality Control Procedures

Development of the 2019/2021 Inventory implemented both internal and external quality assurance and quality control (QA/QC) procedures based on guidelines from the IPCC.[124] The QA/QC methodology used is

[123] (1) Wartmann, S., Sheldon, D., Watterson, J. 2021. Projections of Greenhouse Gas Emissions and Removals: An Introductory Guide for Practitioners. GIZ. Prepared for the Federal Ministry for the Environmental, nature Conservation and Nuclear Safety. Available at: https://unfccc.int/documents/358238. (2) ICF. 2023. *User's Guide for States Using the Greenhouse Gas Projection Tool.* Prepared for the State Energy and Environment Program, U.S. EPA. Available at: https://www.epa.gov/statelocalenergy/download-state-inventory-and-projection-tool?token=1lMB9dPZeyhYruS4fTOcJ9qPVUNbewZFtpFWcSlvaQI. (3) Taylor, T. 2021. *Colorado 2021 Greenhouse Gas Inventory Update With Historical Emissions from 2005 to 2019 and Projections to 2050*. Colorado Air Pollution Control Division. Available at: http://hermes.cde.state.co.us/drupal/islandora/object/co:36031/datastream/OBJ/view

[124] IPCC. 2006. *Chapter 6: Quality Assurance/Quality Control and Verification.* IPCC. Available at: https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/1_Volume1/V1_6_Ch6_QA_QC.pdf.

presented below as: (1) a flow chart showing the steps of the QA/QC process in Figure 25 below; (2) a list of quality control criteria in Table 6; and (3) a sample form for reviewer input in Table 7 below. External QA/QC was performed by an Expert Panel described below. Data inputs were internally verified and cross-checked with multiple sources. Emissions calculations are internally reviewed twice before being passed to DNER and the Expert Panel for a final review.

Table 6. Quality control criteria

Stage	QC Criteria	Procedures
Data inputs	Data input from the original source is accurate and properly sourced	Confirm that correct and reliable references were used
		Confirm that references are accurate and traceable to source
		Cross-check data for transcription errors
		Check for activity data measurements (i.e. ensure that data conversions or other manipulations that are needed are correctly performed, or if direct emissions data have been properly collected)
Emissions calculation	Calculation process is clearly documented	Confirm that calculations are auditable, consistent, and replicable
	Emissions are calculated accurately	Recalculate manually a representative sample of emission calculations to judge accuracy
		Check that correct emission and Global Warming Potential (GWP) factors are used
		Consult with expert panel to review the integrity of the methods and assumptions used
	Appropriate conversion factors are used	Check that units are properly labeled in calculation sheets
		Check that conversion factors are reliable and correct
	Database files have integrity	Confirm that all processing steps are accounted for and that the path of data is represented in the database
		Confirm that the data fields are properly labeled and that data relationships are correctly represented
Reporting (external documentation)	Data sources are consistent and comparable to external sources	Confirm consistency in parameters used for emissions calculations
		Check that emissions data are correctly aggregated
		Compare results to reported emissions from other countries, sites, or plant, as applicable
	Documentation is detailed and transparent	Check that there is detailed internal documentation to support estimates and outline QA/QC process
		Expert panel has been consulted to review the integrity of the methods and assumptions
		Check that inventory data are archived and stored properly

Figure 25. AEC 2019/2021 inventory schematic

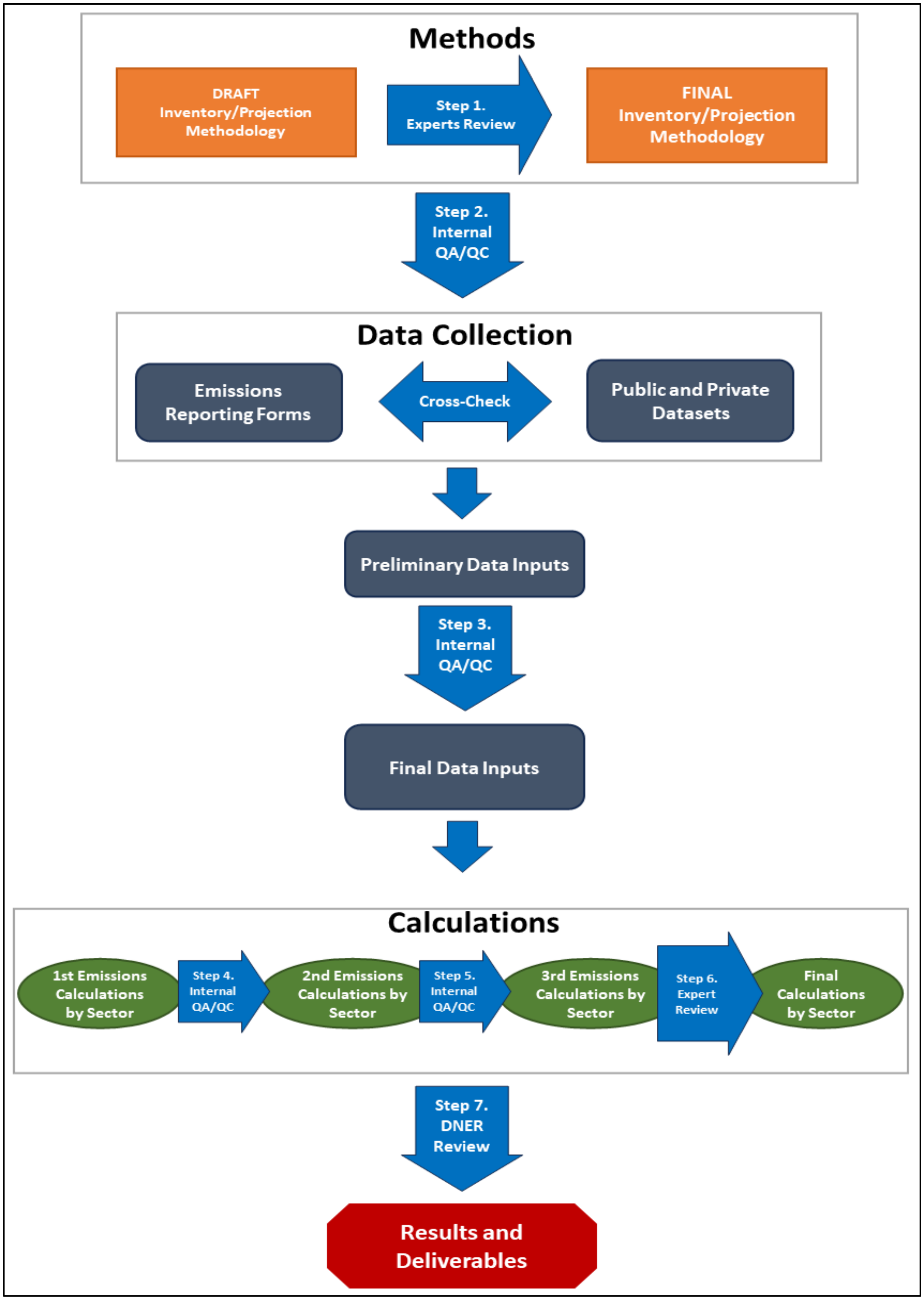

Table 7. Sample form for reviewer input

Puerto Rico 2019/2021 Greenhouse Gas Emissions Inventories			
Reviewer:			
Date:			
Quality Item	**Yes**	**No**	**Comments**
Data inputs			
1. Correct and reliable source references were used			
2. Source references are accurately cited			
3. Data has been cross-checked for transcription errors			
4. Data conversions or other needed manipulations are correctly performed, or else direct emissions data have been properly collected			
Emissions calculation			
5. Calculations are auditable, consistent, and replicable			
6. Correct emission and Global Warming Potential (GWP) factors are used			
7. Created a representative sample of emission calculations and recalculate emissions manually; cross-check if results are equivalent			
8. Consulted with expert panel to review the integrity of the methods and assumptions used			
9. Units are properly labeled in calculation sheets			
10. Conversion factors are reliable and correct			
Reporting (external documentation)			
11. All process steps are accounted for and the path of data is represented in the database			
12. Data fields are properly labeled and that data relationships are correctly represented			

Expert Panel

The AEC team assembled an Expert Panel to offer its input and vast local knowledge regarding the methodology employed and the results of the Inventory and projections. The Expert Panel offered extensive review and feedback on the model and methodology developed, the use of data and assumptions under consideration for the Inventory and its future projections, and on preliminary emissions estimates. The Expert Panel enhances the quality of the final Inventory product bringing to its development process observations regarding strengths, weaknesses, and opportunities in proposed emissions estimation methods and offering its best suggestions for possible improvements on a sector-by-sector basis.

The Panel consists of experts from a variety of backgrounds and experiences related to greenhouse gas emissions, including academics, scientists, agency officials, and service organizations, and nonprofit leaders. The Expert Panel's composition also takes into account different sectors of emissions sources: Power Supply, Direct Fuel, Industrial Processes, Transportation, Agriculture, Forestry and Other Land Use, and Waste Management. Panelists were recruited from in Puerto Rico as well as elsewhere in the United States and the Caribbean.

After outreach via phone and email to 44 experts (more than one-third of who were Puerto Rican), the following candidates were selected to serve on the expert review panel:

- Félix Aponte Ortiz, *University of Puerto Rico*
- Juan Declet-Barreto, *Union of Concerned Scientists (UCS)*
- Ryan Deosaran, *Greenhouse Gas Management Institute (GHGMI)*
- Ernesto Díaz, *Tetra Tech, Inc.*
- Ivonne C. Díaz Rodríguez, *University of Puerto Rico*
- William Gould, *USDA Caribbean Climate Hub*
- Nancy Harris, *World Resources Institute (WRI)*
- Juan Rosario, *AMANESER 2025*
- Sarah Simon, *Apple Creek Associates*
- John Venezia, *ICF Climate Planning*

Sector-specific methodologies

Sector 1: Power Supply

Puerto Rico's Power Supply sector generates electricity and delivers it to homes, businesses and other facilities via transmission and distribution infrastructure. The burning of fossil fuels such as natural gas or oil to generate electricity creates greenhouse gas emissions like CO_2, CH_4, and N_2O. In addition, SF_6 is emitted as a result of electric transmission and distribution activities.[125] As of 2023, there are no waste incineration facilities are used for electric generation in Puerto Rico.

The 2019/2021 Inventory uses the IPCC's "reference approach" methodology to calculate greenhouse gas emissions from all fuel combustion.[126] Estimates of fuel consumption in original units are collected, multiplied by their respective emissions-content, and allocated among the Power Supply, Direct Fuel, and Transportation sectors based on data origin, the purpose, or application of the fuel consumption.[127]

Activity data: Power Supply activity data are the amount of fossil fuels combusted to generate electricity for the entire Puerto Rican economy. AEC reviewed and cross-checked data from PREPA, U.S. EIA, the Department of Regulations and LUMA, EPA, and the Emissions Database for Global Atmospheric Research (EDGAR).

As it did for the 2014 Inventory, PREPA provided fuel use data for all PREPA-owned electric generating units, which includes resources powered by natural gas, residual fuel oil, and distillate fuel oil.[128] Due to data inconsistencies likely resulting from misclassification of fuel oils between residual (No. 6) and distillate (No. 2), U.S. EIA data on residual fuel oil consumption and distillate fuel oil consumption were aggregated into a "total

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[125] Estado Libre Asociado de Puerto Rico. 2014. *Puerto Rico Greenhouse Gases Baseline Report.* Available at: https://drna.pr.gov/wp-content/uploads/2017/05/Puerto-Rico-GHG-2014.pdf. p. 38; 46.

[126] IPCC. 2006. *Chapter 6: Reference Approach.* IPCC. Available at: https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_6_Ch6_Reference_Approach.pdf.

[127] IPCC, 2006, p. 6.5.

[128] Direct Communication with Francisco Pérez Velázquez at PREPA's Office of the Deputy Director of Operations.

fuel oil" category, from which residual fuel oil and distillate fuel oil consumption amounts reported by PREPA were subtracted. PREPA also purchases electricity from coal-, natural gas-, and landfill gas-fired resources. Total coal-fired fuel consumption was collected from U.S. EIA datasets on fuels imported into Puerto Rico.[129] PREPA provided electric generation (in megawatt-hours (MWh)) from natural gas (owned by EcoEléctrica) and landfill gas generating units. AEC used heat rates (in million British thermal units (MMBtu) per MWh) calculated from data reported in EIA Form 923 to estimate the quantity of fuel associated with PREPA's electricity purchases. The heat rate used for EcoEléctrica's natural gas generation was based on data reported by EcoEléctrica to U.S. EIA, while the heat rate for landfill gas was based on a U.S.-wide average for landfill gas-fired internal combustion engines.

Emissions factors: The 2019/2021 Inventory uses U.S. EPA emissions factors for stationary fuel combustion.[130]

IPCC tier: The use of fuel-based activity data and country-specific emission factors is a Tier 2 classification under the IPCC guidelines. (Tier 3 power sector emissions would require calculations on a plant-by-plant basis.)[131]

Projection forecast activity data:

- Business-as-Usual: assumes a decline in electric generation in proportion to the declining Puerto Rican population as forecast by the U.S. Census Bureau (these same projections are used in Puerto Rico's 2045 Puerto Rico Long Range Multimodal Transportation Plan).[132] Relative proportion of fuels used remains constant; base year fuel use value is 2021 data for each fuel. Residential and commercial sectors account for 87 percent of all Puerto Rican electric consumption;[133] change in population is a good and commonly used proxy for change in residential and commercial electric consumption. Puerto Rico's sole coal power plant, AES, is scheduled to retire in Puerto Rico in the year 2027. These Business-as-Usual projections assume a constant level of generation from AES until 2028 and zero generation thereafter.
- Decarbonization: steady reduction of fossil fuel use for power projection at a linear trend reaching zero tons of CO_2e emissions in 2050; AES retires in 2027.
- Severe Hurricanes: starting with the Business-as-Usual forecast as a baseline, assumes a hurricane-year loss to power generation of 10 percent of the island with no power for 10 percent of the year (or, equivalently, 50 percent of the island without power for 2 percent of the year); storms are assumed to strike every third year on average and the average annual impact is applied to every future year; AES retires in 2027.
- High economic growth: starting with the Business-as-Usual forecast as a baseline, a 2 percent increase in natural gas power production every year. Power Supply emissions in the high economic growth

[129] U.S. EIA. 2023. "Puerto Rico Territory Energy Profile." Available at: https://www.eia.gov/state/print.php?sid=RQ
[130] U.S. EPA Center for Corporate Climate Leadership. 2022. *Emission Factors for Greenhouse Gas Inventories.* Available at: https://www.epa.gov/system/files/documents/2022-04/ghg_emission_factors_hub.pdf.
[131] IPCC. 2006. *IPCC Guidelines, Volume 1, Chapter 1.6 "Introduction to the 2006 Guidelines."* IPCC. Available at: https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/1_Volume1/V1_1_Ch1_Introduction.pdf, p. 1.6.
[132] United States Census Bureau. 2023. International Database Tool. Available at: https://www.census.gov/data-tools/demo/idb/#/country?YR_ANIM=2020&COUNTRY_YEAR=2023&COUNTRY_YR_ANIM=2023
[133] Siemens Industry. 2019. *Puerto Rico Integrated Resource Plan 2018-2019.* Prepared for Puerto Rico Electric Power Authority. Available at: https://aeepr.com/es-pr/QuienesSomos/Ley57/Plan%20Integrado%20de%20Recursos/IRP2019%20-%20Ex%201.00%20-%20Main%20Report%20%20REV2%2006072019.pdf. p.3-1

sensitivity are projected to increase at the average annual growth rate of Puerto Rico's GDP as approximated from recent trends in GDP growth for Puerto Rico according to the International Monetary Fund and recent trends in GDP growth for Puerto Rico according to the U.S. Federal Reserve.

- Low economic growth: starting with the Business-as-Usual forecast as a baseline, a 2 percent decrease in all power production in every year. An annual decrease of 2 percent in the low economic growth sensitivity is an assumption designed to parallel growth forecasted in the high economic growth sensitivity. Because the Business-as-Usual scenario already includes the assumption of substantial population decline over the next two decades, and the impacts of that decline on activity data and emissions, the high and low economic growth scenarios are designed purely as a sensitivity, examining the effects on emissions of a range of different growth predictions.

Caveats and assumptions:

Combined heat and power: The power sector includes fuel consumed in Puerto Rico for the production of electricity at combined heat and power (CHP) facilities**.** CHP facilities produce both electricity and thermal output used for heating in colder climates or for industrial uses. In the 2019/2021 Inventories all emissions from CHP units are allocated in their entirety to the power sector.

Exclusion of upstream emissions: Like the 2014 Inventory, the 2019/2021 Inventory does not include upstream emissions from extracting, refining, and transporting fuel used to generate electricity. Emissions are limited to activities occurring within Puerto Rico.

Emissions of nitrous oxide (N_2O): While N_2O emissions from fossil fuel combustion may vary based on the equipment used (e.g., internal combustion vs. boilers for fuel oil), we assume a standard emission factor for each fossil fuel type based on U.S. EPA's emission factors hub.[134]

Emissions from cogeneration facilities: The natural gas subsector encompasses emissions from cogeneration facilities.

Sector 2: Direct Fuel

The Direct Fuel sector encompasses all of Puerto Rico's emissions from fuel use with the exceptions of the Power Supply and Transportation sectors.[135] (Note that Puerto Rico has no fuel exports and bunker fuels are discussed in the Transportation sector section below.) For example, distillate fuel oil, liquified petroleum gases, or kerosene are used by households for back-up generation, water heating and cooking, and businesses to run machinery and for process heating.[136]

[134] U.S. EPA. April 2023. Emissions Factors for Greenhouse Gas Inventories. Available at: https://www.epa.gov/climateleadership/ghg-emission-factors-hub.

[135] Emissions counted in this sector would include fossil fuel combustion for industrial purposes, but not non-combustion sources of greenhouse gas emissions from industrial sectors.

[136] Estado Libre Asociado de Puerto Rico. 2014. *Puerto Rico Greenhouse Gases Baseline Report.* Available at: https://drna.pr.gov/wp-content/uploads/2017/05/Puerto-Rico-GHG-2014.pdf. p. 54.

Activity data: Direct Fuel activity data are the amount of fossil fuels combusted for activities other than electric generation or transportation. The 2014 Inventory used fuel tax revenue data to impute fuel consumption. U.S. EIA, PREPA, Puerto Rico's Department of Consumer Affairs (DCA), Department of Finance (DF), and Maritime Transport Authority (MTA) data on fuel use in Puerto Rico do not agree; in fact, none of these sources are in agreement with any other source.

Given that limitation, Direct Fuel activity data are based on the following assumptions: Total fuel oil per U.S. EIA, less fuel oil used by PREPA, equals a small amount of distillate fuel oil (diesel) assumed to be used in the Direct Fuel sector. U.S. EIA does not report any additional diesel imports, but DCA and DF report diesel used for transportation. We assume, therefore, that all transportation diesel is unrecorded by U.S. EIA.

DCA reports motor diesel and gasoline as a combined value; U.S. EIA reports gasoline imports. We assume that the difference between the two is motor diesel. (It is about one-half the volume of gasoline consumption.)

DF reports revenues for fuel purchases together with tax rates; from that we estimate fuel volume purchased. This amount ignores fuel that is exempt from taxation. According to DF data, revenues from jet fuel and marine diesel combined dropped from $4 million in 2019 to $2 million in 2020 to $0.5 million in 2021 while the tax rate stayed the same. According to U.S. EIA, imports of jet fuel doubled over this same period, reaching an amount greater than DF's jet fuel plus marine diesel in 2020. We assume that the marine diesel estimated for 2019 (as DF jet fuel plus diesel fuel less U.S. EIA jet fuel) remained constant through 2021.

Puerto Rico's direct fuel use data was sourced from U.S. EIA's datasets on Puerto Rican fuel import and consumption of natural gas, fuel oil, kerosene, and liquefied petroleum gases.[137] The direct fuel consumption activity data are calculated by subtracting Power Supply and Transportation sector fuel consumption from total fuel consumption.

U.S. EIA data had inconsistent values for the consumption of residual and distillate fuel oils in 2021, which were constructed from a model and not direct data. Due to data inconsistencies likely resulting from misclassification of fuel oils between residual (No. 6) and distillate (No. 2), U.S. EIA data on residual fuel oil consumption and distillate fuel oil consumption were aggregated into a "total fuel oil" category, from which residual fuel oil and distillate fuel oil consumption amounts reported by PREPA were subtracted. The remaining amount of fuel oil was assumed to be distillate fuel oil, the entirety of which used in the Direct Fuel sector. None of the distillate fuel oil consumption estimated by U.S. EIA was attributed to the Transportation sector, as the quantity of consumption remaining after subtracting consumption for the Power Supply sector was too small to be inclusive of all transportation-related diesel. Diesel for transportation is calculated using data from the DCA.[138]

In addition, kerosene consumption is reported erroneously as a zero value in the U.S. EIA data for the year 2020. To address these gaps in the direct fuel consumption data, AEC imputed values for kerosene consumption and direct distillate fuel oil consumption based on the 2019 consumption values for each fuel.

Emissions factors: The 2019/2021 Inventory uses U.S. EPA emissions factors for stationary fuel combustion.[139]

[137] U.S. EIA. 2023. "Puerto Rico Territory Energy Profile." Available at: https://www.eia.gov/state/print.php?sid=RQ

[138] Puerto Rico DCA. 2022. *Consumption of gasoline*. Available at: https://www.daco.pr.gov/wp-content/uploads/2018/11/Consumo-de-Gasolina-1986-a-actual-13.xlsx

[139] U.S. EPA Center for Corporate Climate Leadership. 2022. *Emission Factors for Greenhouse Gas Inventories.* Available at: https://www.epa.gov/system/files/documents/2022-04/ghg_emission_factors_hub.pdf.

IPCC tier: The use of fuel-based activity data and country-specific emission factors is a Tier 2 classification under the IPCC guidelines. (Tier 3 power sector emissions would require calculations on a technology by technology basis.)[140]

Projection forecast activity data:

- Business-as-Usual: assumes a decline in direct fuel use in proportion to the declining Puerto Rican population; base year fuel use value is 2021 data for each fuel.
- Decarbonization: steady reduction of direct fuel use at a linear trend reaching zero tons of CO_2e emissions in 2050.
- Severe Hurricanes: starting with the Business-as-Usual forecast as a baseline, assumes a hurricane-year loss to fuel imports of 5 percent; storms are assumed to strike every fifth year on average and the average annual impact is applied to every future year.
- High economic growth: starting with the Business-as-Usual forecast as a baseline, a 2 percent increase in direct fuel use in every year.
- Low economic growth: starting with the Business-as-Usual forecast as a baseline, a 2 percent decrease in direct fuel use in every year.

Caveats and assumptions

Separation of fuel uses among Direct Fuel subsectors: U.S. EIA fuel combustion data are not disaggregated among the residential, commercial, institutional, and industrial subsectors. No other sources of data were found that provide this disaggregation.

<u>Sector 3: Industrial Processes and Product Use</u>

Industrial Processes and Product Use encompasses a handful of manufacturing processes in Puerto Rico: cement production, semiconductor manufacturing, and the production and use of substitutes of ozone depleting substances (ODS) in cooling and refrigeration equipment. AEC reviewed and cross-checked data from Puerto Rico's Economic Development Bank (BDE), EPA, U.S. Census Bureau's Statistics of U.S. Businesses (SUSB) and County Business Patterns, Instituto de Estadísticas de Puerto Rico, the U.S. EPA's State Inventory Tool Industrial Processes module, and direct outreach to Puerto Rican manufactures. This sector captures any greenhouse gas emissions from these processes other than those produced by combustion of fossil fuels; emissions from the combustion of fuels for industrial purposes are captured in the Direct Fuel sector.

Industrial Processes subsectors were selected for inclusion in the 2019/2021 Inventory as follows: First, a list was compiled of all industrial process sectors analyzed in Puerto Rico's 2014 Greenhouse Gas Inventory.[141] From this list, one item (glass production) was removed because Puerto Rico's only glass manufacturer discontinued its operations in Puerto Rico in 2008. Potential additional industries were examined based on the Industrial Processes sectors listed in the U.S. EPA's 2022 Inventory of Greenhouse Gas Emissions and Sinks; no additional

[140] IPCC. 2006. *IPCC Guidelines, Volume 2, Chapter 2 ["Stationary Combustion"].* IPCC. Available at: https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/1_Volume1/V1_1_Ch1_Introduction.pdf, p. 2.24.

[141] Estado Libre Asociado de Puerto Rico. 2014. *Puerto Rico Greenhouse Gases Baseline Report.* Available at: https://drna.pr.gov/wp-content/uploads/2017/05/Puerto-Rico-GHG-2014.pdf. Table C-1.

industries were identified that were applicable to Puerto Rico.

Activity data: Very little industrial process data is collected for Puerto Rico. Industrial Processes activity data for cement production were sourced from BDE in sacks (each 94 lbs.) per month.[142] Activity data for Puerto Rico's semiconductor manufacturing and ODS substitutes were not readily available. In absence of these data, AEC used emissions data reported in the EPA's emissions inventory for the entire United States and scaled it down to Puerto Rico based on the respective workforce in each industry. More specifically, AEC apportioned U.S.-wide 2019 and 2021 emissions data (which includes Puerto Rico) reported in the U.S. EPA's *2022 Inventory of U.S. Greenhouse Gas Emissions and Sinks*[143] to Puerto Rico using the ratio of the Puerto Rican workforce to the total U.S. workforce in each of these industries based on the SUSB data.[144] While workforce data for 2019 were available, workforce data for 2021 were not, so 2020 data were used instead. (For comparison, the 2014 Inventory uses a similar methodology for cement emissions estimation, does not include emissions from the semiconductor industry, and bases its ODS emissions on U.S. emissions estimates scaled by population rather than employment.)

Emissions factors: Median emissions factors for cement production were calculated by the U.S. EPA in a 2019 analysis of cement production facilities' annual cement production (in metric tons) and annual CO_2 emissions (in metric tons), based on information reported by facilities to the U.S. EPA's Greenhouse Gas Reporting Program (GHGRP).[145]

IPCC tier: As semiconductors and ODS emissions data were available to our team, these data were used directly in place of the use of activity data and IPCC tiered methodology. The activity data provided to AEC and emissions factors for cement production involved cement values themselves rather than clinker production and hence does not utilize IPCC tiered methodology.

Projection forecast activity data:

- Business-as-Usual: assumes an increase in industrial production in proportion to expected growth in GDP and GNP (we assume a 2 percent annual growth rate loosely based on a 2024 GDP growth forecast from the International Monetary Fund and recent past growth in GNP from the Federal Reserve Economic Data);[146] base year fuel use value is 2021 data for each fuel.
- Business-as-Usual for HFCs only: The Kigali Amendment significantly phases-down future production and consumption of HFCs to reduce emissions of potent HFC greenhouse gases with a high GWP.[147] HFCs are assumed to reduce linearly from average 2011-2014 levels in 2022 to 45 percent of those

[142] Banco de Desarrollo Económico para Puerto Rico (BDE). 2023. *Producción y ventas de cemento*. Available at: https://estadisticas.pr/en/inventario-de-estadisticas/produccion_y_ventas_de_cemento
[143] U.S. EPA. 2022. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2020*. Available at: https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2020
[144] U.S. Census Bureau. 2022. *County Business Patterns* [Table IDs: CB2000CBP and CB1900CBP]. Available at: https://www.census.gov/data/tables/2019/econ/susb/2019-susb-annual.html
[145] U.S. EPA. 2019. "U.S. Cement Industry Carbon Intensities." Available at: https://www.epa.gov/system/files/documents/2021-10/cement-carbon-intensities-fact-sheet.pdf
[146] (1) International Monetary Fund. October 2022. *World Economic Outlook Database.* Available at: https://www.imf.org/en/Publications/WEO/weo-database/2022/October; (2) Federal Reserve Economic Data. 2022. *Gross National Income for Puerto Rico for Puerto Rico.* Available at: https://fred.stlouisfed.org/series/NYGNPMKTPCDPRI
[147] United Nations. 2016. *Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer.* Available at: https://treaties.un.org/Pages/ViewDetails.aspx?src=IND&mtdsg_no=XXVII-2-f&chapter=27&clang=_en

levels in 2024 and 85 percent of those levels in 2035, remaining constant thereafter. All other industrial process emissions grow 2 percent each year.

- Decarbonization: no change from baseline.
- Severe Hurricanes: no change from baseline.
- High economic growth: starting with the Business-as-Usual forecast as a baseline, a 2 percent increase in industrial activity in every year.
- Low economic growth: starting with the Business-as-Usual forecast as a baseline, a 2 percent decrease in industrial activity in every year.

Caveats and assumptions

There is likely imprecision in the emission estimates for Industrial Processes and Product Use sector, particularly for the ODS substitutes and semiconductors subsectors, which lacked any accessible Puerto Rico-specific activity data and thus relied on apportionment of U.S.-wide emissions estimates to Puerto Rico based on workforce size. Ideal data sources would include supplier-provided data on the quantity of each ODS substitute chemical sold by each supplier in Puerto Rico and facility-specific data on the production of semiconductors.

Process-emission producing industries excluded from analysis were also excluded from the 2014 Inventory's analysis due to the likely insignificance of their emissions in Puerto Rico. These industries include metals manufacturing, chemicals manufacturing, and urea applications, among others.

<u>Sector 4: Transportation</u>

The Transportation sector releases emissions from fuel combustion for personal and commercial automobiles, air travel, and marine travel in and from Puerto Rico.

Activity data: Transportation sector activity data are the amount of fossil fuels combusted for transportation activities. AEC reviewed and cross-checked data from U.S. EIA, Puerto Rico's DF and DCA, and the U.S. Department of Transportation. (Note that the 2014 Inventory included use of data for transportation emissions that are no longer made available.)

Fuel use data for motor gasoline and jet fuel was sourced from U.S. EIA datasets on Puerto Rican fuel consumption.[148] On-road diesel fuel consumption in the Transportation sector is equal to Puerto Rico's economy-wide consumption of motor vehicle fuel less its consumption of motor gasoline specifically. (This is a fuel-based emissions estimation methodology; no estimations regarding vehicle miles traveled were used.)

The 2020 *Inventory of U.S. Greenhouse Gas Emissions and Sinks* notes that the U.S. EIA data it uses to calculate total jet fuel consumption include bunker fuels used for international travel, and per the 2006 IPCC guidelines, the U.S. Inventory subtracts out the estimated amount of international bunker fuel use from its total jet fuel consumption estimate.[149] The U.S. Inventory bases its calculation of bunker fuels on unpublished data obtained from the Departments of Defense and Commerce, estimates created in a tool used by the Federal Aviation

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[148] U.S. EIA. 2023. "Puerto Rico Territory Energy Profile." Available at: https://www.eia.gov/state/print.php?sid=RQ

[149] U.S. EPA. 2022. Inventory of U.S. Greenhouse Gas Emissions and Sinks, Annex 2: Methodology and Data for Estimating CO2 Emissions from Fossil Fuel Combustion. Available at: https://www.epa.gov/sites/default/files/2021-04/documents/us-ghg-inventory-2021-annex-2-emissions-fossil-fuel-combustion.pdf. p. A-63

Administration, and assumptions regarding fuel combusted while ships are in port. The 2014 Inventory included fuel from all outgoing air and marine travel, including bunker fuels.

The U.S. Bureau of Transportation Statistics (U.S. BTS) only makes limited data available for Puerto Rico. In 2019 and 2021, U.S. BTS reports that 90 percent and 95 percent, respectively, of passenger miles leaving PR were domestic.[150] For lack of other data, AEC deducts 10 percent and 5 percent of all jet fuel emissions to account for international bunker fuels. U.S. BTS data on the Port of San Juan (drawn from Puerto Rico Port Authority data) record total cargo tonnage as 47 percent domestic in 2019 and 49 percent domestic in 2020, the latest year for which data are available.[151] For lack of other data, AEC deducts 53 percent and 51 percent of all marine diesel emissions to account for international bunker.

Emissions factors: The 2019/2021 Inventory uses U.S. EPA emissions factors for mobile combustion.[152]

IPCC Tier: The use of fuel-based activity data for transportation emissions is a Tier 1 classification for on-road transportation under the IPCC guidelines. (Tier 2 Transportation sector emissions require data on consumption specific to particular technologies: multiple classifications of automobiles, airplanes, boats, etc.)[153] The methodology for calculating marine transportation emissions does not fall under an IPCC-tiered methodology. Aviation emissions calculations are Tier 1. (Tier 2 aviation emissions would require disaggregation of flight data into landing-take-off and cruise phases).[154] New data collection would be necessary to improve transportation emission calculations. IPCC Tier 2 emission calculations for transportation require fuel consumption data specific to each type of technology (automobiles, motorcycles, scooters, small trucks, large trucks, airplanes, boats, etc.). For aviation emissions, Tier 2 requires the disaggregation of flight data into landing/take-off and cruise phases.

Projection forecast activity data:

- Business-as-Usual: assumes a decline in transportation fuel use in proportion to the declining Puerto Rican population; base year fuel use value is 2021 data for each fuel.
- Decarbonization: steady reduction of transportation fuel use at a linear trend reaching zero tons of CO_2e emissions in 2050.
- Severe Hurricanes: starting with the Business-as-Usual forecast as a baseline, assumes a hurricane-year loss to fuel imports of 5 percent; storms are assumed to strike every fifth year on average and the average annual impact is applied to every future year.
- High economic growth: starting with the Business-as-Usual forecast as a baseline, a 2 percent increase in transportation fuel use in every year.

[150] United States Department of Transportation (U.S. DOT). N.d. Revenue Passenger-miles (the number of passengers and the distance flown in thousands (000)). Bureau of Transportation Statistics. Available at: https://www.transtats.bts.gov/Data_Elements.aspx?Data=1

[151] U.S. DOT BTS. N.d. "Port Profiles 2023." Available at: https://explore.dot.gov/views/PortProfiles2023/HomeDashboard?%3Aembed=y&%3AisGuestRedirectFromVizportal=y

[152] U.S. EPA Center for Corporate Climate Leadership. 2022. *Emission Factors for Greenhouse Gas Inventories.* Available at: https://www.epa.gov/system/files/documents/2022-04/ghg_emission_factors_hub.pdf.

[153] IPCC. 2006. *Chapter 3: Mobile Consumption.* IPCC. Available at: https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf.

[154] Ibid, p. 3.59.

- Low economic growth: starting with the Business-as-Usual forecast as a baseline, a 2 percent decrease in transportation fuel use in every year.

Caveats and assumptions:

Quantifying gasoline use for off-road purposes: The 2019/2021 Inventory does not estimate off-road gasoline use, instead assuming that all gasoline fuel use is for on-road purposes. The 2014 Inventory similarly does not estimate emissions from off-road gasoline use.

Quantifying diesel use for on-road purposes: While U.S. EIA data on fuel consumption in Puerto Rico include distillate fuel oil, the total amount of fuel oil (distillate plus residual) reported in the U.S. EIA data is roughly equal to the total fuel oil consumed by Puerto Rico's Power Supply sector (see above) as reported by PREPA, plus a small margin assumed to be distillate fuel oil used in residential and commercial generators. Because U.S. EIA estimates of distillate fuel oil consumption were deemed too low to be inclusive of transportation-related diesel use (based on the estimated diesel-related emissions reported in the 2014 Inventory), no distillate fuel oil captured in U.S. EIA's dataset on Puerto Rican fuel consumption was assumed to be used for transportation. Instead, diesel fuel consumption for the Transportation sector was estimated by first obtaining data on the total motor fuel consumed in Puerto Rico each year from the DCA, and then subtracting from that quantity the estimated consumption of motor gasoline in Puerto Rico, according to U.S. EIA data on Puerto Rican fuel consumption.[155]

Sector 5: Agriculture

Puerto Rico's Agriculture sector includes both livestock and crop production. Emissions from this sector include:[156]

- Emissions from crop residues and crop burning;
- Emissions from rice cultivation;
- Emissions from the soil due to animal waste, fertilizer application, or nitrogen fixation;
- Emissions from changes to the soil's carbon content; and
- Livestock management emissions from enteric fermentation and manure management.

Activity data: The only 2019 and 2021 activity data available regarding Puerto Rico's agriculture is United Nations Food and Agriculture Organization (U.N. FAO) data for 2019 and 2020 on the quantity of crop residues, the amount of crop residues burned, the area and quantity of crop and rice production, the total area of drained organic soils, the quantity of livestock, the amount of livestock manure, the amount of fertilizer used by nutrient type, the footprints of agricultural activities, and total emissions broken down by individual activities.[157] U.N. FAO data are forward projections from Puerto Rico's latest agricultural census, last conducted by the U.S. Department of Agriculture's National Agricultural Statistics Service (NASS) in 2017 and scheduled to be

[155] (1) Puerto Rico DCA. 2022. *Consumption of gasoline.* Available at: https://www.daco.pr.gov/wp-content/uploads/2018/11/Consumo-de-Gasolina-1986-a-actual-13.xlsx; (2) U.S. EIA. 2023. "Puerto Rico Territory Energy Profile." Available at: https://www.eia.gov/state/print.php?sid=RQ

[156] Estado Libre Asociado de Puerto Rico. 2014. *Puerto Rico Greenhouse Gases Baseline Report.* Available at: https://drna.pr.gov/wp-content/uploads/2017/05/Puerto-Rico-GHG-2014.pdf. p. 75.

[157] United Nations Food and Agriculture Organization (U.N. FAO). 2023. *FAOSTAT.* Available at: https://www.fao.org/faostat/en/#data/

conducted every five years.

Because U.N. FAO data offer emissions estimates of each greenhouse gas generated by each individual agricultural activity, these emissions estimates (in metric tons) were used directly in the 2019/2021 Inventory. Moreover, as 2021 estimates are not yet available, 2020 estimates are used in their place.

Emissions factors: The 2019/2021 Inventory uses U.N. FAO emissions estimates and does not require the use of emissions factors for the Agriculture sector.[158]

IPCC Tier: U.N. FAO emissions estimates are calculated using IPCC Tier 1 methodology.[159] These estimates are classified as Tier 1 because U.N. FAO data are not a Puerto Rico-specific source. To achieve IPCC Tier 2 emissions calculations Puerto Rico must update its agricultural census annually, making those results available within six to nine months of the end of each calendar year.

Projection forecast activity data:

- Business-as-Usual: U.N. FAO publishes projected emissions in 2030 and 2050; our projections for intervening years (i.e., 2022-2029 and 2031-2041) were calculated based on a linear interpolation of the data available from U.N. FAO for 2021, 2030, and 2050.
- Decarbonization: no change in Puerto Rico's Agriculture sector activity and emissions.
- Severe Hurricanes: no change in Puerto Rico's Agriculture sector activity and emissions.
- High economic growth: no change in Puerto Rico's Agriculture sector activity and emissions.
- Low economic growth: no change in Puerto Rico's Agriculture sector activity and emissions.

Caveats and assumptions:

Data source availability: U.N. FAO data are based on forward projections of 2017 data and therefore not based on 2019 and 2021 data. AEC unsuccessfully sought out more accurate recent annual agricultural data from the Puerto Rico Department of Agriculture, the University of Puerto Rico at Mayagüez, and the U.S. Department of Agriculture. AEC also performed a detailed review of the 2012 and 2017 Puerto Rico Census of Agriculture. U.S. sources such as EPA's AgStar tool do not include data on Puerto Rico's Agriculture sector.

<u>Sector 6: Forestry and Other Land-Use</u>

The Forestry and Other Land Use sector includes forest, vegetation, and land cover in Puerto Rico that is unaffiliated in any way with agricultural crops, and results in emissions into the atmosphere from vegetation loss or decay and absorbs greenhouse gases through photosynthetic processes and soil carbon sequestration.[160] As such, the emissions calculated for this sector are net emissions (the sum of emissions released and emissions absorbed). Emission-producing activities in this sector include:

- Changes in above- and below-ground tree carbon;
- Tree mortality from forest fires; and

[158] U.N. FAO. 2023. *Emissions totals*. Available at: https://www.fao.org/faostat/en/#data/GT
[159] U.N. FAO. October 2022. *FAOSTAT Domain Emissions Totals: Methodological note.* Available at: https://fenixservices.fao.org/faostat/static/documents/GT/GT_e.pdf
[160] U.N. FAO., 2022, p. 81.

- Changes in forestland, grassland, and cropland area.

Activity data: AEC reviewed and cross-checked data from Global Forest Watch, U.S. Department of Agriculture (USDA), the U.S. Forest Service's EVALIDator, National Land Cover Database, Collect Earth, University of Maryland Department of Geographical Sciences, U.S. EPA State Inventory Tool's Land Use, Land Use Change, and Forestry module, U.N. FAO, and the World Bank.

Activity data for Forestry and Other Land Use includes data on annual tree carbon stocks from EVALIDator, annual tree cover loss due to fires from Global Forest Watch, and year-to-year change in forestland, grassland, and cropland area from U.N. FAO. Activity data are also taken from the U.S. Forest Service EVALIDator tool (2017 and 2018), including: above-ground carbon mass in live trees, below-ground carbon mass in live trees, and average tree density on forestlands.

Emissions factors: Emissions data from the year-to-year change in above-ground carbon and below ground carbon do not require an emissions factor and are converted to CO_2 using the mass ratio of CO_2 to C (44/12). Emissions from tree loss due to fires are calculated using the U.S. EPA's stationary combustion factors for wood and annual data on average tree density from the EVALIDator tool. Emissions from forestland, grassland, and cropland soil area changes are calculated using IPCC emissions factors.[161]

Emissions calculation: Forestry and Other Land Use emissions are calculated by adding together:

- the change in above- and below-ground carbon in live trees (net of biomass losses due to fires) between a particular year and its respective previous year (converted to CO_2);
- the product of tree cover losses due to fires, the average tree density on forestlands, and the U.S. EPA's stationary combustion factor for wood; and
- the sum of changes in area of forestland, grassland, and cropland, each multiplied by its respective soil organic carbon content and converted to CO_2 using the mass ratio of CO_2 to C.

The calculation methodology above represents a "stock change" approach, whereby the difference in carbon stock estimates at two points in time are used to calculate emissions for a forest carbon pool.[162]

IPCC Tier: The use of country-specific forestry and land-use data but default emissions factors results in Tier 1 calculations for the 2019/2021 Inventory calculations (Tier 2 would require both specific country-level data and emissions factors).[163]

Projection forecast activity data:

- Changes in above- and below-ground biomass, tree cover losses due to fires, and changes in forestland area all increase based on the average forest cover growth rate from 2011–2017 in the U.N. FAO data.

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[161] IPCC. 2006. *Guidelines for National Greenhouse Gas Inventories, Volume 4, Chapter 2.* IPCC. Available at: https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_02_Ch2_Generic.pdf.

[162] McRoberts, R., E. Næsset, T. Gobakken. 2018. "Comparing the stock-change and gain–loss approaches for estimating forest carbon emissions for the aboveground biomass pool." *Canadian Journal of Forest Research.* Available at: https://www.fs.usda.gov/research/treesearch/57361.

[163] Eggelston, S., Buendia, L., Miwa, K., Ngara, T., and Tanabe, T. 2006. *2006 IPCC Guidelines for National Greenhouse Gas Inventories: Volume 4 Agriculture, Forestry and Other Land Use*. IPCC. Available at: https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_04_Ch4_Forest_Land.pdf. P. 4.12.

- Business-as-Usual: Puerto Rico's forestland grew an average of 3,621 hectares per year in every year from 2011 through 2017, then dropped 11,304 hectares a single year (2017 to 2018) due to damages from Hurricane María. In 2019, 2020 and 2021, forestland fell an additional 12,562 hectares. In 2022, however, preliminary data suggest growth in Puerto Rico's forestland. Following this more optimistic trend, Business-as-Usual forestland growth projections mimic the annual growth trends seen in the 2021 through 2017 period, growing 3,621 hectares each year. Changes in grassland and cropland are also assumed to follow their respective average changes from 2011–2017 in the U.N. FAO data (-2,923 hectares per year and -430 hectares per year, respectively).
- Decarbonization: Total forestland coverage in Puerto Rico is assumed to grow at double the Business-as-Usual pace (i.e., 7,243 hectares per year). The resulting growth rate of total forest coverage is applied to all activity data, resulting in an increased magnitude of above- and below-ground biomass, tree cover loss due to fires, and grassland area. No changes to cropland area growth are expected.
- Severe Hurricanes: The 2019/2021 Inventory assumes that a severe hurricane or hurricanes—comparable in their forest cover impacts to Hurricane María and Irma in 2017—strikes Puerto Rico every three years starting in 2022. The hurricanes are presumed to reduce total forest coverage at the same rate—over three years—that Hurricanes María and Irma caused in one year (2.1 percent over three years, or 0.42 percent per year). The resulting decline of total forest coverage is applied to all forest activity data, resulting in a decreased magnitude of above- and below-ground biomass and tree cover loss due to fires, as well as an increase (rather than a decrease) in total grassland area. While it is likely that severe hurricanes will impact total croplands and cause some farms to cease to exist, it is unclear whether that land will stay as farmland but fallow, transition to grassland, transition to forestland, or transition to urban developments. As a result of this ambiguity, no changes to cropland area growth are projected in the Severe Hurricanes scenario relative to the Business-as-Usual scenario.
- High economic growth: no change from baseline.
- Low economic growth: no change from baseline.

Caveats and assumptions:

Data sources: A source of activity data accounting comprehensively for emissions from other land use types—both in and of themselves and in relation to forest area—in Puerto Rico or emissions impacts from changes in other land use types (as well as the extent of "managed land"—i.e. land where human interventions and practices affect the ecology of land types[164]) does not exist. The aim is to achieve—in the Forestry and Other Land Use as well as the Agriculture sectors—as comprehensive a coverage as possible of land use, land use change, and forestry emissions and/or removals. Data examined include the U.S. Forest Service's National Land Cover Database[165] and Collect Earth.[166]

Substituting forest carbon stock data in 2014 and 2019: EVALIDator data has unreliable values[167] for 2014

[164] IPCC. 2019. *Glossary.* Available at: https://www.ipcc.ch/site/assets/uploads/2019/06/19R_V0_02_Glossary_advance.pdf. p. G.11.
[165] USGS. 2018. *National Land Cover Database.* Available at: https://www.usgs.gov/centers/eros/science/national-land-cover-database.
[166] Collect Earth. N.d. "Collect Earth: Augmented Visual Interpretation for Land Monitoring." Available at: https://openforis.org/tools/collect-earth/.
[167] The sample size (plot count) in 2014 and 2019 are lower than in other years and result in clear outlier values relative to other years.

and 2019 and no data for 2021 due to small plot sample sizes. As such, AEC imputes these values using the available data for other years (see below for more detail). The EVALIDator tool does not contain and/or does not allow access to Puerto Rico-specific data on above- and below-ground carbon in standing dead trees, carbon in stumps, coarse roots, coarse woody debris, litter, or organic soil. For years with erroneous data due to small sample sizes (such as 2014 and 2019). AEC imputed the above- and below-ground biomass in live trees and average tree density in these years using the average values of variable in question for 2014 carbon stock and density values (taking an average of the values in 2011 through 2013) and projecting forward 2018 values based on year-to-year changes in forest coverage reported by Global Forest Watch data.

Calculating 2020 and 2021 carbon stock and average tree density data: In the absence of current data on 2021 forest above and belowground biomass and area data, the 2019/2021 Inventory imputes 2021 data by carrying-forward corresponding growth rates in total tree cover data from Global Forest Watch.

Accounting for future hurricanes: AEC's Business-as-Usual projections and activity data imputations do not factor in rates of change in carbon stock, forest coverage densities, or total area in the year immediately after a major severe storm (e.g., the rate of change between 2017 and 2018 following Hurricanes María and Irma). (Instead, the impacts of severe storms are represented in the Severe Hurricanes scenario projection.) Hurricanes María and Irma are visible in the available activity data. For instance, there is a large drop in total tree cover between the start of 2017 and the start of 2018 in the U.N. FAO data. In the carbon stock data, there is a visible—but more modest relative to pre-hurricane carbon stock changes—drop from 2017 to 2018.

Forest-fires: To avoid double counting between emissions attributed to forest fires and those to changes in above-ground carbon, the change in above-ground carbon nets out losses associated with forest fires—which are determined by multiplying the annual change by 1 minus the ratio of tree cover loss from fires to total tree cover loss (both of which are sourced to the Global Forest Watch data).

Urban forests: There is no dataset containing information on urban forest cover in Puerto Rico. The 2014 Inventory relied on 2001 urban tree cover data in Gainesville, Florida, and Atlanta, Georgia, to estimate tree cover in Puerto Rico.[168] These data are not only from a different geographic area, but also are more than 20 years old. While a search was conducted for alternate data sources, only one source with minimal relevance was found: A 2011 study of urban mangrove cover in the San Juan Bay watershed estimated that 11.8 percent of the watershed area was covered in mangroves.[169] However, these data are not complete for the entire City of San Juan and were thus not used. Absent more accurate activity data, emissions and sinks from urban forests are omitted from the calculations presented for the Forestry and Other Land Use sector.

Sector 7: Waste Management

The Waste Management sector includes both solid waste management (e.g., landfills and composting) and wastewater treatment (e.g. treatment facilities, septic systems, latrines, and the use of diesel fuel to manage sludge).[170] Solid waste management releases CH_4 from flaring of captured gas in open and closed landfills and

[168] Nowak, D.J., et al. July 2013. "Carbon storage and sequestration by trees in urban and community areas of the United States." *Environmental Pollution 178*, pg. 229-236. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0269749113001383

[169] Brandeis, T.J., et al. 2014. *San Juan Bay Estuary watershed urban forest inventory*. U.S. Department of Agriculture Forest Service, Southern Research Station. Available at: https://www.fs.usda.gov/research/treesearch/45759

[170] Estado Libre Asociado de Puerto Rico. 2014. *Puerto Rico Greenhouse Gases Baseline Report.* Available at: https://drna.pr.gov/wp-content/uploads/2017/05/Puerto-Rico-GHG-2014.pdf. p. 86.

releases CH_4 and N_2O emissions from composting vegetative waste and sludge;[171] as of 2001, 83 percent of Puerto Rico's sludge went to landfills.[172] Wastewater management methods release CH_4 and N_2O emissions during the biological wastewater treatment process as well as N_2O during nitrification and denitrification processes.[173]

Activity data: AEC reviewed and cross-checked data from PRSWA and PRASA, U.S. EPA's National Pollutant Discharge Elimination System (NPDES), Water Pollution Loading Tool, Landfill Methane Outreach Program (LMOP), and LandGEM model results for each landfill. The LandGEM model accounts for CH_4 emissions from both open and closed landfills.

Data on solid waste quantity, emissions, amount recycled, amount composted, and amount landfilled were provided by PRSWA and PRASA. Active landfill statuses are updated as of 2022, and data on total waste accepted per year as well as total greenhouse gas emissions from landfills each year were provided by the PRSWA.[174] Compost data were only provided for the year 2022, so this same value was applied to the years 2019 and 2021 in the absence of activity data for these years.[175]

Data on the quantity of wastewater (monthly data from 2009 to 2023) processed by each wastewater treatment facility in Puerto Rico, as well as the type of treatment undertaken at each facility, were provided by the Aqueducts and Sewer Authority.[176] In order to calculate emission factors, facility-specific data on the daily limit on biological organic demand (BOD) and nitrogen contents of wastewater were acquired from the NPDES website, which publishes operating permits containing relevant data for every facility.[177] In the case where data were missing (two facilities lacked nitrogen limits), values were assumed based on facilities with comparable BOD contents. Approximately, 45 percent of Puerto Rico's households lack municipal sewage service and instead use septic systems or more informal wastewater disposal methods.[178] To account for the emissions from this unaccounted for wastewater, AEC scaled up emissions from municipal wastewater systems by 1.8 to approximate total wastewater emissions.

Emissions factors: The 2019/2021 Inventory uses compost and wastewater emission factors from the IPCC guidelines.[179]

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[171] Estado Libre Asociado de Puerto Rico, 2014, p. 86.

[172] De Jesus, M.E. 2001. *Sludge Management in Puerto Rico: Present and Future*. Massachusetts Institute of Technology. Available at: http://web.mit.edu/watsan/Docs/Student%20Theses/Puerto%20Rico/DeJesus2001.pdf

[173] Campos, J. D. Valenzuela-Heredia, D., Pedrouso, A., Val del Río, A., Belmonte, M., and Mosquera-Corral, A. 2016. "Greenhouse Gas Emissions from Wastewater Treatment Plants: Minimization, Treatment, and Prevention." *Journal of Chemistry.* Available at: https://www.hindawi.com/journals/jchem/2016/3796352/.

[174] Puerto Rico's Title V Landfill Emission Reports for the following 12 landfills: Arecibo, Carolina, Fajardo, Guaynabo, Humacao, Juncos, Mayaguez, Ponce, Salinas, San Juan, Toa Alta, and Toa Baja. Source: Direct communication with V.I. Marrero, Puerto Rico Department of Natural and Environmental Resources.

[175] Direct communication with M. V. Rodriguez, Director of Puerto Rico Land Pollution Control Area

[176] Direct communication with H. Perez at Puerto Rico Aqueducts and Sewers Authority.

[177] (1) U.S. EPA. April 13, 2023. "Puerto Rico NPDES Permits." Available at: https://www.epa.gov/npdes-permits/puerto-rico-npdes-permits; (2) Direct communication with H. Perez at Puerto Rico Aqueducts and Sewers Authority; (3) IPCC. 2006. IPCC Guidelines, Volume 5, Chapter 6.10 "Wastewater Treatment and Discharge" IPCC. Available at: https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_6_Ch6_Wastewater.pdf. Table 6.2, Table 6.3, Equation 6.7.

[178] Personal communications from Expert Panel.

[179] World Resources Institute. 2014. *Global Protocol for Community-Scale Greenhouse Gas Emission Inventories*. Available at: https://ghgprotocol.org/sites/default/files/ghgp/standards/GHGP_GPC_0.pdf. pg. 95, 101-103

IPCC Tier: As landfill emissions data were provided to our team, these data were used directly in place of the use of activity data and IPCC-tiered methodology. For composted waste, Tier 1 methodology was used. For wastewater, IPCC only provides a single method for calculating wastewater emissions, a modified version of which was used for the calculation of wastewater emissions in the 2019/2021 Inventory.

Projection forecast activity data:

- Business-as-Usual: assumes a decline in waste production in proportion to the declining Puerto Rican population; base year waste is 2021 data for each fuel.
- Decarbonization: no change from baseline.
- Severe Hurricanes: no change from baseline.
- High economic growth: no change from baseline.
- Low economic growth: no change from baseline.

Caveats and assumptions:

Industrial waste: Industrial solid waste is not accounted for in the 2019/2021 Inventory due to lack of data: While IPCC guidelines include default wastewater BOD estimates for different industrial subsectors, the underlying production data required to calculate wastewater quantities are unavailable. It was assumed that all industrial wastewater was included in the total amount of water processed at Puerto Rico's wastewater treatment plants.

Waste from energy generation and incineration: Waste from energy generation and incineration processes is not included in the Inventory due to lack of data.

Flaring landfill gas: It was assumed that greenhouse gas emissions from flaring landfill gas were already accounted for and removed from the emissions data received from the PRSWA.

VI. Conclusion

As Puerto Rico moves towards decarbonization, several obstacles and challenges must be addressed to better facilitate changes in the greenhouse gas emission-producing activities on its islands. Puerto Rico has passed strong laws requiring a swift and substantial reduction of CO_2 and other greenhouse gases and has launched planning processes that aim at no less than the transformation of its highest emitting sectors, Power Supply and Transportation, but fail to achieve the decarbonization goals set out in Puerto Rico's 2019 climate law. Achieving Puerto Rico's ambitious and necessary goals will require new efforts in a few critical areas: better data collection, increased climate progress reporting, reprioritization in rebuilding its electric sector, and a new focus in transportation planning.

1. Data collection

The production of accurate, timely greenhouse gas emissions inventories in Puerto Rico is greatly hampered by limitations to its data collection and verification processes. The underlying data quality of several sectors presented in this inventory is poor but could be greatly improved in future Puerto Rico inventories if concrete steps are taken immediately to achieve better data collection.

Required annual reporting: Relevant agencies should be required to submit a specified list of emissions and activities data, for the previous year, by March 31 of each year. These data should be posted online on Puerto Rico's public Inventory of Statistics website. Required annual data submissions should include:

- PREPA fuel consumption and power purchases
- MTA maritime fuel purchases
- Department of Transportation and Public Works (DTPW) on-road gasoline and diesel consumption
- DF tax revenues for jet fuel and maritime fuel
- BDE for Puerto Rico cement production and sales
- DNER Land Pollution Control Area Title V landfill emissions and waste quantities
- PRASA wastewater treatment amounts

New data collection: At present, activity data are not collected for some industrial process-producing industries and for Agriculture, Forestry and Other Land Use, and Waste Management. New data collection processes should be instituted for annual collection of these data and reported on the Inventory of Statistics website. These data should be ready and available each spring for the annual prior year greenhouse gas inventory required by law. New data collection should include:

- Fuel consumption for direct use and transportation annual data from import and distribution companies
- Semiconductor production and sales annual data from industrial facilities
- ODS substitute production and consumption annual data from industrial facilities
- Agriculture Census results conducted annually by Puerto Rico's Department of Agriculture and USDA
- Forestry and other land use and land use changes land area annual data by Puerto Rico's Department of Agriculture and USDA
- Waste categorization study conducted at least once every five years (the last study was conducted in

2003) by the PRSWA

Improved data verification: Puerto Rico's current data collection processes for transportation and direct fuels are flawed leading to profound differences in estimated amounts of fuel consumption published by the U.S. EIA and (separately) several Puerto Rican agencies. An island-wide internal audit of fuel consumption data collection and processing is essential to permit reliable emissions estimation. Such an audit would compare and resolve differences across data sources. Agricultural, forestry and other land use data all lack up to date sources: These data need to be collected more frequently.

Better forecasting credibility: Emissions projection credibility is entirely dependent on the quality of the socio-economic forecasts (population, employment, economic growth, other metrics of well-being) available and their degree of specificity to the inventory in question. For improved emissions projections, Puerto Rico needs credible socio-economic forecasts produced and approved by local experts.

Addressing data and forecasting uncertainty: Every emissions inventory presents the best estimates based on available data. Historical emissions, as well as emissions forecasts, are subject to substantial uncertainties. In the case of Puerto Rico's 2019/2021 inventory, the greatest source of uncertainty lies in the poor quality of the underlying data for Direct Fuel and Transportation sectors. (The effects of poor data quality in the Industrial Processes, Agriculture, Forestry and Other Land Use, and Waste Management sectors is mitigated by the relative scale of these sectors' emissions.) Uncertainty from data quality is difficult to represent quantitatively; the relevant errors are likely ones of precision rather than accuracy. The best solution to narrowing these uncertainties is improving data collection and verification.

2. Lagging behind on 2025 emission reduction targets

Puerto Rico's 2019 climate law mandates greenhouse gas emission reductions of 50 percent by 2025 but has achieved only a 36 percent reduction by 2021. The remaining emission reductions would require careful planning and fast-paced implementation, even if the goal were to achieve them by 2030 or later.

Climate planning with detailed emission reduction measures: Puerto Rico needs a detailed climate plan laying out specific measures, programs, timetables, costs and other impacts necessary to achieve its 2025 emission reduction targets. A multi-sector climate plan—designed with public input and the authorization of elected officials should be published every five years, with progress reports published annually.

Public reporting on emission reduction progress: Public accountability in decarbonization requires clear, measurable targets paired with annual reporting on progress made towards achieving those targets.

3. Electric sector reprioritization

Puerto Rican law also requires the elimination of fossil fuels in the energy sector by 2030 and the achievement of 100 percent renewable energy by 2050. In 2022, just 3 percent of Puerto Rico's electric generation was renewable, and PREPA's 2019 Integrated Resource Plan (IRP) called for additions of new natural gas-fired power plants through 2028 with 1.2 GW of new gas planned from 2021 through 2028. PREPA's IRP does not report greenhouse gas emissions from the Power Supply sector but rather reports on average emission rates per unit of electricity produced and offers plans that do not approach the elimination of fossil fuels in its generation mix.

A new and reprioritized PREPA IRP: A comprehensive planning document—aligned with Puerto Rico's 2019 climate law—is needed to achieve the emissions reductions necessary in the electric sector and to make decarbonization through electrification possible in the Transportation and Direct Fuel sectors.

4. New transportation planning

Puerto Rico's 2018 long-term transportation plan is not consistent with its economy-wide emission reduction targets. Electric vehicles are mentioned as a discussion point in the plan's conclusions but are not part of the detailed modeling exercise presented in the report. Island-wide emission reductions will require changes to the Transportation sector but, as yet, no plan has been developed to implement that transformation, even on a small or exploratory scale.

Transportation planning for lower emissions: This important gap in Puerto Rico's emission reduction progress could be closed through the development of a detailed climate plan together with a new long-term transportation plan that includes greenhouse gas emission reductions as one of its primary goals.

Appendix A: Expert Panel

Félix Aponte Ortiz

University of Puerto Rico

Félix Aponte Ortiz is a retired professor at the University of Puerto Rico's Graduate School of Planning. He is a Planner and Licensed Professional Chemist in Puerto Rico where, for more than three decades, he has worked on the issue of global warming and consequent changes in the climate, both academically and professionally. In his career, he has worked in various agencies and corporations of the Government of Puerto Rico in academic, executive, and scientific functions. Among these, he has been a Member of the Board of Directors of the Puerto Rico Aqueducts and Sewers Authority (PRASA) for six years. Mr. Aponte Ortiz also participated in the development of Puerto Rico's first Greenhouse Gas Inventory in 1976.

Juan Declet-Barreto

Union of Concerned Scientists (UCS)

Juan Declet-Barreto is a social and environmental scientist with expertise in researching and finding solutions to social and environmental inequities. He served as Geographic Information Systems (GIS) specialist at the Arizona Department of Environmental Quality, where he developed air emissions inventories in compliance with air quality protections, as well as an air emissions inventory for the USA-Mexico border. Recently, Mr. Declet-Barreto published a peer-reviewed article where he evaluated the potential increase of Hazardous Air Pollutants (HAPs) following the elimination of federal protections that regulated toxic emissions. He is currently the social scientist for climate vulnerability at the Union of Concerned Scientists.

Ryan Deosaran

Greenhouse Gas Management Institute (GHGMI)

Ryan Deosaran is a Program Manager at the Greenhouse Gas Management Institute (GHGMI) with the Caribbean Cooperative Measurement, Reporting and Verification Hub (MRV Hub). He supports the development of tools and guidance documents for greenhouse gas Inventories and MRV Systems, assists regional capacity building initiatives as a mentor/instructor teaching the 2006 IPCC Guidelines. Mr. Deosaran also supports the MRV Hub Project Director in the execution of the MRV Hub's technical activities and management functions and is dedicated and passionate about working to improve the technical capacity of regional experts in the fields of greenhouse gas Inventories and Finance, Technology Transfer and Capacity Building (FTC).

Ivonne del C. Díaz-Rodríguez

University of Puerto Rico

Dr. Ivonne del C. Díaz-Rodríguez holds a Ph.D. in environmental and natural resource economics, and an M.A. in economics, from the Ohio State University. She is a professor in the Department of Economics at the University of Puerto Rico, Mayagüez Campus, where she teaches microeconomics, environmental and natural resource economics, and ecological economics. She has taught special courses on the Sustainable Development

Goals, the blue economy, and environmental conflicts in Puerto Rico. Dr. Díaz-Rodríguez is the co-author of the Index of Sustainable Economic Welfare for Puerto Rico (ISEW), and has written essays on ecological economics, economies for well-being, and the impacts of catastrophic climate change.

Ernesto Díaz

Tetra Tech, Inc.

Ernesto Díaz is a Regional Manager at Tetra Tech, Inc. as well as the Coordinator of the Puerto Rico Climate Change Council. Previously, Mr. Díaz served 25 years as Director of the Office for Coastal Management and Climate Change as well as Assistant Secretary and Administrator of the Department of Natural and Environmental Resources (DNER). He holds degrees in Oceanography and Marine Sciences from Shoreline College, WA and the University of Puerto Rico, as well as a Master's degree in Environmental Engineering Management from the Polytechnic University of Puerto Rico and post-graduate studies in Energy and Environment at the University of Florida. Mr. Díaz has also served as co-author and Chapter lead of the Fourth National Climate Assessment Report, co-author and editor of the first State of the Puerto Rico Climate Report (2013), the Puerto Rico's *Path to Resilience: Guide to Strategies for Adaptation to Climate Change* (2014), and the most recent report of the State of Puerto Rico's Climate published in 2022.

William Gould

USDA Climate Hubs: Forest Service

William A. Gould is the National Lead of the USDA Climate Hubs and a Research Ecologist with the USDA Forest Service. He is stationed at the USDA Forest Service International Institute of Tropical Forestry in San Juan, Puerto Rico. The USDA Climate Hubs are a unique collaboration across the department's agencies. Ten Regional Climate Hubs are led and hosted by the Agricultural Research Service and Forest Service, with contributions from many agencies. They develop and deliver science, tools, and outreach to reduce the risks of climate change and improve the sustainability of forestry and agriculture.

Nancy Harris

World Resources Institute (WRI)

Nancy Harris is Research Director of Global Forest Watch (GFW) and Land & Carbon Lab (LCL) at the World Resources Institute in Washington, DC. GFW and LCL provide improved data and information about the world's land by merging the latest technology with on-the-ground partnerships. Ms. Harris works to identify thematic and geographic research priorities and leads the acquisition and generation of new data and analytical content. She also supports in-country capacity building efforts and collaborates with partners to produce and communicate policy-relevant research that further advances global understanding of critical drivers and dynamics of land cover change and associated carbon dynamics.

Juan Rosario

AMANESER 2025

Juan Rosario works for the Alliance for Sustainable Resources Management (AMANESER 2025), which is a network of grassroots organizations whose purpose is to promote sustainability in Puerto Rico. He holds a

Bachelor of Science (B.Sc.) from the University of Puerto Rico, Rio Piedras Campus, and a Master of Science (M.Sc.) with a specialty in Environmental Health from the School of Public Health at the Medical Sciences Campus. As part of his professional tasks, Mr. Rosario has worked with multiple platforms that contain information and data on inventories of different substances. These include analysis of data on electricity generation as well as solid waste composition studies. He collaborated in drafting the Reduction and Recycling Law and presented a thesis on solid waste in Puerto Rico. He was elected representative of consumers in the Governing Board of the Puerto Rico Electric Power Authority (PREPA).

Sarah Simon

Apple Creek Associates

Sarah J. Simon, P.E. worked at U.S. EPA Boston for 10 years in permitting and air programs. She evaluated emergency requests for sulfur rule relaxations during the 1978 oil crisis and compiled a fuel use and emissions report for all electric generating stations in New England. Ms. Simon became Deputy Director, Massachusetts DEP Air Quality program, and managed emission inventories, databases, dispersion modeling and air monitoring. In subsequent consulting work, she developed permit applications, administered greenhouse gas plans and subcontracted with the U.S. EPA Landfill Methane Outreach Program. Recently, Ms. Simon was Environmental Compliance Manager at a company operating landfill gas generating stations in 10 states, including California. She listed those renewable energy facilities with state public utility commissions, assisted operators with compliance, and reported energy, emission and green energy credits.

John Venezia

ICF, Climate Planning

John Venezia has 25 years of experience on climate change issues, specializing in greenhouse gasinventory development, designing greenhouse gas measurement, reporting, and verification guidelines, and analyzing the costs and reduction potential of mitigation strategies. He is a senior leader in ICF's Climate Planning division, working with clients to support their efforts to decarbonize and adopt more sustainable practices. As part of the UNCCC Roster of Experts, Mr. Venezia is an internationally recognized expert in greenhouse gas emissions from the energy sector and national greenhouse gas inventories. He has developed and reviewed greenhouse inventories at the national, state, local, and corporate levels.

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Appendix B. Island-wide and sector-specific data tables

Island-wide Results

Business-as-Usual Scenario

Table B-1. Puerto Rico Total Greenhouse Gas Emissions by Gas in MT CO_2e, 2019-2041 (Business-as-Usual: Reference)

Business-as-Usual (BAU) Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Reference (No Sensitivity)	Reference Total (in CO_2e)	31,834,291	32,964,025	32,379,154	31,759,973	31,199,289	27,339,389	26,750,287	26,137,683	25,517,011	24,888,455	24,255,621	23,625,281
	CO_2	27,806,567	28,823,198	28,257,022	27,652,109	27,099,327	23,274,026	22,714,667	22,153,140	21,584,392	21,008,586	20,428,938	19,851,481
	CH_4	3,571,749	3,660,198	3,631,779	3,609,173	3,592,639	3,564,753	3,530,256	3,478,310	3,425,523	3,371,914	3,317,857	3,264,056
	N_2O	332,619	345,175	357,187	367,650	378,317	373,623	380,380	383,239	386,076	388,890	391,694	394,512
	SF_6	41,611	41,673	41,058	40,596	40,216	39,843	39,474	39,109	38,749	38,396	38,054	37,733
	NF_3	5,382	5,446	5,666	5,895	6,133	6,381	6,639	6,907	7,186	7,477	7,779	8,093
	HFC-23	3,752	3,737	3,657	3,577	3,497	3,417	3,336	3,256	3,176	3,096	3,016	2,936
	HFC-32	72,610	84,598	82,785	80,972	79,160	77,347	75,534	73,721	71,908	70,096	68,283	66,470
	HFC-41	3	3	3	3	3	3	3	3	3	3	3	2
	HFC-125	583,028	616,521	603,310	590,098	576,887	563,676	550,465	537,254	524,043	510,832	497,620	484,409
	HFC-134a	608,475	466,127	456,138	446,150	436,161	426,173	416,185	406,196	396,208	386,219	376,231	366,242
	HFC-143a	338,247	287,284	281,128	274,971	268,815	262,659	256,503	250,347	244,191	238,035	231,879	225,723
	HFC-236fa	9,095	7,161	7,008	6,855	6,701	6,548	6,394	6,241	6,087	5,934	5,780	5,627
	C_2F_6	9,166	7,448	7,749	8,062	8,388	8,727	9,079	9,446	9,828	10,225	10,638	11,067
	C_3F_8	877	780	812	845	879	914	951	990	1,030	1,071	1,114	1,160
	C_4F_8	549	514	535	557	579	602	627	652	678	706	734	764
	Biogenic CO_2*	0	0	0	0	0	0	0	0	0	0	0	0

**Biogenic CO_2 has a global warming potential (GWP) of 0, meaning that it is not included in CO_2e calculations for greenhouse gas inventories, per IPCC guidelines.*

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Table B-2. Puerto Rico Total Greenhouse Gas Emissions by Gas in MT CO_2e, 2019-2041 (Business-as-Usual: High Economic Growth)

Business-as-Usual (BAU) Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
High Economic Growth	High Total (in CO_2e)	31,834,291	32,964,025	32,949,735	32,318,614	31,747,038	27,810,276	27,210,028	26,586,113	25,953,985	25,313,832	24,669,324	24,027,355
	CO_2	27,806,567	28,823,198	28,822,458	28,205,692	27,642,099	23,740,536	23,170,112	22,597,354	22,017,231	21,429,909	20,838,666	20,249,660
	CH_4	3,571,749	3,660,198	3,632,727	3,610,104	3,593,553	3,565,437	3,530,924	3,478,962	3,426,158	3,372,532	3,318,458	3,264,639
	N_2O	332,619	345,175	358,720	369,157	379,800	374,776	381,509	384,344	387,156	389,946	392,726	395,519
	SF_6	41,611	41,673	41,879	41,408	41,021	40,640	40,264	39,891	39,524	39,164	38,816	38,488
	NF_3	5,382	5,446	5,780	6,013	6,256	6,509	6,772	7,045	7,330	7,626	7,934	8,255
	HFC-23	3,752	3,737	3,730	3,648	3,567	3,485	3,403	3,322	3,240	3,158	3,076	2,995
	HFC-32	72,610	84,598	84,441	82,592	80,743	78,894	77,045	75,196	73,346	71,497	69,648	67,799
	HFC-41	3	3	3	3	3	3	3	3	3	3	3	2
	HFC-125	583,028	616,521	615,376	601,900	588,425	574,950	561,474	547,999	534,524	521,048	507,573	494,097
	HFC-134a	608,475	466,127	465,261	455,073	444,885	434,697	424,508	414,320	404,132	393,944	383,756	373,567
	HFC-143a	338,247	287,284	286,750	280,471	274,192	267,913	261,633	255,354	249,075	242,796	236,517	230,237
	HFC-236fa	9,095	7,161	7,148	6,992	6,835	6,679	6,522	6,366	6,209	6,052	5,896	5,739
	C_2F_6	9,166	7,448	7,904	8,223	8,555	8,901	9,261	9,635	10,024	10,429	10,850	11,289
	C_3F_8	877	780	828	862	896	933	970	1,009	1,050	1,093	1,137	1,183
	C_4F_8	549	514	546	568	591	615	639	665	692	720	749	779
	Biogenic CO_2*	0	0	0	0	0	0	0	0	0	0	0	0

**Biogenic CO_2 has a global warming potential (GWP) of 0, meaning that it is not included in CO_2e calculations for greenhouse gas inventories, per IPCC guidelines.*

Table B-3. Puerto Rico Total Greenhouse Gas Emissions by Gas in MT CO_2e, 2019-2041 (Business-as-Usual: Low Economic Growth)

Business-as-Usual (BAU) Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Low Economic Growth	Low Total (in CO_2e)	31,834,291	32,964,025	31,808,574	31,201,332	30,651,539	26,868,503	26,290,545	25,689,253	25,080,037	24,463,078	23,841,918	23,223,207
	CO_2	27,806,567	28,823,198	27,691,585	27,098,527	26,556,556	22,807,516	22,259,222	21,708,926	21,151,553	20,587,264	20,019,209	19,453,302
	CH_4	3,571,749	3,660,198	3,630,831	3,608,243	3,591,724	3,564,070	3,529,589	3,477,659	3,424,889	3,371,297	3,317,257	3,263,472
	N_2O	332,619	345,175	355,654	366,143	376,833	372,470	379,250	382,134	384,995	387,834	390,663	393,506
	SF_6	41,611	41,673	40,237	39,784	39,412	39,046	38,685	38,327	37,974	37,628	37,293	36,978
	NF_3	5,382	5,446	5,553	5,777	6,011	6,254	6,506	6,769	7,042	7,327	7,623	7,931
	HFC-23	3,752	3,737	3,584	3,505	3,427	3,348	3,270	3,191	3,113	3,034	2,956	2,877
	HFC-32	72,610	84,598	81,130	79,353	77,576	75,800	74,023	72,247	70,470	68,694	66,917	65,140
	HFC-41	3	3	3	3	3	3	3	3	3	3	2	2
	HFC-125	583,028	616,521	591,243	578,297	565,350	552,403	539,456	526,509	513,562	500,615	487,668	474,721
	HFC-134a	608,475	466,127	447,016	437,227	427,438	417,650	407,861	398,072	388,284	378,495	368,706	358,918
	HFC-143a	338,247	287,284	275,505	269,472	263,439	257,406	251,373	245,340	239,307	233,274	227,241	221,208
	HFC-236fa	9,095	7,161	6,868	6,717	6,567	6,417	6,266	6,116	5,966	5,815	5,665	5,514
	C_2F_6	9,166	7,448	7,594	7,901	8,220	8,552	8,898	9,257	9,631	10,020	10,425	10,846
	C_3F_8	877	780	796	828	861	896	932	970	1,009	1,050	1,092	1,136
	C_4F_8	549	514	524	545	567	590	614	639	665	692	720	749
	Biogenic CO_2*	0	0	0	0	0	0	0	0	0	0	0	0

**Biogenic CO_2 has a global warming potential (GWP) of 0, meaning that it is not included in CO_2e calculations for greenhouse gas inventories, per IPCC guidelines.*

Table B-4. Puerto Rico Total Greenhouse Gas Emissions by Gas in metric tons, 2019-2041 (Business-as-Usual: Reference)

Business-as-Usual (BAU) Scenario		Inventory		Projections									
Metric Tons		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Reference (No Sensitivity)	Reference Total (in metric tons)												
	CO_2	27,806,567	28,823,198	28,257,022	27,652,109	27,099,327	23,274,026	22,714,667	22,153,140	21,584,392	21,008,586	20,428,938	19,851,481
	CH_4	128,020	131,190	130,171	129,361	128,768	127,769	126,532	124,671	122,779	120,857	118,920	116,991
	N_2O	1,218	1,264	1,308	1,347	1,386	1,369	1,393	1,404	1,414	1,425	1,435	1,445
	SF_6	1.65	1.65	1.63	1.61	1.60	1.58	1.57	1.55	1.54	1.52	1.51	1.50
	NF_3	0.31	0.31	0.33	0.34	0.35	0.37	0.38	0.40	0.41	0.43	0.45	0.47
	HFC-23	0.26	0.26	0.25	0.24	0.24	0.23	0.23	0.22	0.22	0.21	0.21	0.20
	HFC-32	94	110	107	105	103	100	98	96	93	91	89	86
	HFC-41	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	HFC-125	156	165	161	158	154	151	147	144	140	137	133	130
	HFC-134a	398	305	298	292	285	279	272	265	259	252	246	239
	HFC-143a	58	49	48	47	46	45	44	43	42	41	40	39
	HFC-236fa	1.05	0.82	0.81	0.79	0.77	0.75	0.74	0.72	0.70	0.68	0.67	0.65
	C_2F_6	0.74	0.60	0.62	0.65	0.68	0.70	0.73	0.76	0.79	0.82	0.86	0.89
	C_3F_8	0.09	0.08	0.09	0.09	0.09	0.10	0.10	0.11	0.11	0.12	0.12	0.12
	C_4F_8	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07
	Biogenic CO_2	261,412	265,521	258,300	252,178	246,593	240,955	235,240	229,439	223,563	217,614	211,626	205,661

Table B-5. Puerto Rico Total Greenhouse Gas Emissions by Gas in metric tons, 2019-2041 (Business-as-Usual: High Economic Growth)

Business-as-Usual (BAU) Scenario		Inventory		Projections									
Metric Tons		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
High Economic Growth	High Total (in metric tons)												
	CO_2	27,806,567	28,823,198	28,822,458	28,205,692	27,642,099	23,740,536	23,170,112	22,597,354	22,017,231	21,429,909	20,838,666	20,249,660
	CH_4	128,020	131,190	130,205	129,394	128,801	127,793	126,556	124,694	122,801	120,879	118,941	117,012
	N_2O	1,218	1,264	1,314	1,352	1,391	1,373	1,397	1,408	1,418	1,428	1,439	1,449
	SF_6	1.65	1.65	1.66	1.64	1.63	1.61	1.60	1.58	1.57	1.55	1.54	1.53
	NF_3	0.31	0.31	0.33	0.35	0.36	0.37	0.39	0.40	0.42	0.44	0.46	0.47
	HFC-23	0.26	0.26	0.26	0.25	0.24	0.24	0.23	0.23	0.22	0.22	0.21	0.21
	HFC-32	94	110	110	107	105	102	100	98	95	93	90	88
	HFC-41	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	HFC-125	156	165	165	161	157	154	150	147	143	139	136	132
	HFC-134a	398	305	304	297	291	284	277	271	264	257	251	244
	HFC-143a	58	49	49	48	47	46	45	44	43	42	41	40
	HFC-236fa	1.05	0.82	0.82	0.80	0.79	0.77	0.75	0.73	0.71	0.70	0.68	0.66
	C_2F_6	0.74	0.60	0.64	0.66	0.69	0.72	0.75	0.78	0.81	0.84	0.88	0.91
	C_3F_8	0.09	0.08	0.09	0.09	0.10	0.10	0.10	0.11	0.11	0.12	0.12	0.13
	C_4F_8	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.08
	Biogenic CO_2	261,412	265,521	258,458	252,332	246,744	241,103	235,384	229,579	223,700	217,748	211,756	205,786

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Table B-6. Puerto Rico Total Greenhouse Gas Emissions by Gas in metric tons, 2019-2041 (Business-as-Usual: Low Economic Growth)

Business-as-Usual (BAU) Scenario		Inventory		Projections									
Metric Tons		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Low Economic Growth	Low Total (in metric tons)												
	CO_2	27,806,567	28,823,198	27,691,585	27,098,527	26,556,556	22,807,516	22,259,222	21,708,926	21,151,553	20,587,264	20,019,209	19,453,302
	CH_4	128,020	131,190	130,137	129,328	128,736	127,744	126,509	124,647	122,756	120,835	118,898	116,970
	N_2O	1,218	1,264	1,303	1,341	1,380	1,364	1,389	1,400	1,410	1,421	1,431	1,441
	SF_6	1.65	1.65	1.60	1.58	1.56	1.55	1.54	1.52	1.51	1.49	1.48	1.47
	NF_3	0.31	0.31	0.32	0.33	0.35	0.36	0.37	0.39	0.40	0.42	0.44	0.46
	HFC-23	0.26	0.26	0.25	0.24	0.23	0.23	0.22	0.22	0.21	0.21	0.20	0.20
	HFC-32	94	110	105	103	101	98	96	94	91	89	87	84
	HFC-41	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	HFC-125	156	165	158	155	151	148	144	141	137	134	130	127
	HFC-134a	398	305	292	286	279	273	267	260	254	247	241	235
	HFC-143a	58	49	47	46	45	44	43	42	41	40	39	38
	HFC-236fa	1.05	0.82	0.79	0.77	0.76	0.74	0.72	0.70	0.69	0.67	0.65	0.63
	C_2F_6	0.74	0.60	0.61	0.64	0.66	0.69	0.72	0.75	0.78	0.81	0.84	0.87
	C_3F_8	0.09	0.08	0.09	0.09	0.09	0.10	0.10	0.10	0.11	0.11	0.12	0.12
	C_4F_8	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.07
	Biogenic CO_2	261,412	265,521	258,142	252,023	246,443	240,808	235,096	229,298	223,426	217,481	211,497	205,535

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Table B-7. Puerto Rico Total Greenhouse Gas Emissions by Sector in MT CO_2e, 2019-2041 (Business-as-Usual)

Business-as-Usual (BAU) Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Reference (No Sensitivity)	Reference Total (in CO_2e)	33,383,731	34,349,863	33,735,837	33,087,514	32,497,702	28,608,692	27,990,494	27,348,812	26,699,078	26,041,479	25,379,621	24,720,276
	Power Supply	18,417,482	18,688,738	18,270,061	17,915,056	17,591,275	13,970,984	13,639,595	13,303,240	12,962,558	12,617,650	12,270,439	11,924,540
	Direct Fuel	539,378	492,339	478,950	467,597	457,242	446,788	436,190	425,434	414,539	403,509	392,405	381,343
	Industrial Processes	1,641,224	1,489,861	1,459,446	1,429,070	1,398,737	1,368,446	1,338,200	1,308,001	1,277,851	1,247,751	1,217,704	1,187,711
	Transportation	8,832,555	9,533,698	9,677,257	9,447,868	9,238,656	9,027,421	8,813,292	8,595,955	8,375,822	8,152,957	7,928,605	7,705,101
	Agriculture	922,848	948,256	995,075	1,041,895	1,088,714	1,135,533	1,168,124	1,186,486	1,204,848	1,223,209	1,241,571	1,259,933
	Forestry and Other Land Use	105,057	202,851	-57,647	-57,627	-57,606	-57,586	-57,565	-57,545	-57,524	-57,504	-57,483	-57,463
	Waste	2,925,188	2,994,121	2,912,696	2,843,654	2,780,684	2,717,106	2,652,657	2,587,241	2,520,985	2,453,906	2,386,380	2,319,109
High Economic Growth	High Total (in CO_2e)	33,383,731	34,349,863	34,333,551	33,672,705	33,071,420	29,104,964	28,475,039	27,821,464	27,159,694	26,489,916	25,815,804	25,144,250
	Power Supply	18,417,482	18,688,738	18,635,462	18,273,357	17,943,101	14,250,403	13,912,387	13,569,304	13,221,810	12,870,003	12,515,847	12,163,031
	Direct Fuel	539,378	492,339	488,529	476,949	466,387	455,724	444,914	433,942	422,830	411,579	400,253	388,970
	Industrial Processes	1,641,224	1,489,861	1,488,634	1,457,652	1,426,711	1,395,815	1,364,964	1,334,161	1,303,408	1,272,706	1,242,058	1,211,466
	Transportation	8,832,555	9,533,698	9,870,802	9,636,826	9,423,429	9,207,969	8,989,558	8,767,874	8,543,338	8,316,016	8,087,177	7,859,203
	Agriculture	922,848	948,256	995,075	1,041,895	1,088,714	1,135,533	1,168,124	1,186,486	1,204,848	1,223,209	1,241,571	1,259,933
	Forestry and Other Land Use	105,057	202,851	-57,647	-57,627	-57,606	-57,586	-57,565	-57,545	-57,524	-57,504	-57,483	-57,463
	Waste	2,925,188	2,994,121	2,912,696	2,843,654	2,780,684	2,717,106	2,652,657	2,587,241	2,520,985	2,453,906	2,386,380	2,319,109
Low Economic Growth	Low Total (in CO_2e)	33,383,731	34,349,863	33,138,122	32,502,322	31,923,984	28,112,419	27,505,948	26,876,159	26,238,463	25,593,041	24,943,438	24,296,302
	Power Supply	18,417,482	18,688,738	17,904,660	17,556,755	17,239,450	13,691,564	13,366,803	13,037,175	12,703,307	12,365,297	12,025,030	11,686,050
	Direct Fuel	539,378	492,339	469,371	458,245	448,098	437,852	427,466	416,925	406,248	395,439	384,557	373,716
	Industrial Processes	1,641,224	1,489,861	1,430,257	1,400,489	1,370,762	1,341,077	1,311,436	1,281,841	1,252,294	1,222,796	1,193,350	1,163,957
	Transportation	8,832,555	9,533,698	9,483,711	9,258,911	9,053,883	8,846,872	8,637,027	8,424,035	8,208,305	7,989,898	7,770,033	7,550,999
	Agriculture	922,848	948,256	995,075	1,041,895	1,088,714	1,135,533	1,168,124	1,186,486	1,204,848	1,223,209	1,241,571	1,259,933
	Forestry and Other Land Use	105,057	202,851	-57,647	-57,627	-57,606	-57,586	-57,565	-57,545	-57,524	-57,504	-57,483	-57,463
	Waste	2,925,188	2,994,121	2,912,696	2,843,654	2,780,684	2,717,106	2,652,657	2,587,241	2,520,985	2,453,906	2,386,380	2,319,109

Decarbonization Scenario

Table B-8. Puerto Rico Total Greenhouse Gas Emissions by Gas in MT CO_2e, 2019-2041 (Decarbonization: Reference)

Decarbonization Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Reference (No Sensitivity)	Reference Total (in CO_2e)	31,834,291	32,964,025	31,322,786	29,519,174	27,721,731	22,630,318	20,817,206	18,988,918	17,159,810	15,329,904	13,499,578	11,669,545
	CO_2	27,806,567	28,823,198	27,204,756	25,419,923	23,635,091	18,582,965	16,804,257	15,031,674	13,259,091	11,486,509	9,713,928	7,941,347
	CH_4	3,571,749	3,660,198	3,630,206	3,605,870	3,587,530	3,557,846	3,521,562	3,467,841	3,413,290	3,357,926	3,302,121	3,246,568
	N_2O	332,619	345,175	354,658	362,340	370,104	362,519	366,403	366,409	366,409	366,404	366,397	366,399
	SF_6	41,611	41,673	41,058	40,596	40,216	39,843	39,474	39,109	38,749	38,396	38,054	37,733
	NF_3	5,382	5,446	5,666	5,895	6,133	6,381	6,639	6,907	7,186	7,477	7,779	8,093
	HFC-23	3,752	3,737	3,657	3,577	3,497	3,417	3,336	3,256	3,176	3,096	3,016	2,936
	HFC-32	72,610	84,598	82,785	80,972	79,160	77,347	75,534	73,721	71,908	70,096	68,283	66,470
	HFC-41	3	3	3	3	3	3	3	3	3	3	3	2
	HFC-125	583,028	616,521	603,310	590,098	576,887	563,676	550,465	537,254	524,043	510,832	497,620	484,409
	HFC-134a	608,475	466,127	456,138	446,150	436,161	426,173	416,185	406,196	396,208	386,219	376,231	366,242
	HFC-143a	338,247	287,284	281,128	274,971	268,815	262,659	256,503	250,347	244,191	238,035	231,879	225,723
	HFC-236fa	9,095	7,161	7,008	6,855	6,701	6,548	6,394	6,241	6,087	5,934	5,780	5,627
	C_2F_6	9,166	7,448	7,749	8,062	8,388	8,727	9,079	9,446	9,828	10,225	10,638	11,067
	C_3F_8	877	780	812	845	879	914	951	990	1,030	1,071	1,114	1,160
	C_4F_8	549	514	535	557	579	602	627	652	678	706	734	764
	Biogenic CO_2*	0	0	0	0	0	0	0	0	0	0	0	0

**Biogenic CO_2 has a global warming potential (GWP) of 0, meaning that it is not included in CO_2e calculations for greenhouse gas inventories, per IPCC guidelines.*

Table B-9. Puerto Rico Total Greenhouse Gas Emissions by Gas in MT CO_2e, 2019-2041 (Decarbonization: High Economic Growth)

	Decarbonization Scenario	Inventory		Projections									
	Metric Tons CO_2e	2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
High Economic Growth	High Total (in CO_2e)	31,834,291	32,964,025	31,871,812	30,032,571	28,199,501	23,006,595	21,157,857	19,293,943	17,429,210	15,563,679	13,697,729	11,832,074
	CO_2	27,806,567	28,823,198	27,748,720	25,928,434	24,108,149	18,955,225	17,141,065	15,333,029	13,524,994	11,716,960	9,908,926	8,100,892
	CH_4	3,571,749	3,660,198	3,631,122	3,606,735	3,588,342	3,558,392	3,522,056	3,468,283	3,413,680	3,358,264	3,302,407	3,246,802
	N_2O	332,619	345,175	356,140	363,741	371,423	363,450	367,253	367,178	367,096	367,010	366,922	366,844
	SF_6	41,611	41,673	41,879	41,408	41,021	40,640	40,264	39,891	39,524	39,164	38,816	38,488
	NF_3	5,382	5,446	5,780	6,013	6,256	6,509	6,772	7,045	7,330	7,626	7,934	8,255
	HFC-23	3,752	3,737	3,730	3,648	3,567	3,485	3,403	3,322	3,240	3,158	3,076	2,995
	HFC-32	72,610	84,598	84,441	82,592	80,743	78,894	77,045	75,196	73,346	71,497	69,648	67,799
	HFC-41	3	3	3	3	3	3	3	3	3	3	3	2
	HFC-125	583,028	616,521	615,376	601,900	588,425	574,950	561,474	547,999	534,524	521,048	507,573	494,097
	HFC-134a	608,475	466,127	465,261	455,073	444,885	434,697	424,508	414,320	404,132	393,944	383,756	373,567
	HFC-143a	338,247	287,284	286,750	280,471	274,192	267,913	261,633	255,354	249,075	242,796	236,517	230,237
	HFC-236fa	9,095	7,161	7,148	6,992	6,835	6,679	6,522	6,366	6,209	6,052	5,896	5,739
	C_2F_6	9,166	7,448	7,904	8,223	8,555	8,901	9,261	9,635	10,024	10,429	10,850	11,289
	C_3F_8	877	780	828	862	896	933	970	1,009	1,050	1,093	1,137	1,183
	C_4F_8	549	514	546	568	591	615	639	665	692	720	749	779
	Biogenic CO_2*	0	0	0	0	0	0	0	0	0	0	0	0

**Biogenic CO_2 has a global warming potential (GWP) of 0, meaning that it is not included in CO_2e calculations for greenhouse gas inventories, per IPCC guidelines.*

Table B-10. Puerto Rico Total Greenhouse Gas Emissions by Gas in MT CO_2e, 2019-2041 (Decarbonization: Low Economic Growth)

Decarbonization Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Low Economic Growth	Low Total (in CO_2e)	31,834,291	32,964,025	30,773,760	29,005,777	27,243,960	22,254,042	20,476,555	18,683,893	16,890,410	15,096,128	13,301,426	11,507,017
	CO_2	27,806,567	28,823,198	26,660,793	24,911,412	23,162,032	18,210,705	16,467,449	14,730,319	12,993,188	11,256,059	9,518,930	7,781,801
	CH_4	3,571,749	3,660,198	3,629,289	3,605,006	3,586,718	3,557,301	3,521,069	3,467,400	3,412,900	3,357,589	3,301,835	3,246,334
	N_2O	332,619	345,175	353,175	360,939	368,785	361,588	365,553	365,641	365,722	365,798	365,872	365,955
	SF_6	41,611	41,673	40,237	39,784	39,412	39,046	38,685	38,327	37,974	37,628	37,293	36,978
	NF_3	5,382	5,446	5,553	5,777	6,011	6,254	6,506	6,769	7,042	7,327	7,623	7,931
	HFC-23	3,752	3,737	3,584	3,505	3,427	3,348	3,270	3,191	3,113	3,034	2,956	2,877
	HFC-32	72,610	84,598	81,130	79,353	77,576	75,800	74,023	72,247	70,470	68,694	66,917	65,140
	HFC-41	3	3	3	3	3	3	3	3	3	3	2	2
	HFC-125	583,028	616,521	591,243	578,297	565,350	552,403	539,456	526,509	513,562	500,615	487,668	474,721
	HFC-134a	608,475	466,127	447,016	437,227	427,438	417,650	407,861	398,072	388,284	378,495	368,706	358,918
	HFC-143a	338,247	287,284	275,505	269,472	263,439	257,406	251,373	245,340	239,307	233,274	227,241	221,208
	HFC-236fa	9,095	7,161	6,868	6,717	6,567	6,417	6,266	6,116	5,966	5,815	5,665	5,514
	C_2F_6	9,166	7,448	7,594	7,901	8,220	8,552	8,898	9,257	9,631	10,020	10,425	10,846
	C_3F_8	877	780	796	828	861	896	932	970	1,009	1,050	1,092	1,136
	C_4F_8	549	514	524	545	567	590	614	639	665	692	720	749
	Biogenic CO_2*	0	0	0	0	0	0	0	0	0	0	0	0

**Biogenic CO_2 has a global warming potential (GWP) of 0, meaning that it is not included in CO_2e calculations for greenhouse gas inventories, per IPCC guidelines.*

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Table B-11. Puerto Rico Total Greenhouse Gas Emissions by Gas in metric tons, 2019-2041 (Decarbonization: Reference)

Decarbonization Scenario		Inventory		Projections									
Metric Tons		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Reference (No Sensitivity)	Reference Total (in metric tons)												
	CO_2	27,806,567	28,823,198	27,204,756	25,419,923	23,635,091	18,582,965	16,804,257	15,031,674	13,259,091	11,486,509	9,713,928	7,941,347
	CH_4	128,020	131,190	130,115	129,243	128,585	127,521	126,221	124,295	122,340	120,356	118,356	116,364
	N_2O	1,218	1,264	1,299	1,327	1,356	1,328	1,342	1,342	1,342	1,342	1,342	1,342
	SF_6	1.65	1.65	1.63	1.61	1.60	1.58	1.57	1.55	1.54	1.52	1.51	1.50
	NF_3	0.31	0.31	0.33	0.34	0.35	0.37	0.38	0.40	0.41	0.43	0.45	0.47
	HFC-23	0.26	0.26	0.25	0.24	0.24	0.23	0.23	0.22	0.22	0.21	0.21	0.20
	HFC-32	94	110	107	105	103	100	98	96	93	91	89	86
	HFC-41	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	HFC-125	156	165	161	158	154	151	147	144	140	137	133	130
	HFC-134a	398	305	298	292	285	279	272	265	259	252	246	239
	HFC-143a	58	49	48	47	46	45	44	43	42	41	40	39
	HFC-236fa	1.05	0.82	0.81	0.79	0.77	0.75	0.74	0.72	0.70	0.68	0.67	0.65
	C_2F_6	0.74	0.60	0.62	0.65	0.68	0.70	0.73	0.76	0.79	0.82	0.86	0.89
	C_3F_8	0.09	0.08	0.09	0.09	0.09	0.10	0.10	0.11	0.11	0.12	0.12	0.12
	C_4F_8	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07
	Biogenic CO_2	261,412	265,521	257,961	251,466	245,492	239,466	233,366	227,182	220,926	214,599	208,234	201,891

Table B-12. Puerto Rico Total Greenhouse Gas Emissions by Gas in metric tons, 2019-2041 (Decarbonization: High Economic Growth)

Decarbonization Scenario		Inventory		Projections									
Metric Tons		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
High Economic Growth	High Total (in metric tons)												
	CO_2	27,806,567	28,823,198	27,748,720	25,928,434	24,108,149	18,955,225	17,141,065	15,333,029	13,524,994	11,716,960	9,908,926	8,100,892
	CH_4	128,020	131,190	130,148	129,274	128,614	127,541	126,239	124,311	122,354	120,368	118,366	116,373
	N_2O	1,218	1,264	1,305	1,332	1,361	1,331	1,345	1,345	1,345	1,344	1,344	1,344
	SF_6	1.65	1.65	1.66	1.64	1.63	1.61	1.60	1.58	1.57	1.55	1.54	1.53
	NF_3	0.31	0.31	0.33	0.35	0.36	0.37	0.39	0.40	0.42	0.44	0.46	0.47
	HFC-23	0.26	0.26	0.26	0.25	0.24	0.24	0.23	0.23	0.22	0.22	0.21	0.21
	HFC-32	94	110	110	107	105	102	100	98	95	93	90	88
	HFC-41	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	HFC-125	156	165	165	161	157	154	150	147	143	139	136	132
	HFC-134a	398	305	304	297	291	284	277	271	264	257	251	244
	HFC-143a	58	49	49	48	47	46	45	44	43	42	41	40
	HFC-236fa	1.05	0.82	0.82	0.80	0.79	0.77	0.75	0.73	0.71	0.70	0.68	0.66
	C_2F_6	0.74	0.60	0.64	0.66	0.69	0.72	0.75	0.78	0.81	0.84	0.88	0.91
	C_3F_8	0.09	0.08	0.09	0.09	0.10	0.10	0.10	0.11	0.11	0.12	0.12	0.13
	C_4F_8	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.08
	Biogenic CO_2	261,412	265,521	258,112	251,606	245,621	239,584	233,472	227,277	221,010	214,672	208,296	201,941

Table B-13. Puerto Rico Total Greenhouse Gas Emissions by Gas in metric tons, 2019-2041 (Decarbonization: Low Economic Growth)

Decarbonization Scenario		Inventory		Projections									
Metric Tons		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Low Economic Growth	Low Total (in metric tons)												
	CO_2	27,806,567	28,823,198	26,660,793	24,911,412	23,162,032	18,210,705	16,467,449	14,730,319	12,993,188	11,256,059	9,518,930	7,781,801
	CH_4	128,020	131,190	130,082	129,212	128,556	127,502	126,203	124,280	122,326	120,344	118,345	116,356
	N_2O	1,218	1,264	1,294	1,322	1,351	1,324	1,339	1,339	1,340	1,340	1,340	1,340
	SF_6	1.65	1.65	1.60	1.58	1.56	1.55	1.54	1.52	1.51	1.49	1.48	1.47
	NF_3	0.31	0.31	0.32	0.33	0.35	0.36	0.37	0.39	0.40	0.42	0.44	0.46
	HFC-23	0.26	0.26	0.25	0.24	0.23	0.23	0.22	0.22	0.21	0.21	0.20	0.20
	HFC-32	94	110	105	103	101	98	96	94	91	89	87	84
	HFC-41	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	HFC-125	156	165	158	155	151	148	144	141	137	134	130	127
	HFC-134a	398	305	292	286	279	273	267	260	254	247	241	235
	HFC-143a	58	49	47	46	45	44	43	42	41	40	39	38
	HFC-236fa	1.05	0.82	0.79	0.77	0.76	0.74	0.72	0.70	0.69	0.67	0.65	0.63
	C_2F_6	0.74	0.60	0.61	0.64	0.66	0.69	0.72	0.75	0.78	0.81	0.84	0.87
	C_3F_8	0.09	0.08	0.09	0.09	0.09	0.10	0.10	0.10	0.11	0.11	0.12	0.12
	C_4F_8	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.07
	Biogenic CO_2	261,412	265,521	257,810	251,326	245,363	239,349	233,259	227,087	220,842	214,526	208,172	201,840

Table B-14. Puerto Rico Total Greenhouse Gas Emissions by Sector in MT CO_2e, 2019-2041 (Decarbonization)

Decarbonization Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Reference (No Sensitivity)	Reference Total (in CO_2e)	33,383,731	34,349,863	32,679,468	30,846,715	29,020,144	23,899,621	22,057,413	20,200,046	18,341,877	16,482,927	14,623,577	12,764,540
	Power Supply	18,417,482	18,688,738	17,628,410	16,568,222	15,508,103	11,154,597	10,094,461	9,034,315	7,974,159	6,913,993	5,853,823	4,793,655
	Direct Fuel	539,378	492,339	458,385	424,430	390,476	356,521	322,567	288,613	254,658	220,704	186,749	152,795
	Industrial Processes	1,641,224	1,489,861	1,459,446	1,429,070	1,398,737	1,368,446	1,338,200	1,308,001	1,277,851	1,247,751	1,217,704	1,187,711
	Transportation	8,832,555	9,533,698	9,261,733	8,575,678	7,889,624	7,203,570	6,517,516	5,831,461	5,145,407	4,459,353	3,773,299	3,087,244
	Agriculture	922,848	948,256	995,075	1,041,895	1,088,714	1,135,533	1,168,124	1,186,486	1,204,848	1,223,209	1,241,571	1,259,933
	Forestry and Other Land Use	105,057	202,851	-36,276	-36,235	-36,194	-36,153	-36,112	-36,071	-36,030	-35,989	-35,948	-35,907
	Waste	2,925,188	2,994,121	2,912,696	2,843,654	2,780,684	2,717,106	2,652,657	2,587,241	2,520,985	2,453,906	2,386,380	2,319,109
High Economic Growth	High Total (in CO_2e)	33,383,731	34,349,863	33,255,628	31,386,663	29,523,883	24,301,283	22,422,868	20,529,294	18,634,919	16,739,764	14,844,209	12,948,968
	Power Supply	18,417,482	18,688,738	17,980,978	16,899,587	15,818,266	11,377,689	10,296,351	9,215,001	8,133,642	7,052,273	5,970,899	4,889,528
	Direct Fuel	539,378	492,339	467,552	432,919	398,285	363,652	329,018	294,385	259,751	225,118	190,484	155,851
	Industrial Processes	1,641,224	1,489,861	1,488,634	1,457,652	1,426,711	1,395,815	1,364,964	1,334,161	1,303,408	1,272,706	1,242,058	1,211,466
	Transportation	8,832,555	9,533,698	9,446,967	8,747,192	8,047,417	7,347,641	6,647,866	5,948,091	5,248,315	4,548,540	3,848,765	3,148,989
	Agriculture	922,848	948,256	995,075	1,041,895	1,088,714	1,135,533	1,168,124	1,186,486	1,204,848	1,223,209	1,241,571	1,259,933
	Forestry and Other Land Use	105,057	202,851	-36,276	-36,235	-36,194	-36,153	-36,112	-36,071	-36,030	-35,989	-35,948	-35,907
	Waste	2,925,188	2,994,121	2,912,696	2,843,654	2,780,684	2,717,106	2,652,657	2,587,241	2,520,985	2,453,906	2,386,380	2,319,109
Low Economic Growth	Low Total (in CO_2e)	33,383,731	34,349,863	32,103,309	30,306,767	28,516,405	23,497,958	21,691,958	19,870,798	18,048,836	16,226,091	14,402,946	12,580,112
	Power Supply	18,417,482	18,688,738	17,275,842	16,236,858	15,197,941	10,931,505	9,892,572	8,853,628	7,814,675	6,775,713	5,736,746	4,697,782
	Direct Fuel	539,378	492,339	449,217	415,942	382,666	349,391	316,116	282,840	249,565	216,290	183,014	149,739
	Industrial Processes	1,641,224	1,489,861	1,430,257	1,400,489	1,370,762	1,341,077	1,311,436	1,281,841	1,252,294	1,222,796	1,193,350	1,163,957
	Transportation	8,832,555	9,533,698	9,076,498	8,404,165	7,731,832	7,059,499	6,387,165	5,714,832	5,042,499	4,370,166	3,697,833	3,025,499
	Agriculture	922,848	948,256	995,075	1,041,895	1,088,714	1,135,533	1,168,124	1,186,486	1,204,848	1,223,209	1,241,571	1,259,933
	Forestry and Other Land Use	105,057	202,851	-36,276	-36,235	-36,194	-36,153	-36,112	-36,071	-36,030	-35,989	-35,948	-35,907
	Waste	2,925,188	2,994,121	2,912,696	2,843,654	2,780,684	2,717,106	2,652,657	2,587,241	2,520,985	2,453,906	2,386,380	2,319,109

Severe Hurricanes Scenario

Table B-15. Puerto Rico Total Greenhouse Gas Emissions by Gas in MT CO_2e, 2019-2041 (Severe Hurricanes: Reference)

Severe Hurricanes Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Reference (No Sensitivity)	Reference Total (in CO_2e)	31,834,291	32,964,025	32,075,917	31,463,081	30,908,182	27,054,125	26,470,944	25,864,352	25,249,769	24,627,378	24,000,750	23,376,593
	CO_2	27,806,567	28,823,198	27,955,192	27,356,593	26,809,566	22,990,076	22,436,609	21,881,062	21,318,371	20,748,698	20,175,223	19,603,918
	CH_4	3,571,749	3,660,198	3,631,313	3,608,718	3,592,193	3,564,318	3,529,832	3,477,896	3,425,119	3,371,521	3,317,475	3,263,684
	N_2O	332,619	345,175	356,466	366,946	377,628	372,949	379,721	382,597	385,450	388,280	391,101	393,935
	SF_6	41,611	41,673	40,837	40,381	40,006	39,637	39,273	38,913	38,558	38,210	37,874	37,557
	NF_3	5,382	5,446	5,666	5,895	6,133	6,381	6,639	6,907	7,186	7,477	7,779	8,093
	HFC-23	3,752	3,737	3,657	3,577	3,497	3,417	3,336	3,256	3,176	3,096	3,016	2,936
	HFC-32	72,610	84,598	82,785	80,972	79,160	77,347	75,534	73,721	71,908	70,096	68,283	66,470
	HFC-41	3	3	3	3	3	3	3	3	3	3	3	2
	HFC-125	583,028	616,521	603,310	590,098	576,887	563,676	550,465	537,254	524,043	510,832	497,620	484,409
	HFC-134a	608,475	466,127	456,138	446,150	436,161	426,173	416,185	406,196	396,208	386,219	376,231	366,242
	HFC-143a	338,247	287,284	281,128	274,971	268,815	262,659	256,503	250,347	244,191	238,035	231,879	225,723
	HFC-236fa	9,095	7,161	7,008	6,855	6,701	6,548	6,394	6,241	6,087	5,934	5,780	5,627
	C_2F_6	9,166	7,448	7,749	8,062	8,388	8,727	9,079	9,446	9,828	10,225	10,638	11,067
	C_3F_8	877	780	812	845	879	914	951	990	1,030	1,071	1,114	1,160
	C_4F_8	549	514	535	557	579	602	627	652	678	706	734	764
	Biogenic CO_2*	0	0	0	0	0	0	0	0	0	0	0	0

**Biogenic CO_2 has a global warming potential (GWP) of 0, meaning that it is not included in CO_2e calculations for greenhouse gas inventories, per IPCC guidelines.*

Table B-16. Puerto Rico Total Greenhouse Gas Emissions by Gas in MT CO_2e, 2019-2041 (Severe Hurricanes: High Economic Growth)

Severe Hurricanes Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
High Economic Growth	High Total (in CO_2e)	31,834,291	32,964,025	32,641,115	32,016,468	31,450,794	27,519,991	26,925,784	26,308,001	25,682,084	25,048,220	24,410,043	23,774,381
	CO_2	27,806,567	28,823,198	28,515,274	27,904,948	27,347,226	23,451,591	22,887,177	22,320,520	21,746,575	21,165,510	20,580,566	19,997,834
	CH_4	3,571,749	3,660,198	3,632,251	3,609,639	3,593,099	3,564,993	3,530,491	3,478,539	3,425,746	3,372,130	3,318,067	3,264,260
	N_2O	332,619	345,175	357,985	368,439	379,098	374,089	380,838	383,689	386,518	389,324	392,120	394,930
	SF_6	41,611	41,673	41,654	41,188	40,806	40,430	40,059	39,691	39,329	38,974	38,631	38,308
	NF_3	5,382	5,446	5,780	6,013	6,256	6,509	6,772	7,045	7,330	7,626	7,934	8,255
	HFC-23	3,752	3,737	3,730	3,648	3,567	3,485	3,403	3,322	3,240	3,158	3,076	2,995
	HFC-32	72,610	84,598	84,441	82,592	80,743	78,894	77,045	75,196	73,346	71,497	69,648	67,799
	HFC-41	3	3	3	3	3	3	3	3	3	3	3	2
	HFC-125	583,028	616,521	615,376	601,900	588,425	574,950	561,474	547,999	534,524	521,048	507,573	494,097
	HFC-134a	608,475	466,127	465,261	455,073	444,885	434,697	424,508	414,320	404,132	393,944	383,756	373,567
	HFC-143a	338,247	287,284	286,750	280,471	274,192	267,913	261,633	255,354	249,075	242,796	236,517	230,237
	HFC-236fa	9,095	7,161	7,148	6,992	6,835	6,679	6,522	6,366	6,209	6,052	5,896	5,739
	C_2F_6	9,166	7,448	7,904	8,223	8,555	8,901	9,261	9,635	10,024	10,429	10,850	11,289
	C_3F_8	877	780	828	862	896	933	970	1,009	1,050	1,093	1,137	1,183
	C_4F_8	549	514	546	568	591	615	639	665	692	720	749	779
	Biogenic CO_2*	0	0	0	0	0	0	0	0	0	0	0	0

**Biogenic CO_2 has a global warming potential (GWP) of 0, meaning that it is not included in CO_2e calculations for greenhouse gas inventories, per IPCC guidelines.*

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Table B-17. Puerto Rico Total Greenhouse Gas Emissions by Gas in MT CO_2e, 2019-2041 (Severe Hurricanes: Low Economic Growth)

Severe Hurricanes Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Low Economic Growth	Low Total (in CO_2e)	31,834,291	32,964,025	31,510,718	30,909,695	30,365,571	26,588,259	26,016,104	25,420,703	24,817,453	24,206,535	23,591,457	22,978,804
	CO_2	27,806,567	28,823,198	27,395,110	26,808,237	26,271,906	22,528,560	21,986,040	21,441,603	20,890,166	20,331,887	19,769,881	19,210,001
	CH_4	3,571,749	3,660,198	3,630,374	3,607,796	3,591,288	3,563,643	3,529,172	3,477,253	3,424,493	3,370,911	3,316,882	3,263,107
	N_2O	332,619	345,175	354,947	365,453	376,158	371,810	378,605	381,505	384,382	387,236	390,082	392,940
	SF_6	41,611	41,673	40,021	39,573	39,206	38,845	38,488	38,135	37,787	37,446	37,116	36,806
	NF_3	5,382	5,446	5,553	5,777	6,011	6,254	6,506	6,769	7,042	7,327	7,623	7,931
	HFC-23	3,752	3,737	3,584	3,505	3,427	3,348	3,270	3,191	3,113	3,034	2,956	2,877
	HFC-32	72,610	84,598	81,130	79,353	77,576	75,800	74,023	72,247	70,470	68,694	66,917	65,140
	HFC-41	3	3	3	3	3	3	3	3	3	3	2	2
	HFC-125	583,028	616,521	591,243	578,297	565,350	552,403	539,456	526,509	513,562	500,615	487,668	474,721
	HFC-134a	608,475	466,127	447,016	437,227	427,438	417,650	407,861	398,072	388,284	378,495	368,706	358,918
	HFC-143a	338,247	287,284	275,505	269,472	263,439	257,406	251,373	245,340	239,307	233,274	227,241	221,208
	HFC-236fa	9,095	7,161	6,868	6,717	6,567	6,417	6,266	6,116	5,966	5,815	5,665	5,514
	C_2F_6	9,166	7,448	7,594	7,901	8,220	8,552	8,898	9,257	9,631	10,020	10,425	10,846
	C_3F_8	877	780	796	828	861	896	932	970	1,009	1,050	1,092	1,136
	C_4F_8	549	514	524	545	567	590	614	639	665	692	720	749
	Biogenic CO_2*	0	0	0	0	0	0	0	0	0	0	0	0

**Biogenic CO_2 has a global warming potential (GWP) of 0, meaning that it is not included in CO_2e calculations for greenhouse gas inventories, per IPCC guidelines.*

Table B-18. Puerto Rico Total Greenhouse Gas Emissions by Gas in metric tons, 2019-2041 (Severe Hurricanes: Reference)

Severe Hurricanes Scenario		Inventory		Projections									
Metric Tons		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Reference (No Sensitivity)	Reference Total (in metric tons)												
	CO_2	27,806,567	28,823,198	27,955,192	27,356,593	26,809,566	22,990,076	22,436,609	21,881,062	21,318,371	20,748,698	20,175,223	19,603,918
	CH_4	128,020	131,190	130,155	129,345	128,752	127,753	126,517	124,656	122,764	120,843	118,906	116,978
	N_2O	1,218	1,264	1,306	1,344	1,383	1,366	1,391	1,401	1,412	1,422	1,433	1,443
	SF_6	1.65	1.65	1.62	1.60	1.59	1.57	1.56	1.54	1.53	1.52	1.50	1.49
	NF_3	0.31	0.31	0.33	0.34	0.35	0.37	0.38	0.40	0.41	0.43	0.45	0.47
	HFC-23	0.26	0.26	0.25	0.24	0.24	0.23	0.23	0.22	0.22	0.21	0.21	0.20
	HFC-32	94	110	107	105	103	100	98	96	93	91	89	86
	HFC-41	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	HFC-125	156	165	161	158	154	151	147	144	140	137	133	130
	HFC-134a	398	305	298	292	285	279	272	265	259	252	246	239
	HFC-143a	58	49	48	47	46	45	44	43	42	41	40	39
	HFC-236fa	1.05	0.82	0.81	0.79	0.77	0.75	0.74	0.72	0.70	0.68	0.67	0.65
	C_2F_6	0.74	0.60	0.62	0.65	0.68	0.70	0.73	0.76	0.79	0.82	0.86	0.89
	C_3F_8	0.09	0.08	0.09	0.09	0.09	0.10	0.10	0.11	0.11	0.12	0.12	0.12
	C_4F_8	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07
	Biogenic CO_2	261,412	265,521	258,248	252,126	246,543	240,906	235,192	229,392	223,517	217,570	211,583	205,619

Table B-19. Puerto Rico Total Greenhouse Gas Emissions by Gas in metric tons, 2019-2041 (Severe Hurricanes: High Economic Growth)

Severe Hurricanes Scenario		Inventory		Projections									
Metric Tons		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
High Economic Growth	High Total (in metric tons)												
	CO_2	27,806,567	28,823,198	28,515,274	27,904,948	27,347,226	23,451,591	22,887,177	22,320,520	21,746,575	21,165,510	20,580,566	19,997,834
	CH_4	128,020	131,190	130,188	129,378	128,785	127,778	126,541	124,679	122,787	120,865	118,927	116,999
	N_2O	1,218	1,264	1,311	1,350	1,389	1,370	1,395	1,405	1,416	1,426	1,436	1,447
	SF_6	1.65	1.65	1.65	1.63	1.62	1.60	1.59	1.58	1.56	1.55	1.53	1.52
	NF_3	0.31	0.31	0.33	0.35	0.36	0.37	0.39	0.40	0.42	0.44	0.46	0.47
	HFC-23	0.26	0.26	0.26	0.25	0.24	0.24	0.23	0.23	0.22	0.22	0.21	0.21
	HFC-32	94	110	110	107	105	102	100	98	95	93	90	88
	HFC-41	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	HFC-125	156	165	165	161	157	154	150	147	143	139	136	132
	HFC-134a	398	305	304	297	291	284	277	271	264	257	251	244
	HFC-143a	58	49	49	48	47	46	45	44	43	42	41	40
	HFC-236fa	1.05	0.82	0.82	0.80	0.79	0.77	0.75	0.73	0.71	0.70	0.68	0.66
	C_2F_6	0.74	0.60	0.64	0.66	0.69	0.72	0.75	0.78	0.81	0.84	0.88	0.91
	C_3F_8	0.09	0.08	0.09	0.09	0.10	0.10	0.10	0.11	0.11	0.12	0.12	0.13
	C_4F_8	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.08
	Biogenic CO_2	261,412	265,521	258,405	252,279	246,693	241,052	235,335	229,531	223,653	217,702	211,712	205,744

Table B-20. Puerto Rico Total Greenhouse Gas Emissions by Gas in metric tons, 2019-2041 (Severe Hurricanes: Low Economic Growth)

Severe Hurricanes Scenario		Inventory		Projections									
Metric Tons		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Low Economic Growth	Low Total (in metric tons)												
	CO_2	27,806,567	28,823,198	27,395,110	26,808,237	26,271,906	22,528,560	21,986,040	21,441,603	20,890,166	20,331,887	19,769,881	19,210,001
	CH_4	128,020	131,190	130,121	129,312	128,720	127,729	126,494	124,633	122,742	120,821	118,885	116,957
	N_2O	1,218	1,264	1,300	1,339	1,378	1,362	1,387	1,397	1,408	1,418	1,429	1,439
	SF_6	1.65	1.65	1.59	1.57	1.56	1.54	1.53	1.51	1.50	1.49	1.47	1.46
	NF_3	0.31	0.31	0.32	0.33	0.35	0.36	0.37	0.39	0.40	0.42	0.44	0.46
	HFC-23	0.26	0.26	0.25	0.24	0.23	0.23	0.22	0.22	0.21	0.21	0.20	0.20
	HFC-32	94	110	105	103	101	98	96	94	91	89	87	84
	HFC-41	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	HFC-125	156	165	158	155	151	148	144	141	137	134	130	127
	HFC-134a	398	305	292	286	279	273	267	260	254	247	241	235
	HFC-143a	58	49	47	46	45	44	43	42	41	40	39	38
	HFC-236fa	1.05	0.82	0.79	0.77	0.76	0.74	0.72	0.70	0.69	0.67	0.65	0.63
	C_2F_6	0.74	0.60	0.61	0.64	0.66	0.69	0.72	0.75	0.78	0.81	0.84	0.87
	C_3F_8	0.09	0.08	0.09	0.09	0.09	0.10	0.10	0.10	0.11	0.11	0.12	0.12
	C_4F_8	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.07
	Biogenic CO_2	261,412	265,521	258,091	251,973	246,393	240,760	235,049	229,253	223,382	217,438	211,454	205,494

Table B-21. Puerto Rico Total Greenhouse Gas Emissions by Sector in MT CO_2e, 2019-2041 (Severe Hurricanes)

Severe Hurricanes Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Reference (No Sensitivity)	Reference Total (in CO_2e)	33,383,731	34,349,863	33,432,599	32,790,622	32,206,596	28,323,427	27,711,151	27,075,480	26,431,836	25,780,402	25,124,750	24,471,587
	Power Supply	18,417,482	18,688,738	18,170,216	17,817,578	17,495,956	13,877,844	13,548,665	13,214,551	12,876,141	12,533,532	12,188,636	11,845,044
	Direct Fuel	539,378	492,339	470,967	459,804	449,622	439,342	428,920	418,343	407,630	396,784	385,865	374,988
	Industrial Processes	1,641,224	1,489,861	1,459,446	1,429,070	1,398,737	1,368,446	1,338,200	1,308,001	1,277,851	1,247,751	1,217,704	1,187,711
	Transportation	8,832,555	9,533,698	9,515,969	9,290,404	9,084,678	8,876,964	8,666,404	8,452,689	8,236,225	8,017,075	7,796,462	7,576,683
	Agriculture	922,848	948,256	995,075	1,041,895	1,088,714	1,135,533	1,168,124	1,186,486	1,204,848	1,223,209	1,241,571	1,259,933
	Forestry and Other Land Use	105,057	202,851	-91,770	-91,782	-91,795	-91,807	-91,819	-91,831	-91,843	-91,856	-91,868	-91,880
	Waste	2,925,188	2,994,121	2,912,696	2,843,654	2,780,684	2,717,106	2,652,657	2,587,241	2,520,985	2,453,906	2,386,380	2,319,109
High Economic Growth	High Total (in CO_2e)	33,383,731	34,349,863	34,024,931	33,370,559	32,775,176	28,814,679	28,190,795	27,543,352	26,887,793	26,224,304	25,556,523	24,891,276
	Power Supply	18,417,482	18,688,738	18,533,621	18,173,930	17,845,875	14,155,401	13,819,638	13,478,842	13,133,664	12,784,203	12,432,408	12,081,944
	Direct Fuel	539,378	492,339	480,387	469,000	458,614	448,128	437,499	426,710	415,782	404,719	393,582	382,487
	Industrial Processes	1,641,224	1,489,861	1,488,634	1,457,652	1,426,711	1,395,815	1,364,964	1,334,161	1,303,408	1,272,706	1,242,058	1,211,466
	Transportation	8,832,555	9,533,698	9,706,288	9,476,212	9,266,372	9,054,503	8,839,732	8,621,742	8,400,949	8,177,416	7,952,391	7,728,217
	Agriculture	922,848	948,256	995,075	1,041,895	1,088,714	1,135,533	1,168,124	1,186,486	1,204,848	1,223,209	1,241,571	1,259,933
	Forestry and Other Land Use	105,057	202,851	-91,770	-91,782	-91,795	-91,807	-91,819	-91,831	-91,843	-91,856	-91,868	-91,880
	Waste	2,925,188	2,994,121	2,912,696	2,843,654	2,780,684	2,717,106	2,652,657	2,587,241	2,520,985	2,453,906	2,386,380	2,319,109
Low Economic Growth	Low Total (in CO_2e)	33,383,731	34,349,863	32,840,267	32,210,685	31,638,016	27,832,175	27,231,507	26,607,609	25,975,879	25,336,499	24,692,976	24,051,899
	Power Supply	18,417,482	18,688,738	17,806,812	17,461,227	17,146,037	13,600,287	13,277,691	12,950,260	12,618,619	12,282,861	11,944,863	11,608,143
	Direct Fuel	539,378	492,339	461,548	450,608	440,629	430,555	420,342	409,976	399,477	388,848	378,148	367,488
	Industrial Processes	1,641,224	1,489,861	1,430,257	1,400,489	1,370,762	1,341,077	1,311,436	1,281,841	1,252,294	1,222,796	1,193,350	1,163,957
	Transportation	8,832,555	9,533,698	9,325,650	9,104,596	8,902,985	8,699,424	8,493,076	8,283,635	8,071,500	7,856,733	7,640,532	7,425,149
	Agriculture	922,848	948,256	995,075	1,041,895	1,088,714	1,135,533	1,168,124	1,186,486	1,204,848	1,223,209	1,241,571	1,259,933
	Forestry and Other Land Use	105,057	202,851	-91,770	-91,782	-91,795	-91,807	-91,819	-91,831	-91,843	-91,856	-91,868	-91,880
	Waste	2,925,188	2,994,121	2,912,696	2,843,654	2,780,684	2,717,106	2,652,657	2,587,241	2,520,985	2,453,906	2,386,380	2,319,109

Applied Economics Clinic
Economic and Policy Analysis of Energy, Environment and Equity

Power Supply

Business-as-Usual Scenario

Table B-22. Puerto Rico Power Supply Greenhouse Gas Emissions by Gas in MT CO_2e, 2019-2041 (Business-as-Usual)

Business-as-Usual (BAU) Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Ref (No Sensitivity)	Reference Total (in CO_2e)	191,016,793	187,269,825	184,851,496	183,792,168	183,050,770	159,436,262	158,784,815	158,173,712	157,611,253	157,101,562	156,663,364	156,328,903
	CO_2	18,312,884	18,586,925	18,170,307	17,817,048	17,494,860	13,902,263	13,572,505	13,237,804	12,898,798	12,555,586	12,210,083	11,865,886
	CH_4	26,993	25,605	25,201	24,858	24,546	13,488	13,168	12,843	12,514	12,181	11,846	11,512
	N_2O	43,599	42,204	41,473	40,854	40,289	24,374	23,796	23,209	22,615	22,013	21,407	20,804
	SF_6	34,005	34,005	33,080	32,296	31,581	30,859	30,127	29,384	28,631	27,870	27,103	26,339
	Biogenic CO_2	0	0	0	0	0	0	0	0	0	0	0	0
High Economic Growth	High Total (in CO_2e)	86,840,043	84,783,893	83,770,679	83,407,165	83,188,003	73,180,442	73,009,815	72,861,686	72,739,904	72,646,483	72,589,887	72,584,545
	CO_2	18,312,884	18,586,925	18,533,713	18,173,389	17,844,757	14,180,308	13,843,955	13,502,560	13,156,774	12,806,698	12,454,285	12,103,204
	CH_4	26,993	25,605	25,705	25,355	25,036	13,757	13,431	13,100	12,764	12,425	12,083	11,742
	N_2O	43,599	42,204	42,303	41,671	41,095	24,862	24,272	23,673	23,067	22,453	21,835	21,220
	SF_6	34,005	34,005	33,742	32,942	32,212	31,476	30,729	29,972	29,204	28,427	27,645	26,865
	Biogenic CO_2	0	0	0	0	0	0	0	0	0	0	0	0
Low Economic Growth	Low Total (in CO_2e)	48,924,304	46,419,717	46,270,634	46,639,834	47,088,940	44,342,870	44,856,214	45,402,307	45,983,674	46,602,129	47,262,161	47,970,736
	CO_2	18,312,884	18,586,925	17,806,900	17,460,707	17,144,963	13,624,218	13,301,055	12,973,048	12,640,822	12,304,474	11,965,881	11,628,568
	CH_4	26,993	25,605	24,697	24,361	24,055	13,218	12,904	12,586	12,264	11,937	11,609	11,282
	N_2O	43,599	42,204	40,644	40,037	39,483	23,887	23,320	22,745	22,162	21,573	20,979	20,388
	SF_6	34,005	34,005	32,419	31,650	30,949	30,242	29,524	28,796	28,059	27,312	26,561	25,812
	Biogenic CO_2	0	0	0	0	0	0	0	0	0	0	0	0

**Biogenic CO_2 has a global warming potential (GWP) of 0, meaning that it is not included in CO_2e calculations for greenhouse gas inventories, per IPCC guidelines.*

Table B-23. Puerto Rico Power Supply Greenhouse Gas Emissions by Subsector in MT CO_2e, 2019-2041 (Business-as-Usual)

Business-as-Usual (BAU) Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Reference (No Sensitivity)	Reference Total (in CO_2e)	18,417,482	18,688,738	18,270,061	17,915,056	17,591,275	13,970,984	13,639,595	13,303,240	12,962,558	12,617,650	12,270,439	11,924,540
	Residual Fuel Oil	6,277,954	7,882,410	7,668,048	7,486,286	7,320,510	7,153,132	6,983,461	6,811,247	6,636,819	6,460,226	6,282,454	6,105,355
	Distillate Fuel Oil	4,280,510	3,652,200	3,552,879	3,468,662	3,391,852	3,314,300	3,235,685	3,155,893	3,075,074	2,993,252	2,910,884	2,828,828
	Bituminous Coal	4,058,659	3,291,671	3,291,671	3,291,671	3,291,671	0	0	0	0	0	0	0
	Natural Gas	3,765,675	3,826,701	3,722,634	3,634,393	3,553,914	3,472,656	3,390,286	3,306,680	3,222,000	3,136,269	3,049,965	2,963,988
	Electricity T&D	34,005	34,005	33,080	32,296	31,581	30,859	30,127	29,384	28,631	27,870	27,103	26,339
	Anthracite Coal	633	1,710	1,710	1,710	1,710	0	0	0	0	0	0	0
	Landfill Gas	46	41	40	39	38	37	36	35	34	33	33	32
High Economic Growth	High Total (in CO_2e)	18,417,482	18,688,738	18,635,462	18,273,357	17,943,101	14,250,403	13,912,387	13,569,304	13,221,810	12,870,003	12,515,847	12,163,031
	Residual Fuel Oil	6,277,954	7,882,410	7,821,409	7,636,011	7,466,920	7,296,194	7,123,130	6,947,472	6,769,555	6,589,431	6,408,103	6,227,462
	Distillate Fuel Oil	4,280,510	3,652,200	3,623,936	3,538,035	3,459,689	3,380,586	3,300,399	3,219,011	3,136,575	3,053,117	2,969,102	2,885,404
	Bituminous Coal	4,058,659	3,291,671	3,357,504	3,357,504	3,357,504	0	0	0	0	0	0	0
	Natural Gas	3,765,675	3,826,701	3,797,087	3,707,081	3,624,992	3,542,109	3,458,091	3,372,814	3,286,440	3,198,994	3,110,965	3,023,268
	Electricity T&D	34,005	34,005	33,742	32,942	32,212	31,476	30,729	29,972	29,204	28,427	27,645	26,865
	Anthracite Coal	633	1,710	1,744	1,744	1,744	0	0	0	0	0	0	0
	Landfill Gas	46	41	40	40	39	38	37	36	35	34	33	32
Low Economic Growth	Low Total (in CO_2e)	18,417,482	18,688,738	17,904,660	17,556,755	17,239,450	13,691,564	13,366,803	13,037,175	12,703,307	12,365,297	12,025,030	11,686,050
	Residual Fuel Oil	6,277,954	7,882,410	7,514,687	7,336,560	7,174,100	7,010,069	6,843,792	6,675,022	6,504,083	6,331,022	6,156,805	5,983,248
	Distillate Fuel Oil	4,280,510	3,652,200	3,481,821	3,399,289	3,324,015	3,248,014	3,170,972	3,092,775	3,013,572	2,933,387	2,852,666	2,772,251
	Bituminous Coal	4,058,659	3,291,671	3,225,837	3,225,837	3,225,837	0	0	0	0	0	0	0
	Natural Gas	3,765,675	3,826,701	3,648,181	3,561,706	3,482,836	3,403,203	3,322,480	3,240,547	3,157,560	3,073,543	2,988,966	2,904,708
	Electricity T&D	34,005	34,005	32,419	31,650	30,949	30,242	29,524	28,796	28,059	27,312	26,561	25,812
	Anthracite Coal	633	1,710	1,676	1,676	1,676	0	0	0	0	0	0	0
	Landfill Gas	46	41	39	38	37	36	35	35	34	33	32	31

Decarbonization Scenario

Table B-24. Puerto Rico Power Supply Greenhouse Gas Emissions by Gas in MT CO_2e, 2019-2041 (Decarbonization)

Decarbonization Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Ref (No Sensitivity)	Reference Total (in CO_2e)	191,016,793	187,269,825	179,770,460	173,127,007	166,554,777	137,134,171	130,712,000	124,369,421	118,109,663	111,936,076	105,852,173	99,861,634
	CO_2	18,312,884	18,586,925	17,530,398	16,473,872	15,417,346	11,093,526	10,037,000	8,980,473	7,923,947	6,867,421	5,810,895	4,754,368
	CH_4	26,993	25,605	24,580	23,555	22,530	10,763	9,738	8,713	7,688	6,663	5,638	4,613
	N_2O	43,599	42,204	40,352	38,499	36,647	19,450	17,597	15,745	13,893	12,040	10,188	8,336
	SF_6	34,005	34,005	33,080	32,296	31,581	30,859	30,127	29,384	28,631	27,870	27,103	26,339
	Biogenic CO_2	0	0	0	0	0	0	0	0	0	0	0	0
High Economic Growth	High Total (in CO_2e)	86,840,043	84,783,893	81,530,421	78,704,835	75,914,826	63,347,323	60,632,352	57,957,182	55,323,428	52,732,764	50,186,944	47,687,805
	CO_2	18,312,884	18,586,925	17,881,006	16,803,349	15,725,693	11,315,396	10,237,740	9,160,083	8,082,426	7,004,769	5,927,112	4,849,456
	CH_4	26,993	25,605	25,072	24,026	22,981	10,978	9,932	8,887	7,841	6,796	5,750	4,705
	N_2O	43,599	42,204	41,159	39,269	37,380	19,839	17,949	16,060	14,170	12,281	10,392	8,502
	SF_6	34,005	34,005	33,742	32,942	32,212	31,476	30,729	29,972	29,204	28,427	27,645	26,865
	Biogenic CO_2	0	0	0	0	0	0	0	0	0	0	0	0
Low Economic Growth	Low Total (in CO_2e)	48,924,304	46,419,717	45,354,809	44,717,505	44,115,641	40,323,057	39,796,264	39,309,295	38,863,759	38,461,333	38,103,761	37,792,864
	CO_2	18,312,884	18,586,925	17,179,790	16,144,395	15,108,999	10,871,655	9,836,260	8,800,864	7,765,468	6,730,072	5,694,677	4,659,281
	CH_4	26,993	25,605	24,088	23,084	22,079	10,547	9,543	8,538	7,534	6,529	5,525	4,520
	N_2O	43,599	42,204	39,545	37,729	35,914	19,061	17,245	15,430	13,615	11,799	9,984	8,169
	SF_6	34,005	34,005	32,419	31,650	30,949	30,242	29,524	28,796	28,059	27,312	26,561	25,812
	Biogenic CO_2	0	0	0	0	0	0	0	0	0	0	0	0

Biogenic CO_2 has a global warming potential (GWP) of 0, meaning that it is not included in CO_2e calculations for greenhouse gas inventories, per IPCC guidelines.

Table B-25. Puerto Rico Power Supply Greenhouse Gas Emissions by Subsector in MT CO_2e, 2019-2041 (Decarbonization)

Decarbonization Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Reference (No Sensitivity)	Reference Total (in CO_2e)	18,417,482	18,688,738	17,628,410	16,568,222	15,508,103	11,154,597	10,094,461	9,034,315	7,974,159	6,913,993	5,853,823	4,793,655
	Residual Fuel Oil	6,277,954	7,882,410	7,338,796	6,795,181	6,251,567	5,707,952	5,164,338	4,620,723	4,077,109	3,533,494	2,989,880	2,446,265
	Distillate Fuel Oil	4,280,510	3,652,200	3,400,324	3,148,449	2,896,573	2,644,697	2,392,821	2,140,945	1,889,069	1,637,193	1,385,317	1,133,441
	Bituminous Coal	4,058,659	3,291,671	3,291,671	3,291,671	3,291,671	0	0	0	0	0	0	0
	Natural Gas	3,765,675	3,826,701	3,562,791	3,298,881	3,034,970	2,771,060	2,507,149	2,243,239	1,979,328	1,715,418	1,451,507	1,187,597
	Electricity T&D	34,005	34,005	33,080	32,296	31,581	30,859	30,127	29,384	28,631	27,870	27,103	26,339
	Anthracite Coal	633	1,710	1,710	1,710	1,710	0	0	0	0	0	0	0
	Landfill Gas	46	41	38	35	32	30	27	24	21	18	15	13
High Economic Growth	High Total (in CO_2e)	18,417,482	18,688,738	17,980,978	16,899,587	15,818,266	11,377,689	10,296,351	9,215,001	8,133,642	7,052,273	5,970,899	4,889,528
	Residual Fuel Oil	6,277,954	7,882,410	7,485,572	6,931,085	6,376,598	5,822,111	5,267,624	4,713,138	4,158,651	3,604,164	3,049,677	2,495,191
	Distillate Fuel Oil	4,280,510	3,652,200	3,468,331	3,211,418	2,954,504	2,697,591	2,440,677	2,183,764	1,926,851	1,669,937	1,413,024	1,156,110
	Bituminous Coal	4,058,659	3,291,671	3,357,504	3,357,504	3,357,504	0	0	0	0	0	0	0
	Natural Gas	3,765,675	3,826,701	3,634,047	3,364,858	3,095,670	2,826,481	2,557,292	2,288,104	2,018,915	1,749,726	1,480,538	1,211,349
	Electricity T&D	34,005	34,005	33,742	32,942	32,212	31,476	30,729	29,972	29,204	28,427	27,645	26,865
	Anthracite Coal	633	1,710	1,744	1,744	1,744	0	0	0	0	0	0	0
	Landfill Gas	46	41	39	36	33	30	27	24	22	19	16	13
Low Economic Growth	Low Total (in CO_2e)	18,417,482	18,688,738	17,275,842	16,236,858	15,197,941	10,931,505	9,892,572	8,853,628	7,814,675	6,775,713	5,736,746	4,697,782
	Residual Fuel Oil	6,277,954	7,882,410	7,192,020	6,659,278	6,126,535	5,593,793	5,061,051	4,528,309	3,995,567	3,462,824	2,930,082	2,397,340
	Distillate Fuel Oil	4,280,510	3,652,200	3,332,318	3,085,480	2,838,641	2,591,803	2,344,965	2,098,126	1,851,288	1,604,449	1,357,611	1,110,773
	Bituminous Coal	4,058,659	3,291,671	3,225,837	3,225,837	3,225,837	0	0	0	0	0	0	0
	Natural Gas	3,765,675	3,826,701	3,491,535	3,232,903	2,974,271	2,715,638	2,457,006	2,198,374	1,939,742	1,681,110	1,422,477	1,163,845
	Electricity T&D	34,005	34,005	32,419	31,650	30,949	30,242	29,524	28,796	28,059	27,312	26,561	25,812
	Anthracite Coal	633	1,710	1,676	1,676	1,676	0	0	0	0	0	0	0
	Landfill Gas	46	41	37	34	32	29	26	23	21	18	15	12

Severe Hurricanes Scenario

Table B-26. Puerto Rico Power Supply Greenhouse Gas Emissions by Gas in MT CO_2e, 2019-2041 (Severe Hurricanes)

Severe Hurricanes Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Ref (No Sensitivity)	Reference Total (in CO_2e)	191,016,793	187,269,825	183,917,807	182,880,611	182,159,398	158,565,271	157,934,483	157,344,350	156,803,130	156,314,941	155,898,389	155,585,493
	CO_2	18,312,884	18,586,925	18,070,953	17,720,050	17,400,009	13,809,581	13,482,021	13,149,552	12,812,806	12,471,882	12,128,682	11,786,780
	CH_4	26,993	25,605	25,104	24,764	24,453	13,398	13,080	12,757	12,431	12,100	11,767	11,435
	N_2O	43,599	42,204	41,299	40,684	40,123	24,212	23,637	23,054	22,464	21,866	21,265	20,665
	SF_6	34,005	34,005	32,860	32,081	31,370	30,653	29,926	29,188	28,440	27,684	26,922	26,163
	Biogenic CO_2	0	0	0	0	0	0	0	0	0	0	0	0
High Economic Growth	High Total (in CO_2e)	86,840,043	84,783,893	83,345,774	82,992,332	82,782,356	72,784,070	72,622,845	72,484,259	72,372,142	72,288,507	72,241,761	72,246,233
	CO_2	18,312,884	18,586,925	18,432,372	18,074,451	17,748,010	14,085,773	13,751,662	13,412,543	13,069,062	12,721,320	12,371,256	12,022,516
	CH_4	26,993	25,605	25,606	25,259	24,943	13,666	13,341	13,012	12,679	12,342	12,002	11,664
	N_2O	43,599	42,204	42,125	41,498	40,925	24,696	24,110	23,515	22,913	22,304	21,690	21,078
	SF_6	34,005	34,005	33,517	32,722	31,998	31,266	30,524	29,772	29,009	28,237	27,460	26,686
	Biogenic CO_2	0	0	0	0	0	0	0	0	0	0	0	0
Low Economic Growth	Low Total (in CO_2e)	48,924,304	46,419,717	46,061,383	46,435,543	46,889,174	44,147,670	44,665,644	45,216,437	45,802,564	46,425,838	47,090,721	47,804,130
	CO_2	18,312,884	18,586,925	17,709,534	17,365,649	17,052,009	13,533,390	13,212,381	12,886,561	12,556,550	12,222,445	11,886,109	11,551,045
	CH_4	26,993	25,605	24,602	24,269	23,964	13,130	12,818	12,502	12,182	11,858	11,532	11,207
	N_2O	43,599	42,204	40,473	39,870	39,321	23,727	23,165	22,593	22,015	21,429	20,839	20,252
	SF_6	34,005	34,005	32,202	31,439	30,743	30,040	29,327	28,604	27,872	27,130	26,384	25,640
	Biogenic CO_2	0	0	0	0	0	0	0	0	0	0	0	0

Biogenic CO_2 has a global warming potential (GWP) of 0, meaning that it is not included in CO_2e calculations for greenhouse gas inventories, per IPCC guidelines.

Table B-27. Puerto Rico Power Supply Greenhouse Gas Emissions by Subsector in MT CO_2e, 2019-2041 (Severe Hurricanes)

Severe Hurricanes Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Reference (No Sensitivity)	Reference Total (in CO_2e)	18,417,482	18,688,738	18,170,216	17,817,578	17,495,956	13,877,844	13,548,665	13,214,551	12,876,141	12,533,532	12,188,636	11,845,044
	Residual Fuel Oil	6,277,954	7,882,410	7,616,927	7,436,377	7,271,707	7,105,444	6,936,905	6,765,839	6,592,574	6,417,158	6,240,571	6,064,652
	Distillate Fuel Oil	4,280,510	3,652,200	3,529,193	3,445,537	3,369,240	3,292,205	3,214,114	3,134,853	3,054,573	2,973,297	2,891,478	2,809,969
	Bituminous Coal	4,058,659	3,291,671	3,291,671	3,291,671	3,291,671	0	0	0	0	0	0	0
	Natural Gas	3,765,675	3,826,701	3,697,817	3,610,164	3,530,221	3,449,505	3,367,684	3,284,636	3,200,520	3,115,360	3,029,632	2,944,228
	Electricity T&D	34,005	34,005	32,860	32,081	31,370	30,653	29,926	29,188	28,440	27,684	26,922	26,163
	Anthracite Coal	633	1,710	1,710	1,710	1,710	0	0	0	0	0	0	0
	Landfill Gas	46	41	39	38	38	37	36	35	34	33	32	31
High Economic Growth	High Total (in CO_2e)	18,417,482	18,688,738	18,533,621	18,173,930	17,845,875	14,155,401	13,819,638	13,478,842	13,133,664	12,784,203	12,432,408	12,081,944
	Residual Fuel Oil	6,277,954	7,882,410	7,769,266	7,585,104	7,417,141	7,247,553	7,075,643	6,901,156	6,724,425	6,545,501	6,365,383	6,185,945
	Distillate Fuel Oil	4,280,510	3,652,200	3,599,777	3,514,448	3,436,625	3,358,049	3,278,396	3,197,550	3,115,665	3,032,763	2,949,308	2,866,168
	Bituminous Coal	4,058,659	3,291,671	3,357,504	3,357,504	3,357,504	0	0	0	0	0	0	0
	Natural Gas	3,765,675	3,826,701	3,771,773	3,682,367	3,600,825	3,518,495	3,435,037	3,350,329	3,264,530	3,177,667	3,090,225	3,003,113
	Electricity T&D	34,005	34,005	33,517	32,722	31,998	31,266	30,524	29,772	29,009	28,237	27,460	26,686
	Anthracite Coal	633	1,710	1,744	1,744	1,744	0	0	0	0	0	0	0
	Landfill Gas	46	41	40	39	38	38	37	36	35	34	33	32
Low Economic Growth	Low Total (in CO_2e)	18,417,482	18,688,738	17,806,812	17,461,227	17,146,037	13,600,287	13,277,691	12,950,260	12,618,619	12,282,861	11,944,863	11,608,143
	Residual Fuel Oil	6,277,954	7,882,410	7,464,589	7,287,649	7,126,272	6,963,335	6,798,167	6,630,522	6,460,722	6,288,815	6,115,760	5,943,359
	Distillate Fuel Oil	4,280,510	3,652,200	3,458,609	3,376,627	3,301,855	3,226,360	3,149,832	3,072,156	2,993,482	2,913,831	2,833,649	2,753,769
	Bituminous Coal	4,058,659	3,291,671	3,225,837	3,225,837	3,225,837	0	0	0	0	0	0	0
	Natural Gas	3,765,675	3,826,701	3,623,860	3,537,961	3,459,617	3,380,515	3,300,330	3,218,943	3,136,510	3,053,053	2,969,039	2,885,344
	Electricity T&D	34,005	34,005	32,202	31,439	30,743	30,040	29,327	28,604	27,872	27,130	26,384	25,640
	Anthracite Coal	633	1,710	1,676	1,676	1,676	0	0	0	0	0	0	0
	Landfill Gas	46	41	39	38	37	36	35	34	33	33	32	31

Direct Fuel

Business-as-Usual Scenario

Table B-28. Puerto Rico Direct Fuel Greenhouse Gas Emissions by Gas in MT CO_2e, 2019-2041 (Business-as-Usual)

Business-as-Usual (BAU) Scenario		Inventory		Projections											
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Ref (No Sens)	Reference Total (in CO_2e)	26,729,360	24,282,570	25,011,232	25,807,757	26,646,603	27,521,553	28,433,795	29,384,764	30,376,215	31,409,842	32,487,817	33,612,756
	CO_2	537,158	490,332	476,997	465,691	455,379	444,967	434,412	423,699	412,849	401,864	390,805	379,789
	CH_4	721	654	636	621	607	593	579	565	550	536	521	506
	N_2O	1,499	1,353	1,317	1,285	1,257	1,228	1,199	1,169	1,140	1,109	1,079	1,048
High Economic	High Total (in CO_2e)	14,722,489	13,372,029	13,802,682	14,268,657	14,757,800	15,267,653	15,798,935	16,352,484	16,929,278	17,530,284	18,156,679	18,809,841
	CO_2	537,158	490,332	486,537	475,005	464,486	453,866	443,100	432,173	421,106	409,901	398,621	387,385
	CH_4	721	654	649	633	619	605	591	576	561	546	531	516
	N_2O	1,499	1,353	1,343	1,311	1,282	1,253	1,223	1,193	1,162	1,131	1,100	1,069
Low Economic	Low Total (in CO_2e)	10,388,738	9,433,524	9,771,700	10,136,309	10,517,075	10,913,537	11,326,288	11,755,979	12,203,320	12,669,032	13,153,923	13,658,885
	CO_2	537,158	490,332	467,457	456,377	446,271	436,067	425,724	415,225	404,592	393,827	382,989	372,193
	CH_4	721	654	623	608	595	581	568	554	539	525	511	496
	N_2O	1,499	1,353	1,290	1,260	1,232	1,204	1,175	1,146	1,117	1,087	1,057	1,027

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Table B-29. Puerto Rico Direct Fuel Greenhouse Gas Emissions by Subsector in MT CO_2e, 2019-2041 (Business-as-Usual)

Business-as-Usual (BAU) Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Ref (No Sens)	Reference Total (in CO_2e)	539,378	492,339	478,950	467,597	457,242	446,788	436,190	425,434	414,539	403,509	392,405	381,343
	Liquefied Petroleum Gases	471,246	410,633	399,466	389,997	381,361	372,642	363,803	354,831	345,744	336,545	327,284	318,058
	Distillate Fuel Oil	65,138	78,755	76,613	74,797	73,141	71,469	69,773	68,053	66,310	64,546	62,769	61,000
	Kerosene	2,994	2,951	2,870	2,802	2,740	2,678	2,614	2,550	2,484	2,418	2,352	2,286
High Economic	High Total (in CO_2e)	539,378	492,339	488,529	476,949	466,387	455,724	444,914	433,942	422,830	411,579	400,253	388,970
	Liquefied Petroleum Gases	471,246	410,633	407,456	397,797	388,988	380,095	371,079	361,928	352,659	343,276	333,830	324,419
	Distillate Fuel Oil	65,138	78,755	78,145	76,293	74,604	72,898	71,169	69,414	67,636	65,836	64,025	62,220
	Kerosene	2,994	2,951	2,928	2,858	2,795	2,731	2,666	2,601	2,534	2,467	2,399	2,331
Low Economic	Low Total (in CO_2e)	539,378	492,339	469,371	458,245	448,098	437,852	427,466	416,925	406,248	395,439	384,557	373,716
	Liquefied Petroleum Gases	471,246	410,633	391,477	382,197	373,734	365,189	356,527	347,735	338,830	329,814	320,738	311,697
	Distillate Fuel Oil	65,138	78,755	75,081	73,301	71,678	70,039	68,378	66,692	64,984	63,255	61,514	59,780
	Kerosene	2,994	2,951	2,813	2,746	2,686	2,624	2,562	2,499	2,435	2,370	2,305	2,240

Decarbonization Scenario

Table B-30. Puerto Rico Direct Fuel Greenhouse Gas Emissions by Gas in MT CO_2e, 2019-2041 (Decarbonization)

Decarbonization Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Ref (No Sens)	Reference Total (in CO_2e)	26,729,360	24,282,570	24,868,098	25,507,316	26,181,907	26,893,298	27,642,976	28,432,489	29,263,445	30,137,519	31,056,453	32,022,059
	CO_2	537,158	490,332	456,516	422,700	388,884	355,068	321,252	287,436	253,620	219,804	185,988	152,172
	CH_4	721	654	609	563	518	473	428	383	338	293	248	203
	N_2O	1,499	1,353	1,260	1,167	1,073	980	887	793	700	607	513	420
High Economic	High Total (in CO_2e)	14,722,489	13,372,029	13,741,398	14,140,021	14,558,836	14,998,658	15,460,338	15,944,757	16,452,834	16,985,525	17,543,824	18,128,767
	CO_2	537,158	490,332	465,646	431,154	396,662	362,169	327,677	293,185	258,692	224,200	189,708	155,215
	CH_4	721	654	621	575	529	483	437	391	345	299	253	207
	N_2O	1,499	1,353	1,285	1,190	1,095	1,000	904	809	714	619	524	428
Low Economic	Low Total (in CO_2e)	10,388,738	9,433,524	9,751,546	10,094,005	10,451,644	10,825,075	11,214,938	11,621,895	12,046,637	12,489,883	12,952,381	13,434,907
	CO_2	537,158	490,332	447,386	414,246	381,106	347,967	314,827	281,687	248,548	215,408	182,268	149,129
	CH_4	721	654	596	552	508	464	420	376	331	287	243	199
	N_2O	1,499	1,353	1,235	1,143	1,052	960	869	778	686	595	503	412

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Table B-31. Puerto Rico Direct Fuel Greenhouse Gas Emissions by Subsector in MT CO_2e, 2019-2041 (Decarbonization)

Decarbonization Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Ref (No Sens)	Reference Total (in CO_2e)	539,378	492,339	458,385	424,430	390,476	356,521	322,567	288,613	254,658	220,704	186,749	152,795
	Liquefied Petroleum Gases	471,246	410,633	382,314	353,994	325,675	297,355	269,036	240,716	212,397	184,077	155,757	127,438
	Distillate Fuel Oil	65,138	78,755	73,324	67,892	62,461	57,029	51,598	46,167	40,735	35,304	29,873	24,441
	Kerosene	2,994	2,951	2,747	2,544	2,340	2,137	1,933	1,730	1,526	1,323	1,119	916
High Economic	High Total (in CO_2e)	539,378	492,339	467,552	432,919	398,285	363,652	329,018	294,385	259,751	225,118	190,484	155,851
	Liquefied Petroleum Gases	471,246	410,633	389,960	361,074	332,188	303,302	274,416	245,530	216,645	187,759	158,873	129,987
	Distillate Fuel Oil	65,138	78,755	74,790	69,250	63,710	58,170	52,630	47,090	41,550	36,010	30,470	24,930
	Kerosene	2,994	2,951	2,802	2,595	2,387	2,179	1,972	1,764	1,557	1,349	1,142	934
Low Economic	Low Total (in CO_2e)	539,378	492,339	449,217	415,942	382,666	349,391	316,116	282,840	249,565	216,290	183,014	149,739
	Liquefied Petroleum Gases	471,246	410,633	374,668	346,914	319,161	291,408	263,655	235,902	208,149	180,395	152,642	124,889
	Distillate Fuel Oil	65,138	78,755	71,857	66,534	61,212	55,889	50,566	45,243	39,921	34,598	29,275	23,952
	Kerosene	2,994	2,951	2,692	2,493	2,293	2,094	1,895	1,695	1,496	1,296	1,097	897

Severe Hurricanes Scenario

Table B-32. Puerto Rico Direct Fuel Greenhouse Gas Emissions by Gas in MT CO_2e, 2019-2041 (Severe Hurricanes)

Severe Hurricanes Scenario		Inventory		Projections											
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Ref (No Sens)	Reference Total (in CO_2e)	26,729,360	24,282,570	24,955,673	25,753,515	26,593,563	27,469,726	28,383,197	29,335,414	30,328,128	31,363,035	32,442,298	33,568,520
	CO_2	537,158	490,332	469,047	457,929	447,789	437,551	427,172	416,638	405,968	395,166	384,292	373,459
	CH_4	721	654	625	610	597	583	569	555	541	527	512	498
	N_2O	1,499	1,353	1,295	1,264	1,236	1,208	1,179	1,150	1,121	1,091	1,061	1,031
High Economic	High Total (in CO_2e)	14,722,489	13,372,029	13,778,894	14,245,433	14,735,091	15,245,462	15,777,271	16,331,354	16,908,690	17,510,243	18,137,189	18,790,901
	CO_2	537,158	490,332	478,428	467,088	456,745	446,302	435,715	424,971	414,087	403,069	391,978	380,928
	CH_4	721	654	638	623	609	595	581	567	552	537	523	508
	N_2O	1,499	1,353	1,321	1,289	1,261	1,232	1,203	1,173	1,143	1,113	1,082	1,051
Low Economic	Low Total (in CO_2e)	10,388,738	9,433,524	9,763,877	10,128,671	10,509,607	10,906,239	11,319,164	11,749,031	12,196,549	12,662,441	13,147,514	13,652,656
	CO_2	537,158	490,332	459,666	448,771	438,833	428,800	418,628	408,305	397,849	387,263	376,606	365,990
	CH_4	721	654	613	598	585	572	558	544	530	516	502	488
	N_2O	1,499	1,353	1,269	1,239	1,211	1,184	1,155	1,127	1,098	1,069	1,040	1,010

Table B-33. Puerto Rico Direct Fuel Greenhouse Gas Emissions by Subsector in MT CO_2e, 2019-2041 (Severe Hurricanes)

Severe Hurricanes Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Ref (No Sens)	Reference Total (in CO_2e)	539,378	492,339	470,967	459,804	449,622	439,342	428,920	418,343	407,630	396,784	385,865	374,988
	Liquefied Petroleum Gases	471,246	410,633	392,808	383,497	375,005	366,431	357,739	348,917	339,982	330,936	321,829	312,757
	Distillate Fuel Oil	65,138	78,755	75,336	73,551	71,922	70,277	68,610	66,918	65,205	63,470	61,723	59,983
	Kerosene	2,994	2,951	2,823	2,756	2,695	2,633	2,571	2,507	2,443	2,378	2,313	2,247
High Economic	High Total (in CO_2e)	539,378	492,339	480,387	469,000	458,614	448,128	437,499	426,710	415,782	404,719	393,582	382,487
	Liquefied Petroleum Gases	471,246	410,633	400,665	391,167	382,505	373,760	364,894	355,896	346,782	337,554	328,266	319,012
	Distillate Fuel Oil	65,138	78,755	76,843	75,022	73,360	71,683	69,983	68,257	66,509	64,739	62,958	61,183
	Kerosene	2,994	2,951	2,879	2,811	2,749	2,686	2,622	2,557	2,492	2,426	2,359	2,292
Low Economic	Low Total (in CO_2e)	539,378	492,339	461,548	450,608	440,629	430,555	420,342	409,976	399,477	388,848	378,148	367,488
	Liquefied Petroleum Gases	471,246	410,633	384,952	375,827	367,505	359,102	350,585	341,939	333,182	324,317	315,393	306,502
	Distillate Fuel Oil	65,138	78,755	73,830	72,080	70,483	68,872	67,238	65,580	63,901	62,200	60,489	58,784
	Kerosene	2,994	2,951	2,766	2,701	2,641	2,580	2,519	2,457	2,394	2,330	2,266	2,202

Industrial Processes and Product Use

Business-as-Usual Scenario

Table B-34. Puerto Rico Industrial Processes and Product Use Greenhouse Gas Emissions by Gas in MT CO_2e, 2019-2041 (Business-as-Usual: Reference)

Business-as-Usual (BAU) Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Reference (No Sensitivity)	Reference Total (in CO_2e)	1,641,224	1,489,861	1,459,446	1,429,070	1,398,737	1,368,446	1,338,200	1,308,001	1,277,851	1,247,751	1,217,704	1,187,711
	CO_2	439	276	287	298	310	323	336	350	364	378	394	410
	N_2O	1,994	2,298	2,390	2,487	2,587	2,692	2,801	2,914	3,032	3,154	3,282	3,414
	SF_6	7,606	7,668	7,978	8,300	8,635	8,984	9,347	9,725	10,118	10,527	10,952	11,394
	NF_3	5,382	5,446	5,666	5,895	6,133	6,381	6,639	6,907	7,186	7,477	7,779	8,093
	HFC-23	3,752	3,737	3,657	3,577	3,497	3,417	3,336	3,256	3,176	3,096	3,016	2,936
	HFC-32	72,610	84,598	82,785	80,972	79,160	77,347	75,534	73,721	71,908	70,096	68,283	66,470
	HFC-41	3.2	3.1	3.0	3.0	2.9	2.8	2.8	2.7	2.6	2.6	2.5	2.4
	HFC-125	583,028	616,521	603,310	590,098	576,887	563,676	550,465	537,254	524,043	510,832	497,620	484,409
	HFC-134a	608,475	466,127	456,138	446,150	436,161	426,173	416,185	406,196	396,208	386,219	376,231	366,242
	HFC-143a	338,247	287,284	281,128	274,971	268,815	262,659	256,503	250,347	244,191	238,035	231,879	225,723
	HFC-236fa	9,095	7,161	7,008	6,855	6,701	6,548	6,394	6,241	6,087	5,934	5,780	5,627
	C_2F_6	9,166	7,448	7,749	8,062	8,388	8,727	9,079	9,446	9,828	10,225	10,638	11,067
	C_3F_8	877	780	812	845	879	914	951	990	1,030	1,071	1,114	1,160
	C_4F_8	549	514	535	557	579	602	627	652	678	706	734	764

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Table B-35. Puerto Rico Industrial Processes and Product Use Greenhouse Gas Emissions by Gas in MT CO_2e, 2019-2041 (Business-as-Usual: High Growth)

	Business-as-Usual (BAU) Scenario	Inventory		Projections											
	Metric Tons CO_2e	2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
High Economic Growth	High Total (in CO_2e)	1,641,224	1,489,861	1,488,634	1,457,652	1,426,711	1,395,815	1,364,964	1,334,161	1,303,408	1,272,706	1,242,058	1,211,466
	CO_2	439	276	292	304	317	329	343	357	371	386	402	418
	N_2O	1,994	2,298	2,438	2,537	2,639	2,746	2,857	2,972	3,092	3,217	3,347	3,482
	SF_6	7,606	7,668	8,137	8,466	8,808	9,164	9,534	9,919	10,320	10,737	11,171	11,622
	NF_3	5,382	5,446	5,780	6,013	6,256	6,509	6,772	7,045	7,330	7,626	7,934	8,255
	HFC-23	3,752	3,737	3,730	3,648	3,567	3,485	3,403	3,322	3,240	3,158	3,076	2,995
	HFC-32	72,610	84,598	84,441	82,592	80,743	78,894	77,045	75,196	73,346	71,497	69,648	67,799
	HFC-41	3.2	3.1	3.1	3.0	3.0	2.9	2.8	2.8	2.7	2.6	2.6	2.5
	HFC-125	583,028	616,521	615,376	601,900	588,425	574,950	561,474	547,999	534,524	521,048	507,573	494,097
	HFC-134a	608,475	466,127	465,261	455,073	444,885	434,697	424,508	414,320	404,132	393,944	383,756	373,567
	HFC-143a	338,247	287,284	286,750	280,471	274,192	267,913	261,633	255,354	249,075	242,796	236,517	230,237
	HFC-236fa	9,095	7,161	7,148	6,992	6,835	6,679	6,522	6,366	6,209	6,052	5,896	5,739
	C_2F_6	9,166	7,448	7,904	8,223	8,555	8,901	9,261	9,635	10,024	10,429	10,850	11,289
	C_3F_8	877	780	828	862	896	933	970	1,009	1,050	1,093	1,137	1,183
	C_4F_8	549	514	546	568	591	615	639	665	692	720	749	779

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Table B-36. Puerto Rico Industrial Processes and Product Use Greenhouse Gas Emissions by Gas in MT CO_2e, 2019-2041 (Business-as-Usual: Low Growth)

Business-as-Usual (BAU) Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Low Economic Growth	Low Total (in CO_2e)	1,641,224	1,489,861	1,430,257	1,400,489	1,370,762	1,341,077	1,311,436	1,281,841	1,252,294	1,222,796	1,193,350	1,163,957
	CO_2	439	276	281	292	304	316	329	343	356	371	386	401
	N_2O	1,994	2,298	2,343	2,437	2,536	2,638	2,745	2,856	2,971	3,091	3,216	3,346
	SF_6	7,606	7,668	7,818	8,134	8,463	8,805	9,160	9,530	9,915	10,316	10,733	11,166
	NF_3	5,382	5,446	5,553	5,777	6,011	6,254	6,506	6,769	7,042	7,327	7,623	7,931
	HFC-23	3,752	3,737	3,584	3,505	3,427	3,348	3,270	3,191	3,113	3,034	2,956	2,877
	HFC-32	72,610	84,598	81,130	79,353	77,576	75,800	74,023	72,247	70,470	68,694	66,917	65,140
	HFC-41	3.2	3.1	3.0	2.9	2.8	2.8	2.7	2.6	2.6	2.5	2.5	2.4
	HFC-125	583,028	616,521	591,243	578,297	565,350	552,403	539,456	526,509	513,562	500,615	487,668	474,721
	HFC-134a	608,475	466,127	447,016	437,227	427,438	417,650	407,861	398,072	388,284	378,495	368,706	358,918
	HFC-143a	338,247	287,284	275,505	269,472	263,439	257,406	251,373	245,340	239,307	233,274	227,241	221,208
	HFC-236fa	9,095	7,161	6,868	6,717	6,567	6,417	6,266	6,116	5,966	5,815	5,665	5,514
	C_2F_6	9,166	7,448	7,594	7,901	8,220	8,552	8,898	9,257	9,631	10,020	10,425	10,846
	C_3F_8	877	780	796	828	861	896	932	970	1,009	1,050	1,092	1,136
	C_4F_8	549	514	524	545	567	590	614	639	665	692	720	749

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Table B-37. Puerto Rico Industrial Processes and Product Use Greenhouse Gas Emissions by Subsector in MT CO_2e, 2019-2041 (Business-as-Usual)

Business-as-Usual (BAU) Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Ref (No Sens)	Reference Total (in CO_2e)	1,641,224	1,489,861	1,459,446	1,429,070	1,398,737	1,368,446	1,338,200	1,308,001	1,277,851	1,247,751	1,217,704	1,187,711
	ODS Substitutes	1,611,752	1,461,946	1,430,620	1,399,294	1,367,969	1,336,644	1,305,318	1,273,993	1,242,668	1,211,342	1,180,017	1,148,692
	Semiconductors	29,063	27,669	28,570	29,510	30,491	31,514	32,582	33,696	34,859	36,071	37,335	38,654
	Cement	408	246	256	266	277	288	300	312	325	338	351	366
High Economic	High Total (in CO_2e)	1,641,224	1,489,861	1,488,634	1,457,652	1,426,711	1,395,815	1,364,964	1,334,161	1,303,408	1,272,706	1,242,058	1,211,466
	ODS Substitutes	1,611,752	1,461,946	1,459,232	1,427,280	1,395,328	1,363,376	1,331,425	1,299,473	1,267,521	1,235,569	1,203,618	1,171,666
	Semiconductors	29,063	27,669	29,141	30,100	31,100	32,144	33,234	34,370	35,556	36,792	38,082	39,427
	Cement	408	246	261	272	283	294	306	318	331	344	358	373
Low Economic	Low Total (in CO_2e)	1,641,224	1,489,861	1,430,257	1,400,489	1,370,762	1,341,077	1,311,436	1,281,841	1,252,294	1,222,796	1,193,350	1,163,957
	ODS Substitutes	1,611,752	1,461,946	1,402,008	1,371,309	1,340,610	1,309,911	1,279,212	1,248,513	1,217,814	1,187,116	1,156,417	1,125,718
	Semiconductors	29,063	27,669	27,998	28,919	29,881	30,884	31,931	33,022	34,162	35,350	36,589	37,881
	Cement	408	246	251	261	272	282	294	306	318	331	344	358

Decarbonization Scenario

Table B-38. Puerto Rico Industrial Processes and Product Use Greenhouse Gas Emissions by Gas in MT CO_2e, 2019-2041 (Decarbonization: Reference)

Decarbonization Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Reference (No Sensitivity)	Reference Total (in CO_2e)	1,641,224	1,489,861	1,459,446	1,429,070	1,398,737	1,368,446	1,338,200	1,308,001	1,277,851	1,247,751	1,217,704	1,187,711
	CO_2	439	276	287	298	310	323	336	350	364	378	394	410
	N_2O	1,994	2,298	2,390	2,487	2,587	2,692	2,801	2,914	3,032	3,154	3,282	3,414
	SF_6	7,606	7,668	7,978	8,300	8,635	8,984	9,347	9,725	10,118	10,527	10,952	11,394
	NF_3	5,382	5,446	5,666	5,895	6,133	6,381	6,639	6,907	7,186	7,477	7,779	8,093
	HFC-23	3,752	3,737	3,657	3,577	3,497	3,417	3,336	3,256	3,176	3,096	3,016	2,936
	HFC-32	72,610	84,598	82,785	80,972	79,160	77,347	75,534	73,721	71,908	70,096	68,283	66,470
	HFC-41	3.2	3.1	3.0	3.0	2.9	2.8	2.8	2.7	2.6	2.6	2.5	2.4
	HFC-125	583,028	616,521	603,310	590,098	576,887	563,676	550,465	537,254	524,043	510,832	497,620	484,409
	HFC-134a	608,475	466,127	456,138	446,150	436,161	426,173	416,185	406,196	396,208	386,219	376,231	366,242
	HFC-143a	338,247	287,284	281,128	274,971	268,815	262,659	256,503	250,347	244,191	238,035	231,879	225,723
	HFC-236fa	9,095	7,161	7,008	6,855	6,701	6,548	6,394	6,241	6,087	5,934	5,780	5,627
	C_2F_6	9,166	7,448	7,749	8,062	8,388	8,727	9,079	9,446	9,828	10,225	10,638	11,067
	C_3F_8	877	780	812	845	879	914	951	990	1,030	1,071	1,114	1,160
	C_4F_8	549	514	535	557	579	602	627	652	678	706	734	764

Table B-39. Puerto Rico Industrial Processes and Product Use Greenhouse Gas Emissions by Gas in MT CO_2e, 2019-2041 (Decarbonization: High Growth)

Decarbonization Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
High Economic Growth	High Total (in CO_2e)	1,641,224	1,489,861	1,488,634	1,457,652	1,426,711	1,395,815	1,364,964	1,334,161	1,303,408	1,272,706	1,242,058	1,211,466
	CO_2	439	276	292	304	317	329	343	357	371	386	402	418
	N_2O	1,994	2,298	2,438	2,537	2,639	2,746	2,857	2,972	3,092	3,217	3,347	3,482
	SF_6	7,606	7,668	8,137	8,466	8,808	9,164	9,534	9,919	10,320	10,737	11,171	11,622
	NF_3	5,382	5,446	5,780	6,013	6,256	6,509	6,772	7,045	7,330	7,626	7,934	8,255
	HFC-23	3,752	3,737	3,730	3,648	3,567	3,485	3,403	3,322	3,240	3,158	3,076	2,995
	HFC-32	72,610	84,598	84,441	82,592	80,743	78,894	77,045	75,196	73,346	71,497	69,648	67,799
	HFC-41	3.2	3.1	3.1	3.0	3.0	2.9	2.8	2.8	2.7	2.6	2.6	2.5
	HFC-125	583,028	616,521	615,376	601,900	588,425	574,950	561,474	547,999	534,524	521,048	507,573	494,097
	HFC-134a	608,475	466,127	465,261	455,073	444,885	434,697	424,508	414,320	404,132	393,944	383,756	373,567
	HFC-143a	338,247	287,284	286,750	280,471	274,192	267,913	261,633	255,354	249,075	242,796	236,517	230,237
	HFC-236fa	9,095	7,161	7,148	6,992	6,835	6,679	6,522	6,366	6,209	6,052	5,896	5,739
	C_2F_6	9,166	7,448	7,904	8,223	8,555	8,901	9,261	9,635	10,024	10,429	10,850	11,289
	C_3F_8	877	780	828	862	896	933	970	1,009	1,050	1,093	1,137	1,183
	C_4F_8	549	514	546	568	591	615	639	665	692	720	749	779

Table B-40. Puerto Rico Industrial Processes and Product Use Greenhouse Gas Emissions by Gas in MT CO_2e, 2019-2041 (Decarbonization: Low Growth)

Decarbonization Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Low Economic Growth	Low Total (in CO_2e)	1,641,224	1,489,861	1,430,257	1,400,489	1,370,762	1,341,077	1,311,436	1,281,841	1,252,294	1,222,796	1,193,350	1,163,957
	CO_2	439	276	281	292	304	316	329	343	356	371	386	401
	N_2O	1,994	2,298	2,343	2,437	2,536	2,638	2,745	2,856	2,971	3,091	3,216	3,346
	SF_6	7,606	7,668	7,818	8,134	8,463	8,805	9,160	9,530	9,915	10,316	10,733	11,166
	NF_3	5,382	5,446	5,553	5,777	6,011	6,254	6,506	6,769	7,042	7,327	7,623	7,931
	HFC-23	3,752	3,737	3,584	3,505	3,427	3,348	3,270	3,191	3,113	3,034	2,956	2,877
	HFC-32	72,610	84,598	81,130	79,353	77,576	75,800	74,023	72,247	70,470	68,694	66,917	65,140
	HFC-41	3.2	3.1	3.0	2.9	2.8	2.8	2.7	2.6	2.6	2.5	2.5	2.4
	HFC-125	583,028	616,521	591,243	578,297	565,350	552,403	539,456	526,509	513,562	500,615	487,668	474,721
	HFC-134a	608,475	466,127	447,016	437,227	427,438	417,650	407,861	398,072	388,284	378,495	368,706	358,918
	HFC-143a	338,247	287,284	275,505	269,472	263,439	257,406	251,373	245,340	239,307	233,274	227,241	221,208
	HFC-236fa	9,095	7,161	6,868	6,717	6,567	6,417	6,266	6,116	5,966	5,815	5,665	5,514
	C_2F_6	9,166	7,448	7,594	7,901	8,220	8,552	8,898	9,257	9,631	10,020	10,425	10,846
	C_3F_8	877	780	796	828	861	896	932	970	1,009	1,050	1,092	1,136
	C_4F_8	549	514	524	545	567	590	614	639	665	692	720	749

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Table B-41. Puerto Rico Industrial Processes and Product Use Greenhouse Gas Emissions by Subsector in MT CO_2e, 2019-2041 (Decarbonization)

Decarbonization Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Ref (No Sens)	Reference Total (in CO_2e)	1,641,224	1,489,861	1,459,446	1,429,070	1,398,737	1,368,446	1,338,200	1,308,001	1,277,851	1,247,751	1,217,704	1,187,711
	ODS Substitutes	1,611,752	1,461,946	1,430,620	1,399,294	1,367,969	1,336,644	1,305,318	1,273,993	1,242,668	1,211,342	1,180,017	1,148,692
	Semiconductors	29,063	27,669	28,570	29,510	30,491	31,514	32,582	33,696	34,859	36,071	37,335	38,654
	Cement	408	246	256	266	277	288	300	312	325	338	351	366
High Economic	High Total (in CO_2e)	1,641,224	1,489,861	1,488,634	1,457,652	1,426,711	1,395,815	1,364,964	1,334,161	1,303,408	1,272,706	1,242,058	1,211,466
	ODS Substitutes	1,611,752	1,461,946	1,459,232	1,427,280	1,395,328	1,363,376	1,331,425	1,299,473	1,267,521	1,235,569	1,203,618	1,171,666
	Semiconductors	29,063	27,669	29,141	30,100	31,100	32,144	33,234	34,370	35,556	36,792	38,082	39,427
	Cement	408	246	261	272	283	294	306	318	331	344	358	373
Low Economic	Low Total (in CO_2e)	1,641,224	1,489,861	1,430,257	1,400,489	1,370,762	1,341,077	1,311,436	1,281,841	1,252,294	1,222,796	1,193,350	1,163,957
	ODS Substitutes	1,611,752	1,461,946	1,402,008	1,371,309	1,340,610	1,309,911	1,279,212	1,248,513	1,217,814	1,187,116	1,156,417	1,125,718
	Semiconductors	29,063	27,669	27,998	28,919	29,881	30,884	31,931	33,022	34,162	35,350	36,589	37,881
	Cement	408	246	251	261	272	282	294	306	318	331	344	358

Severe Hurricanes Scenario

Table B-42. Puerto Rico Industrial Processes and Product Use Greenhouse Gas Emissions by Gas in MT CO_2e, 2019-2041 (Severe Hurricanes: Reference)

Severe Hurricanes Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Reference (No Sensitivity)	Reference Total (in CO_2e)	1,641,224	1,489,861	1,459,446	1,429,070	1,398,737	1,368,446	1,338,200	1,308,001	1,277,851	1,247,751	1,217,704	1,187,711
	CO_2	439	276	287	298	310	323	336	350	364	378	394	410
	N_2O	1,994	2,298	2,390	2,487	2,587	2,692	2,801	2,914	3,032	3,154	3,282	3,414
	SF_6	7,606	7,668	7,978	8,300	8,635	8,984	9,347	9,725	10,118	10,527	10,952	11,394
	NF_3	5,382	5,446	5,666	5,895	6,133	6,381	6,639	6,907	7,186	7,477	7,779	8,093
	HFC-23	3,752	3,737	3,657	3,577	3,497	3,417	3,336	3,256	3,176	3,096	3,016	2,936
	HFC-32	72,610	84,598	82,785	80,972	79,160	77,347	75,534	73,721	71,908	70,096	68,283	66,470
	HFC-41	3.2	3.1	3.0	3.0	2.9	2.8	2.8	2.7	2.6	2.6	2.5	2.4
	HFC-125	583,028	616,521	603,310	590,098	576,887	563,676	550,465	537,254	524,043	510,832	497,620	484,409
	HFC-134a	608,475	466,127	456,138	446,150	436,161	426,173	416,185	406,196	396,208	386,219	376,231	366,242
	HFC-143a	338,247	287,284	281,128	274,971	268,815	262,659	256,503	250,347	244,191	238,035	231,879	225,723
	HFC-236fa	9,095	7,161	7,008	6,855	6,701	6,548	6,394	6,241	6,087	5,934	5,780	5,627
	C_2F_6	9,166	7,448	7,749	8,062	8,388	8,727	9,079	9,446	9,828	10,225	10,638	11,067
	C_3F_8	877	780	812	845	879	914	951	990	1,030	1,071	1,114	1,160
	C_4F_8	549	514	535	557	579	602	627	652	678	706	734	764

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Table B-43. Puerto Rico Industrial Processes and Product Use Greenhouse Gas Emissions by Gas in MT CO_2e, 2019-2041 (Severe Hurricanes: High Growth)

Severe Hurricanes Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
High Economic Growth	High Total (in CO_2e)	1,641,224	1,489,861	1,488,634	1,457,652	1,426,711	1,395,815	1,364,964	1,334,161	1,303,408	1,272,706	1,242,058	1,211,466
	CO_2	439	276	292	304	317	329	343	357	371	386	402	418
	N_2O	1,994	2,298	2,438	2,537	2,639	2,746	2,857	2,972	3,092	3,217	3,347	3,482
	SF_6	7,606	7,668	8,137	8,466	8,808	9,164	9,534	9,919	10,320	10,737	11,171	11,622
	NF_3	5,382	5,446	5,780	6,013	6,256	6,509	6,772	7,045	7,330	7,626	7,934	8,255
	HFC-23	3,752	3,737	3,730	3,648	3,567	3,485	3,403	3,322	3,240	3,158	3,076	2,995
	HFC-32	72,610	84,598	84,441	82,592	80,743	78,894	77,045	75,196	73,346	71,497	69,648	67,799
	HFC-41	3.2	3.1	3.1	3.0	3.0	2.9	2.8	2.8	2.7	2.6	2.6	2.5
	HFC-125	583,028	616,521	615,376	601,900	588,425	574,950	561,474	547,999	534,524	521,048	507,573	494,097
	HFC-134a	608,475	466,127	465,261	455,073	444,885	434,697	424,508	414,320	404,132	393,944	383,756	373,567
	HFC-143a	338,247	287,284	286,750	280,471	274,192	267,913	261,633	255,354	249,075	242,796	236,517	230,237
	HFC-236fa	9,095	7,161	7,148	6,992	6,835	6,679	6,522	6,366	6,209	6,052	5,896	5,739
	C_2F_6	9,166	7,448	7,904	8,223	8,555	8,901	9,261	9,635	10,024	10,429	10,850	11,289
	C_3F_8	877	780	828	862	896	933	970	1,009	1,050	1,093	1,137	1,183
	C_4F_8	549	514	546	568	591	615	639	665	692	720	749	779

Table B-44. Puerto Rico Industrial Processes and Product Use Greenhouse Gas Emissions by Gas in MT CO_2e, 2019-2041 (Severe Hurricanes: Low Growth)

Severe Hurricanes Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Low Economic Growth	Low Total (in CO_2e)	1,641,224	1,489,861	1,430,257	1,400,489	1,370,762	1,341,077	1,311,436	1,281,841	1,252,294	1,222,796	1,193,350	1,163,957
	CO_2	439	276	281	292	304	316	329	343	356	371	386	401
	N_2O	1,994	2,298	2,343	2,437	2,536	2,638	2,745	2,856	2,971	3,091	3,216	3,346
	SF_6	7,606	7,668	7,818	8,134	8,463	8,805	9,160	9,530	9,915	10,316	10,733	11,166
	NF_3	5,382	5,446	5,553	5,777	6,011	6,254	6,506	6,769	7,042	7,327	7,623	7,931
	HFC-23	3,752	3,737	3,584	3,505	3,427	3,348	3,270	3,191	3,113	3,034	2,956	2,877
	HFC-32	72,610	84,598	81,130	79,353	77,576	75,800	74,023	72,247	70,470	68,694	66,917	65,140
	HFC-41	3.2	3.1	3.0	2.9	2.8	2.8	2.7	2.6	2.6	2.5	2.5	2.4
	HFC-125	583,028	616,521	591,243	578,297	565,350	552,403	539,456	526,509	513,562	500,615	487,668	474,721
	HFC-134a	608,475	466,127	447,016	437,227	427,438	417,650	407,861	398,072	388,284	378,495	368,706	358,918
	HFC-143a	338,247	287,284	275,505	269,472	263,439	257,406	251,373	245,340	239,307	233,274	227,241	221,208
	HFC-236fa	9,095	7,161	6,868	6,717	6,567	6,417	6,266	6,116	5,966	5,815	5,665	5,514
	C_2F_6	9,166	7,448	7,594	7,901	8,220	8,552	8,898	9,257	9,631	10,020	10,425	10,846
	C_3F_8	877	780	796	828	861	896	932	970	1,009	1,050	1,092	1,136
	C_4F_8	549	514	524	545	567	590	614	639	665	692	720	749

Table B-45. Puerto Rico Industrial Processes and Product Use Greenhouse Gas Emissions by Subsector in MT CO_2e, 2019-2041 (Severe Hurricanes)

Severe Hurricanes Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Ref (No Sens)	Reference Total (in CO_2e)	1,641,224	1,489,861	1,459,446	1,429,070	1,398,737	1,368,446	1,338,200	1,308,001	1,277,851	1,247,751	1,217,704	1,187,711
	ODS Substitutes	1,611,752	1,461,946	1,430,620	1,399,294	1,367,969	1,336,644	1,305,318	1,273,993	1,242,668	1,211,342	1,180,017	1,148,692
	Semiconductors	29,063	27,669	28,570	29,510	30,491	31,514	32,582	33,696	34,859	36,071	37,335	38,654
	Cement	408	246	256	266	277	288	300	312	325	338	351	366
High Economic	High Total (in CO_2e)	1,641,224	1,489,861	1,488,634	1,457,652	1,426,711	1,395,815	1,364,964	1,334,161	1,303,408	1,272,706	1,242,058	1,211,466
	ODS Substitutes	1,611,752	1,461,946	1,459,232	1,427,280	1,395,328	1,363,376	1,331,425	1,299,473	1,267,521	1,235,569	1,203,618	1,171,666
	Semiconductors	29,063	27,669	29,141	30,100	31,100	32,144	33,234	34,370	35,556	36,792	38,082	39,427
	Cement	408	246	261	272	283	294	306	318	331	344	358	373
Low Economic	Low Total (in CO_2e)	1,641,224	1,489,861	1,430,257	1,400,489	1,370,762	1,341,077	1,311,436	1,281,841	1,252,294	1,222,796	1,193,350	1,163,957
	ODS Substitutes	1,611,752	1,461,946	1,402,008	1,371,309	1,340,610	1,309,911	1,279,212	1,248,513	1,217,814	1,187,116	1,156,417	1,125,718
	Semiconductors	29,063	27,669	27,998	28,919	29,881	30,884	31,931	33,022	34,162	35,350	36,589	37,881
	Cement	408	246	251	261	272	282	294	306	318	331	344	358

Transportation

Business-as-Usual Scenario

Table B-46. Puerto Rico Transportation Greenhouse Gas Emissions by Gas in MT CO_2e, 2019-2041 (Business-as-Usual)

Business-as-Usual (BAU) Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Ref (No Sens)	Reference Total (in CO_2e)	8,832,555	9,533,698	9,677,257	9,447,868	9,238,656	9,027,421	8,813,292	8,595,955	8,375,822	8,152,957	7,928,605	7,705,101
	CO_2	8,792,582	9,487,718	9,624,229	9,396,098	9,188,032	8,977,954	8,764,999	8,548,852	8,329,925	8,108,282	7,885,159	7,662,880
	CH_4	15,252	15,587	21,554	21,043	20,577	20,107	19,630	19,146	18,656	18,159	17,659	17,162
	N_2O	24,721	30,392	31,473	30,727	30,047	29,360	28,664	27,957	27,241	26,516	25,786	25,059
High Economic	High Total (in CO_2e)	8,832,555	9,533,698	9,870,802	9,636,826	9,423,429	9,207,969	8,989,558	8,767,874	8,543,338	8,316,016	8,087,177	7,859,203
	CO_2	8,792,582	9,487,718	9,816,713	9,584,020	9,371,792	9,157,513	8,940,299	8,719,829	8,496,524	8,270,448	8,042,863	7,816,138
	CH_4	15,252	15,587	21,985	21,464	20,989	20,509	20,022	19,529	19,029	18,522	18,013	17,505
	N_2O	24,721	30,392	32,103	31,342	30,648	29,947	29,237	28,516	27,786	27,046	26,302	25,561
Low Economic	Low Total (in CO_2e)	8,832,555	9,533,698	9,483,711	9,258,911	9,053,883	8,846,872	8,637,027	8,424,035	8,208,305	7,989,898	7,770,033	7,550,999
	CO_2	8,792,582	9,487,718	9,431,744	9,208,176	9,004,271	8,798,395	8,589,699	8,377,875	8,163,327	7,946,117	7,727,456	7,509,623
	CH_4	15,252	15,587	21,123	20,622	20,166	19,705	19,237	18,763	18,282	17,796	17,306	16,818
	N_2O	24,721	30,392	30,844	30,113	29,446	28,773	28,090	27,398	26,696	25,986	25,271	24,558

Table B-47. Puerto Rico Transportation Greenhouse Gas Emissions by Subsector in MT CO_2e, 2019-2041 (Business-as-Usual)

Business-as-Usual (BAU) Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Ref (No Sens)	Reference Total (in CO_2e)	8,832,555	9,533,698	9,677,257	9,447,868	9,238,656	9,027,421	8,813,292	8,595,955	8,375,822	8,152,957	7,928,605	7,705,101
	Motor Gasoline	4,999,132	5,106,819	4,967,939	4,850,180	4,742,778	4,634,338	4,524,413	4,412,839	4,299,832	4,185,421	4,070,247	3,955,509
	Marine Diesel	356,125	374,117	736,849	719,383	703,453	687,369	671,065	654,516	637,755	620,785	603,703	586,684
	Motor Diesel	2,848,965	2,759,635	2,684,586	2,620,951	2,562,913	2,504,314	2,444,913	2,384,620	2,323,553	2,261,728	2,199,490	2,137,487
	Jet Fuel	628,332	1,293,127	1,287,882	1,257,354	1,229,511	1,201,400	1,172,903	1,143,979	1,114,683	1,085,023	1,055,165	1,025,421
High Economic	High Total (in CO_2e)	8,832,555	9,533,698	9,870,802	9,636,826	9,423,429	9,207,969	8,989,558	8,767,874	8,543,338	8,316,016	8,087,177	7,859,203
	Motor Gasoline	4,999,132	5,106,819	5,067,298	4,947,184	4,837,634	4,727,025	4,614,901	4,501,096	4,385,828	4,269,130	4,151,652	4,034,619
	Marine Diesel	356,125	374,117	751,586	733,771	717,522	701,116	684,486	667,606	650,510	633,201	615,777	598,418
	Motor Diesel	2,848,965	2,759,635	2,738,278	2,673,371	2,614,172	2,554,401	2,493,811	2,432,313	2,370,024	2,306,962	2,243,479	2,180,237
	Jet Fuel	628,332	1,293,127	1,313,640	1,282,501	1,254,102	1,225,428	1,196,361	1,166,858	1,136,976	1,106,723	1,076,269	1,045,929
Low Economic	Low Total (in CO_2e)	8,832,555	9,533,698	9,483,711	9,258,911	9,053,883	8,846,872	8,637,027	8,424,035	8,208,305	7,989,898	7,770,033	7,550,999
	Motor Gasoline	4,999,132	5,106,819	4,868,580	4,753,176	4,647,923	4,541,651	4,433,924	4,324,583	4,213,835	4,101,713	3,988,842	3,876,399
	Marine Diesel	356,125	374,117	722,112	704,995	689,384	673,622	657,643	641,426	625,000	608,370	591,629	574,951
	Motor Diesel	2,848,965	2,759,635	2,630,895	2,568,532	2,511,655	2,454,228	2,396,014	2,336,928	2,277,082	2,216,493	2,155,500	2,094,737
	Jet Fuel	628,332	1,293,127	1,262,124	1,232,207	1,204,921	1,177,372	1,149,445	1,121,099	1,092,389	1,063,323	1,034,062	1,004,912

Decarbonization Scenario

Table B-48. Puerto Rico Transportation Greenhouse Gas Emissions by Gas in MT CO_2e, 2019-2041 (Decarbonization)

Decarbonization Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Ref (No Sens)	Reference Total (in CO_2e)	8,832,555	9,533,698	9,261,733	8,575,678	7,889,624	7,203,570	6,517,516	5,831,461	5,145,407	4,459,353	3,773,299	3,087,244
	CO_2	8,792,582	9,487,718	9,210,982	8,528,687	7,846,392	7,164,097	6,481,802	5,799,507	5,117,212	4,434,917	3,752,622	3,070,327
	CH_4	15,252	15,587	20,629	19,101	17,573	16,045	14,516	12,988	11,460	9,932	8,404	6,876
	N_2O	24,721	30,392	30,122	27,891	25,660	23,428	21,197	18,966	16,734	14,503	12,272	10,041
High Economic	High Total (in CO_2e)	8,832,555	9,533,698	9,446,967	8,747,192	8,047,417	7,347,641	6,647,866	5,948,091	5,248,315	4,548,540	3,848,765	3,148,989
	CO_2	8,792,582	9,487,718	9,395,202	8,699,261	8,003,320	7,307,379	6,611,438	5,915,497	5,219,556	4,523,616	3,827,675	3,131,734
	CH_4	15,252	15,587	21,041	19,483	17,924	16,365	14,807	13,248	11,690	10,131	8,572	7,014
	N_2O	24,721	30,392	30,724	28,449	26,173	23,897	21,621	19,345	17,069	14,793	12,517	10,241
Low Economic	Low Total (in CO_2e)	8,832,555	9,533,698	9,076,498	8,404,165	7,731,832	7,059,499	6,387,165	5,714,832	5,042,499	4,370,166	3,697,833	3,025,499
	CO_2	8,792,582	9,487,718	9,026,762	8,358,113	7,689,464	7,020,815	6,352,166	5,683,517	5,014,868	4,346,219	3,677,570	3,008,921
	CH_4	15,252	15,587	20,216	18,719	17,221	15,724	14,226	12,729	11,231	9,734	8,236	6,739
	N_2O	24,721	30,392	29,520	27,333	25,146	22,960	20,773	18,586	16,400	14,213	12,027	9,840

Applied Economics Clinic
Economic and Policy Analysis of Energy, Environment and Equity

Table B-49. Puerto Rico Transportation Greenhouse Gas Emissions by Subsector in MT CO_2e, 2019-2041 (Decarbonization)

Decarbonization Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Ref (No Sens)	Reference Total (in CO_2e)	8,832,555	9,533,698	9,261,733	8,575,678	7,889,624	7,203,570	6,517,516	5,831,461	5,145,407	4,459,353	3,773,299	3,087,244
	Motor Gasoline	4,999,132	5,106,819	4,754,625	4,402,430	4,050,236	3,698,042	3,345,847	2,993,653	2,641,458	2,289,264	1,937,069	1,584,875
	Marine Diesel	356,125	374,117	705,210	652,972	600,734	548,497	496,259	444,021	391,783	339,546	287,308	235,070
	Motor Diesel	2,848,965	2,759,635	2,569,315	2,378,996	2,188,676	1,998,356	1,808,037	1,617,717	1,427,397	1,237,078	1,046,758	856,438
	Jet Fuel	628,332	1,293,127	1,232,583	1,141,280	1,049,978	958,675	867,373	776,071	684,768	593,466	502,163	410,861
High Economic	High Total (in CO_2e)	8,832,555	9,533,698	9,446,967	8,747,192	8,047,417	7,347,641	6,647,866	5,948,091	5,248,315	4,548,540	3,848,765	3,148,989
	Motor Gasoline	4,999,132	5,106,819	4,849,717	4,490,479	4,131,241	3,772,002	3,412,764	3,053,526	2,694,287	2,335,049	1,975,811	1,616,572
	Marine Diesel	356,125	374,117	719,314	666,032	612,749	559,467	506,184	452,902	399,619	346,336	293,054	239,771
	Motor Diesel	2,848,965	2,759,635	2,620,702	2,426,575	2,232,449	2,038,323	1,844,197	1,650,071	1,455,945	1,261,819	1,067,693	873,567
	Jet Fuel	628,332	1,293,127	1,257,234	1,164,106	1,070,977	977,849	884,720	791,592	698,463	605,335	512,207	419,078
Low Economic	Low Total (in CO_2e)	8,832,555	9,533,698	9,076,498	8,404,165	7,731,832	7,059,499	6,387,165	5,714,832	5,042,499	4,370,166	3,697,833	3,025,499
	Motor Gasoline	4,999,132	5,106,819	4,659,532	4,314,382	3,969,231	3,624,081	3,278,930	2,933,780	2,588,629	2,243,479	1,898,328	1,553,177
	Marine Diesel	356,125	374,117	691,106	639,913	588,720	537,527	486,334	435,141	383,948	332,755	281,562	230,369
	Motor Diesel	2,848,965	2,759,635	2,517,929	2,331,416	2,144,902	1,958,389	1,771,876	1,585,363	1,398,849	1,212,336	1,025,823	839,310
	Jet Fuel	628,332	1,293,127	1,207,931	1,118,455	1,028,978	939,502	850,025	760,549	671,073	581,596	492,120	402,644

Severe Hurricanes Scenario

Table B-50. Puerto Rico Transportation Greenhouse Gas Emissions by Gas in MT CO_2e, 2019-2041 (Severe Hurricanes)

Severe Hurricanes Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Ref (No Sens)	Reference Total (in CO_2e)	8,832,555	9,533,698	9,515,969	9,290,404	9,084,678	8,876,964	8,666,404	8,452,689	8,236,225	8,017,075	7,796,462	7,576,683
	CO_2	8,792,582	9,487,718	9,463,825	9,239,496	9,034,898	8,828,321	8,618,916	8,406,371	8,191,093	7,973,144	7,753,740	7,535,166
	CH_4	15,252	15,587	21,195	20,693	20,234	19,772	19,303	18,827	18,345	17,856	17,365	16,876
	N_2O	24,721	30,392	30,949	30,215	29,546	28,871	28,186	27,491	26,787	26,074	25,357	24,642
High Economic	High Total (in CO_2e)	8,832,555	9,533,698	9,706,288	9,476,212	9,266,372	9,054,503	8,839,732	8,621,742	8,400,949	8,177,416	7,952,391	7,728,217
	CO_2	8,792,582	9,487,718	9,653,102	9,424,286	9,215,596	9,004,888	8,791,294	8,574,499	8,354,915	8,132,607	7,908,815	7,685,869
	CH_4	15,252	15,587	21,619	21,106	20,639	20,167	19,689	19,203	18,711	18,214	17,712	17,213
	N_2O	24,721	30,392	31,568	30,820	30,137	29,448	28,750	28,041	27,323	26,596	25,864	25,135
Low Economic	Low Total (in CO_2e)	8,832,555	9,533,698	9,325,650	9,104,596	8,902,985	8,699,424	8,493,076	8,283,635	8,071,500	7,856,733	7,640,532	7,425,149
	CO_2	8,792,582	9,487,718	9,274,549	9,054,706	8,854,200	8,651,755	8,446,537	8,238,244	8,027,271	7,813,681	7,598,665	7,384,462
	CH_4	15,252	15,587	20,771	20,279	19,830	19,376	18,917	18,450	17,978	17,499	17,018	16,538
	N_2O	24,721	30,392	30,330	29,611	28,955	28,293	27,622	26,941	26,251	25,553	24,849	24,149

Table B-51. Puerto Rico Transportation Greenhouse Gas Emissions by Subsector in MT CO_2e, 2019-2041 (Severe Hurricanes)

Severe Hurricanes Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Ref (No Sens)	Reference Total (in CO_2e)	8,832,555	9,533,698	9,515,969	9,290,404	9,084,678	8,876,964	8,666,404	8,452,689	8,236,225	8,017,075	7,796,462	7,576,683
	Motor Gasoline	4,999,132	5,106,819	4,885,140	4,769,344	4,663,732	4,557,099	4,449,006	4,339,292	4,228,168	4,115,664	4,002,410	3,889,584
	Marine Diesel	356,125	374,117	724,568	707,393	691,729	675,913	659,880	643,608	627,125	610,439	593,641	576,906
	Motor Diesel	2,848,965	2,759,635	2,639,843	2,577,269	2,520,198	2,462,576	2,404,164	2,344,877	2,284,827	2,224,032	2,162,832	2,101,862
	Jet Fuel	628,332	1,293,127	1,266,417	1,236,398	1,209,020	1,181,376	1,153,354	1,124,912	1,096,105	1,066,939	1,037,579	1,008,330
High Economic	High Total (in CO_2e)	8,832,555	9,533,698	9,706,288	9,476,212	9,266,372	9,054,503	8,839,732	8,621,742	8,400,949	8,177,416	7,952,391	7,728,217
	Motor Gasoline	4,999,132	5,106,819	4,982,843	4,864,731	4,757,006	4,648,241	4,537,986	4,426,078	4,312,731	4,197,978	4,082,458	3,967,375
	Marine Diesel	356,125	374,117	739,060	721,541	705,563	689,431	673,078	656,480	639,668	622,648	605,514	588,445
	Motor Diesel	2,848,965	2,759,635	2,692,640	2,628,814	2,570,602	2,511,827	2,452,247	2,391,774	2,330,524	2,268,513	2,206,088	2,143,900
	Jet Fuel	628,332	1,293,127	1,291,746	1,261,126	1,233,200	1,205,004	1,176,421	1,147,411	1,118,027	1,088,278	1,058,331	1,028,497
Low Economic	Low Total (in CO_2e)	8,832,555	9,533,698	9,325,650	9,104,596	8,902,985	8,699,424	8,493,076	8,283,635	8,071,500	7,856,733	7,640,532	7,425,149
	Motor Gasoline	4,999,132	5,106,819	4,787,437	4,673,957	4,570,457	4,465,957	4,360,026	4,252,506	4,143,604	4,033,351	3,922,362	3,811,792
	Marine Diesel	356,125	374,117	710,077	693,245	677,894	662,395	646,683	630,735	614,583	598,230	581,768	565,368
	Motor Diesel	2,848,965	2,759,635	2,587,047	2,525,724	2,469,794	2,413,324	2,356,081	2,297,979	2,239,130	2,179,552	2,119,575	2,059,825
	Jet Fuel	628,332	1,293,127	1,241,089	1,211,670	1,184,839	1,157,749	1,130,287	1,102,414	1,074,182	1,045,601	1,016,828	988,164

Agriculture

Business-as-Usual Scenario

Table B-52. Puerto Rico Agriculture Greenhouse Gas Emissions by Gas in MT CO_2e, 2019-2041 (Business-as-Usual)

Business-as-Usual (BAU) Scenario		Inventory		Projections											
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Ref (No Sens)	Reference Total (in CO_2e)	922,848	948,256	995,075	1,041,895	1,088,714	1,135,533	1,168,124	1,186,486	1,204,848	1,223,209	1,241,571	1,259,933
	CO_2	58,501	55,115	42,868	30,620	18,372	6,124	0	0	0	0	0	0
	CH_4	640,037	662,249	708,677	755,105	801,533	847,961	877,905	891,367	904,828	918,290	931,751	945,213
	N_2O	224,309	230,891	243,530	256,170	268,809	281,449	290,219	295,119	300,019	304,919	309,820	314,720
High Economic	High Total (in CO_2e)	922,848	948,256	995,075	1,041,895	1,088,714	1,135,533	1,168,124	1,186,486	1,204,848	1,223,209	1,241,571	1,259,933
	CO_2	58,501	55,115	42,868	30,620	18,372	6,124	0	0	0	0	0	0
	CH_4	640,037	662,249	708,677	755,105	801,533	847,961	877,905	891,367	904,828	918,290	931,751	945,213
	N_2O	224,309	230,891	243,530	256,170	268,809	281,449	290,219	295,119	300,019	304,919	309,820	314,720
Low Economic	Low Total (in CO_2e)	922,848	948,256	995,075	1,041,895	1,088,714	1,135,533	1,168,124	1,186,486	1,204,848	1,223,209	1,241,571	1,259,933
	CO_2	58,501	55,115	42,868	30,620	18,372	6,124	0	0	0	0	0	0
	CH_4	640,037	662,249	708,677	755,105	801,533	847,961	877,905	891,367	904,828	918,290	931,751	945,213
	N_2O	224,309	230,891	243,530	256,170	268,809	281,449	290,219	295,119	300,019	304,919	309,820	314,720

Table B-53. Puerto Rico Agriculture Greenhouse Gas Emissions by Subsector in MT CO_2e, 2019-2041 (Business-as-Usual)

Business-as-Usual (BAU) Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Reference (No Sensitivity)	Reference Total (in CO_2e)	922,848	948,256	995,075	1,041,895	1,088,714	1,135,533	1,168,124	1,186,486	1,204,848	1,223,209	1,241,571	1,259,933
	Crop Residues	12	16	49	81	113	146	166	174	182	190	198	206
	Rice Cultivation	310	301	234	167	100	33	0	0	0	0	0	0
	Burning - Crop residues	3	6	10	14	18	22	24	25	26	26	27	28
	Enteric Fermentation	618,465	639,837	684,756	729,676	774,595	819,515	848,435	861,355	874,275	887,195	900,116	913,036
	Manure Management	33,872	33,556	32,583	31,610	30,637	29,664	29,448	29,988	30,529	31,069	31,610	32,150
	Manure left on Pasture	165,766	171,783	184,035	196,287	208,539	220,791	228,777	232,495	236,213	239,932	243,650	247,368
	Manure applied to Soils	43,352	45,233	48,668	52,102	55,536	58,971	61,275	62,449	63,623	64,797	65,970	67,144
	Drained organic soils	61,068	57,523	44,740	31,957	19,174	6,391	0	0	0	0	0	0
High Economic Growth	High Total (in CO_2e)	922,848	948,256	995,075	1,041,895	1,088,714	1,135,533	1,168,124	1,186,486	1,204,848	1,223,209	1,241,571	1,259,933
	Crop Residues	12	16	49	81	113	146	166	174	182	190	198	206
	Rice Cultivation	310	301	234	167	100	33	0	0	0	0	0	0
	Burning - Crop residues	3	6	10	14	18	22	24	25	26	26	27	28
	Enteric Fermentation	618,465	639,837	684,756	729,676	774,595	819,515	848,435	861,355	874,275	887,195	900,116	913,036
	Manure Management	33,872	33,556	32,583	31,610	30,637	29,664	29,448	29,988	30,529	31,069	31,610	32,150
	Manure left on Pasture	165,766	171,783	184,035	196,287	208,539	220,791	228,777	232,495	236,213	239,932	243,650	247,368
	Manure applied to Soils	43,352	45,233	48,668	52,102	55,536	58,971	61,275	62,449	63,623	64,797	65,970	67,144
	Drained organic soils	61,068	57,523	44,740	31,957	19,174	6,391	0	0	0	0	0	0
Low Economic Growth	Low Total (in CO_2e)	922,848	948,256	995,075	1,041,895	1,088,714	1,135,533	1,168,124	1,186,486	1,204,848	1,223,209	1,241,571	1,259,933
	Crop Residues	12	16	49	81	113	146	166	174	182	190	198	206
	Rice Cultivation	310	301	234	167	100	33	0	0	0	0	0	0
	Burning - Crop residues	3	6	10	14	18	22	24	25	26	26	27	28
	Enteric Fermentation	618,465	639,837	684,756	729,676	774,595	819,515	848,435	861,355	874,275	887,195	900,116	913,036
	Manure Management	33,872	33,556	32,583	31,610	30,637	29,664	29,448	29,988	30,529	31,069	31,610	32,150
	Manure left on Pasture	165,766	171,783	184,035	196,287	208,539	220,791	228,777	232,495	236,213	239,932	243,650	247,368
	Manure applied to Soils	43,352	45,233	48,668	52,102	55,536	58,971	61,275	62,449	63,623	64,797	65,970	67,144
	Drained organic soils	61,068	57,523	44,740	31,957	19,174	6,391	0	0	0	0	0	0

Decarbonization Scenario

Table B-54. Puerto Rico Agriculture Greenhouse Gas Emissions by Gas in MT CO_2e, 2019-2041 (Decarbonization)

Decarbonization Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Ref (No Sens)	Reference Total (in CO_2e)	922,848	948,256	995,075	1,041,895	1,088,714	1,135,533	1,168,124	1,186,486	1,204,848	1,223,209	1,241,571	1,259,933
	CO_2	58,501	55,115	42,868	30,620	18,372	6,124	0	0	0	0	0	0
	CH_4	640,037	662,249	708,677	755,105	801,533	847,961	877,905	891,367	904,828	918,290	931,751	945,213
	N_2O	224,309	230,891	243,530	256,170	268,809	281,449	290,219	295,119	300,019	304,919	309,820	314,720
High Economic	High Total (in CO_2e)	922,848	948,256	995,075	1,041,895	1,088,714	1,135,533	1,168,124	1,186,486	1,204,848	1,223,209	1,241,571	1,259,933
	CO_2	58,501	55,115	42,868	30,620	18,372	6,124	0	0	0	0	0	0
	CH_4	640,037	662,249	708,677	755,105	801,533	847,961	877,905	891,367	904,828	918,290	931,751	945,213
	N_2O	224,309	230,891	243,530	256,170	268,809	281,449	290,219	295,119	300,019	304,919	309,820	314,720
Low Economic	Low Total (in CO_2e)	922,848	948,256	995,075	1,041,895	1,088,714	1,135,533	1,168,124	1,186,486	1,204,848	1,223,209	1,241,571	1,259,933
	CO_2	58,501	55,115	42,868	30,620	18,372	6,124	0	0	0	0	0	0
	CH_4	640,037	662,249	708,677	755,105	801,533	847,961	877,905	891,367	904,828	918,290	931,751	945,213
	N_2O	224,309	230,891	243,530	256,170	268,809	281,449	290,219	295,119	300,019	304,919	309,820	314,720

Table B-55. Puerto Rico Agriculture Greenhouse Gas Emissions by Subsector in MT CO_2e, 2019-2041 (Decarbonization)

	Decarbonization Scenario	Inventory		Projections									
	Metric Tons CO_2e	2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Reference (No Sensitivity)	Reference Total (in CO_2e)	922,848	948,256	995,075	1,041,895	1,088,714	1,135,533	1,168,124	1,186,486	1,204,848	1,223,209	1,241,571	1,259,933
	Crop Residues	12	16	49	81	113	146	166	174	182	190	198	206
	Rice Cultivation	310	301	234	167	100	33	0	0	0	0	0	0
	Burning - Crop residues	3	6	10	14	18	22	24	25	26	26	27	28
	Enteric Fermentation	618,465	639,837	684,756	729,676	774,595	819,515	848,435	861,355	874,275	887,195	900,116	913,036
	Manure Management	33,872	33,556	32,583	31,610	30,637	29,664	29,448	29,988	30,529	31,069	31,610	32,150
	Manure left on Pasture	165,766	171,783	184,035	196,287	208,539	220,791	228,777	232,495	236,213	239,932	243,650	247,368
	Manure applied to Soils	43,352	45,233	48,668	52,102	55,536	58,971	61,275	62,449	63,623	64,797	65,970	67,144
	Drained organic soils	61,068	57,523	44,740	31,957	19,174	6,391	0	0	0	0	0	0
High Economic Growth	High Total (in CO_2e)	922,848	948,256	995,075	1,041,895	1,088,714	1,135,533	1,168,124	1,186,486	1,204,848	1,223,209	1,241,571	1,259,933
	Crop Residues	12	16	49	81	113	146	166	174	182	190	198	206
	Rice Cultivation	310	301	234	167	100	33	0	0	0	0	0	0
	Burning - Crop residues	3	6	10	14	18	22	24	25	26	26	27	28
	Enteric Fermentation	618,465	639,837	684,756	729,676	774,595	819,515	848,435	861,355	874,275	887,195	900,116	913,036
	Manure Management	33,872	33,556	32,583	31,610	30,637	29,664	29,448	29,988	30,529	31,069	31,610	32,150
	Manure left on Pasture	165,766	171,783	184,035	196,287	208,539	220,791	228,777	232,495	236,213	239,932	243,650	247,368
	Manure applied to Soils	43,352	45,233	48,668	52,102	55,536	58,971	61,275	62,449	63,623	64,797	65,970	67,144
	Drained organic soils	61,068	57,523	44,740	31,957	19,174	6,391	0	0	0	0	0	0
Low Economic Growth	Low Total (in CO_2e)	922,848	948,256	995,075	1,041,895	1,088,714	1,135,533	1,168,124	1,186,486	1,204,848	1,223,209	1,241,571	1,259,933
	Crop Residues	12	16	49	81	113	146	166	174	182	190	198	206
	Rice Cultivation	310	301	234	167	100	33	0	0	0	0	0	0
	Burning - Crop residues	3	6	10	14	18	22	24	25	26	26	27	28
	Enteric Fermentation	618,465	639,837	684,756	729,676	774,595	819,515	848,435	861,355	874,275	887,195	900,116	913,036
	Manure Management	33,872	33,556	32,583	31,610	30,637	29,664	29,448	29,988	30,529	31,069	31,610	32,150
	Manure left on Pasture	165,766	171,783	184,035	196,287	208,539	220,791	228,777	232,495	236,213	239,932	243,650	247,368
	Manure applied to Soils	43,352	45,233	48,668	52,102	55,536	58,971	61,275	62,449	63,623	64,797	65,970	67,144
	Drained organic soils	61,068	57,523	44,740	31,957	19,174	6,391	0	0	0	0	0	0

Severe Hurricanes Scenario

Table B-56. Puerto Rico Agriculture Greenhouse Gas Emissions by Gas in MT CO_2e, 2019-2041 (Severe Hurricanes)

Severe Hurricanes Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Ref (No Sens)	Reference Total (in CO_2e)	922,848	948,256	995,075	1,041,895	1,088,714	1,135,533	1,168,124	1,186,486	1,204,848	1,223,209	1,241,571	1,259,933
	CO_2	58,501	55,115	42,868	30,620	18,372	6,124	0	0	0	0	0	0
	CH_4	640,037	662,249	708,677	755,105	801,533	847,961	877,905	891,367	904,828	918,290	931,751	945,213
	N_2O	224,309	230,891	243,530	256,170	268,809	281,449	290,219	295,119	300,019	304,919	309,820	314,720
High Economic	High Total (in CO_2e)	922,848	948,256	995,075	1,041,895	1,088,714	1,135,533	1,168,124	1,186,486	1,204,848	1,223,209	1,241,571	1,259,933
	CO_2	58,501	55,115	42,868	30,620	18,372	6,124	0	0	0	0	0	0
	CH_4	640,037	662,249	708,677	755,105	801,533	847,961	877,905	891,367	904,828	918,290	931,751	945,213
	N_2O	224,309	230,891	243,530	256,170	268,809	281,449	290,219	295,119	300,019	304,919	309,820	314,720
Low Economic	Low Total (in CO_2e)	922,848	948,256	995,075	1,041,895	1,088,714	1,135,533	1,168,124	1,186,486	1,204,848	1,223,209	1,241,571	1,259,933
	CO_2	58,501	55,115	42,868	30,620	18,372	6,124	0	0	0	0	0	0
	CH_4	640,037	662,249	708,677	755,105	801,533	847,961	877,905	891,367	904,828	918,290	931,751	945,213
	N_2O	224,309	230,891	243,530	256,170	268,809	281,449	290,219	295,119	300,019	304,919	309,820	314,720

Table B-57. Puerto Rico Agriculture Greenhouse Gas Emissions by Subsector in MT CO_2e, 2019-2041 (Severe Hurricanes)

Severe Hurricanes Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Reference (No Sensitivity)	Reference Total (in CO_2e)	922,848	948,256	995,075	1,041,895	1,088,714	1,135,533	1,168,124	1,186,486	1,204,848	1,223,209	1,241,571	1,259,933
	Crop Residues	12	16	49	81	113	146	166	174	182	190	198	206
	Rice Cultivation	310	301	234	167	100	33	0	0	0	0	0	0
	Burning - Crop residues	3	6	10	14	18	22	24	25	26	26	27	28
	Enteric Fermentation	618,465	639,837	684,756	729,676	774,595	819,515	848,435	861,355	874,275	887,195	900,116	913,036
	Manure Management	33,872	33,556	32,583	31,610	30,637	29,664	29,448	29,988	30,529	31,069	31,610	32,150
	Manure left on Pasture	165,766	171,783	184,035	196,287	208,539	220,791	228,777	232,495	236,213	239,932	243,650	247,368
	Manure applied to Soils	43,352	45,233	48,668	52,102	55,536	58,971	61,275	62,449	63,623	64,797	65,970	67,144
	Drained organic soils	61,068	57,523	44,740	31,957	19,174	6,391	0	0	0	0	0	0
High Economic Growth	High Total (in CO_2e)	922,848	948,256	995,075	1,041,895	1,088,714	1,135,533	1,168,124	1,186,486	1,204,848	1,223,209	1,241,571	1,259,933
	Crop Residues	12	16	49	81	113	146	166	174	182	190	198	206
	Rice Cultivation	310	301	234	167	100	33	0	0	0	0	0	0
	Burning - Crop residues	3	6	10	14	18	22	24	25	26	26	27	28
	Enteric Fermentation	618,465	639,837	684,756	729,676	774,595	819,515	848,435	861,355	874,275	887,195	900,116	913,036
	Manure Management	33,872	33,556	32,583	31,610	30,637	29,664	29,448	29,988	30,529	31,069	31,610	32,150
	Manure left on Pasture	165,766	171,783	184,035	196,287	208,539	220,791	228,777	232,495	236,213	239,932	243,650	247,368
	Manure applied to Soils	43,352	45,233	48,668	52,102	55,536	58,971	61,275	62,449	63,623	64,797	65,970	67,144
	Drained organic soils	61,068	57,523	44,740	31,957	19,174	6,391	0	0	0	0	0	0
Low Economic Growth	Low Total (in CO_2e)	922,848	948,256	995,075	1,041,895	1,088,714	1,135,533	1,168,124	1,186,486	1,204,848	1,223,209	1,241,571	1,259,933
	Crop Residues	12	16	49	81	113	146	166	174	182	190	198	206
	Rice Cultivation	310	301	234	167	100	33	0	0	0	0	0	0
	Burning - Crop residues	3	6	10	14	18	22	24	25	26	26	27	28
	Enteric Fermentation	618,465	639,837	684,756	729,676	774,595	819,515	848,435	861,355	874,275	887,195	900,116	913,036
	Manure Management	33,872	33,556	32,583	31,610	30,637	29,664	29,448	29,988	30,529	31,069	31,610	32,150
	Manure left on Pasture	165,766	171,783	184,035	196,287	208,539	220,791	228,777	232,495	236,213	239,932	243,650	247,368
	Manure applied to Soils	43,352	45,233	48,668	52,102	55,536	58,971	61,275	62,449	63,623	64,797	65,970	67,144
	Drained organic soils	61,068	57,523	44,740	31,957	19,174	6,391	0	0	0	0	0	0

Forestry and Other Land Use

Business-as-Usual Scenario

Table B-58. Puerto Rico Forestry and Other Land Use Greenhouse Gas Emissions by Gas in MT CO_2e, 2019-2041 (Business-as-Usual)

Business-as-Usual (BAU) Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Ref (No Sens)	Reference Total (in CO_2e)	105,057	202,851	-57,647	-57,627	-57,606	-57,586	-57,565	-57,545	-57,524	-57,504	-57,483	-57,463
	CO_2	105,003	202,832	-57,665	-57,645	-57,625	-57,605	-57,585	-57,564	-57,544	-57,524	-57,504	-57,484
	CH_4	9	3	3	3	3	3	3	3	3	3	3	4
	N_2O	45	15	15	16	16	16	16	16	17	17	17	17
High Economic	High Total (in CO_2e)	105,057	202,851	-57,647	-57,627	-57,606	-57,586	-57,565	-57,545	-57,524	-57,504	-57,483	-57,463
	CO_2	105,003	202,832	-57,665	-57,645	-57,625	-57,605	-57,585	-57,564	-57,544	-57,524	-57,504	-57,484
	CH_4	9	3	3	3	3	3	3	3	3	3	3	4
	N_2O	45	15	15	16	16	16	16	16	17	17	17	17
Low Economic	Low Total (in CO_2e)	105,057	202,851	-57,647	-57,627	-57,606	-57,586	-57,565	-57,545	-57,524	-57,504	-57,483	-57,463
	CO_2	105,003	202,832	-57,665	-57,645	-57,625	-57,605	-57,585	-57,564	-57,544	-57,524	-57,504	-57,484
	CH_4	9	3	3	3	3	3	3	3	3	3	3	4
	N_2O	45	15	15	16	16	16	16	16	17	17	17	17

Table B-59. Puerto Rico Forestry and Other Land Use Greenhouse Gas Emissions by Subsector in MT CO_2e, 2019-2041 (Business-as-Usual)

Business-as-Usual (BAU) Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Reference (No Sensitivity)	Reference Total (in CO_2e)	105,057	202,851	-57,647	-57,627	-57,606	-57,586	-57,565	-57,545	-57,524	-57,504	-57,483	-57,463
	Tree carbon change (above-ground)	14,255	14,502	-18,176	-18,176	-18,176	-18,176	-18,176	-18,176	-18,176	-18,176	-18,176	-18,176
	Tree carbon change (below-ground)	2,929	2,894	-3,627	-3,627	-3,627	-3,627	-3,627	-3,627	-3,627	-3,627	-3,627	-3,627
	Tree mortality from fires	4,372	1,456	1,476	1,497	1,517	1,538	1,558	1,579	1,599	1,620	1,640	1,660
	Forestland change	1,616,663	688,617	-863,076	-863,076	-863,076	-863,076	-863,076	-863,076	-863,076	-863,076	-863,076	-863,076
	Grassland change	-808,331	1,376,208	731,464	731,464	731,464	731,464	731,464	731,464	731,464	731,464	731,464	731,464
	Cropland change	-724,830	-1,880,826	94,292	94,292	94,292	94,292	94,292	94,292	94,292	94,292	94,292	94,292
High Economic Growth	High Total (in CO_2e)	105,057	202,851	-57,647	-57,627	-57,606	-57,586	-57,565	-57,545	-57,524	-57,504	-57,483	-57,463
	Tree carbon change (above-ground)	14,255	14,502	-18,176	-18,176	-18,176	-18,176	-18,176	-18,176	-18,176	-18,176	-18,176	-18,176
	Tree carbon change (below-ground)	2,929	2,894	-3,627	-3,627	-3,627	-3,627	-3,627	-3,627	-3,627	-3,627	-3,627	-3,627
	Tree mortality from fires	4,372	1,456	1,476	1,497	1,517	1,538	1,558	1,579	1,599	1,620	1,640	1,660
	Forestland change	1,616,663	688,617	-863,076	-863,076	-863,076	-863,076	-863,076	-863,076	-863,076	-863,076	-863,076	-863,076
	Grassland change	-808,331	1,376,208	731,464	731,464	731,464	731,464	731,464	731,464	731,464	731,464	731,464	731,464
	Cropland change	-724,830	-1,880,826	94,292	94,292	94,292	94,292	94,292	94,292	94,292	94,292	94,292	94,292
Low Economic Growth	Low Total (in CO_2e)	105,057	202,851	-57,647	-57,627	-57,606	-57,586	-57,565	-57,545	-57,524	-57,504	-57,483	-57,463
	Tree carbon change (above-ground)	14,255	14,502	-18,176	-18,176	-18,176	-18,176	-18,176	-18,176	-18,176	-18,176	-18,176	-18,176
	Tree carbon change (below-ground)	2,929	2,894	-3,627	-3,627	-3,627	-3,627	-3,627	-3,627	-3,627	-3,627	-3,627	-3,627
	Tree mortality from fires	4,372	1,456	1,476	1,497	1,517	1,538	1,558	1,579	1,599	1,620	1,640	1,660
	Forestland change	1,616,663	688,617	-863,076	-863,076	-863,076	-863,076	-863,076	-863,076	-863,076	-863,076	-863,076	-863,076
	Grassland change	-808,331	1,376,208	731,464	731,464	731,464	731,464	731,464	731,464	731,464	731,464	731,464	731,464
	Cropland change	-724,830	-1,880,826	94,292	94,292	94,292	94,292	94,292	94,292	94,292	94,292	94,292	94,292

Decarbonization Scenario

Table B-60. Puerto Rico Forestry and Other Land Use Greenhouse Gas Emissions by Gas in MT CO_2e, 2019-2041 (Decarbonization)

Decarbonization Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Ref (No Sens)	Reference Total (in CO_2e)	105,057	202,851	-36,276	-36,235	-36,194	-36,153	-36,112	-36,071	-36,030	-35,989	-35,948	-35,907
	CO_2	105,003	202,832	-36,294	-36,254	-36,213	-36,173	-36,133	-36,092	-36,052	-36,011	-35,971	-35,930
	CH_4	9	3	3	3	3	3	4	4	4	4	4	4
	N_2O	45	15	16	16	16	17	17	18	18	18	19	19
High Economic	High Total (in CO_2e)	105,057	202,851	-36,276	-36,235	-36,194	-36,153	-36,112	-36,071	-36,030	-35,989	-35,948	-35,907
	CO_2	105,003	202,832	-36,294	-36,254	-36,213	-36,173	-36,133	-36,092	-36,052	-36,011	-35,971	-35,930
	CH_4	9	3	3	3	3	3	4	4	4	4	4	4
	N_2O	45	15	16	16	16	17	17	18	18	18	19	19
Low Economic	Low Total (in CO_2e)	105,057	202,851	-36,276	-36,235	-36,194	-36,153	-36,112	-36,071	-36,030	-35,989	-35,948	-35,907
	CO_2	105,003	202,832	-36,294	-36,254	-36,213	-36,173	-36,133	-36,092	-36,052	-36,011	-35,971	-35,930
	CH_4	9	3	3	3	3	3	4	4	4	4	4	4
	N_2O	45	15	16	16	16	17	17	18	18	18	19	19

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Table B-61. Puerto Rico Forestry and Other Land Use Greenhouse Gas Emissions by Subsector in MT CO_2e, 2019-2041 (Decarbonization)

Decarbonization Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Reference (No Sensitivity)	Reference Total (in CO_2e)	105,057	202,851	-36,276	-36,235	-36,194	-36,153	-36,112	-36,071	-36,030	-35,989	-35,948	-35,907
	Tree carbon change (above-ground)	14,255	14,502	-36,351	-36,351	-36,351	-36,351	-36,351	-36,351	-36,351	-36,351	-36,351	-36,351
	Tree carbon change (below-ground)	2,929	2,894	-7,254	-7,254	-7,254	-7,254	-7,254	-7,254	-7,254	-7,254	-7,254	-7,254
	Tree mortality from fires	4,372	1,456	1,497	1,538	1,579	1,620	1,660	1,701	1,742	1,783	1,824	1,865
	Forestland change	1,616,663	688,617	-1,726,153	-1,726,153	-1,726,153	-1,726,153	-1,726,153	-1,726,153	-1,726,153	-1,726,153	-1,726,153	-1,726,153
	Grassland change	-808,331	1,376,208	1,637,694	1,637,694	1,637,694	1,637,694	1,637,694	1,637,694	1,637,694	1,637,694	1,637,694	1,637,694
	Cropland change	-724,830	-1,880,826	94,292	94,292	94,292	94,292	94,292	94,292	94,292	94,292	94,292	94,292
High Economic Growth	High Total (in CO_2e)	105,057	202,851	-36,276	-36,235	-36,194	-36,153	-36,112	-36,071	-36,030	-35,989	-35,948	-35,907
	Tree carbon change (above-ground)	14,255	14,502	-36,351	-36,351	-36,351	-36,351	-36,351	-36,351	-36,351	-36,351	-36,351	-36,351
	Tree carbon change (below-ground)	2,929	2,894	-7,254	-7,254	-7,254	-7,254	-7,254	-7,254	-7,254	-7,254	-7,254	-7,254
	Tree mortality from fires	4,372	1,456	1,497	1,538	1,579	1,620	1,660	1,701	1,742	1,783	1,824	1,865
	Forestland change	1,616,663	688,617	-1,726,153	-1,726,153	-1,726,153	-1,726,153	-1,726,153	-1,726,153	-1,726,153	-1,726,153	-1,726,153	-1,726,153
	Grassland change	-808,331	1,376,208	1,637,694	1,637,694	1,637,694	1,637,694	1,637,694	1,637,694	1,637,694	1,637,694	1,637,694	1,637,694
	Cropland change	-724,830	-1,880,826	94,292	94,292	94,292	94,292	94,292	94,292	94,292	94,292	94,292	94,292
Low Economic Growth	Low Total (in CO_2e)	105,057	202,851	-36,276	-36,235	-36,194	-36,153	-36,112	-36,071	-36,030	-35,989	-35,948	-35,907
	Tree carbon change (above-ground)	14,255	14,502	-36,351	-36,351	-36,351	-36,351	-36,351	-36,351	-36,351	-36,351	-36,351	-36,351
	Tree carbon change (below-ground)	2,929	2,894	-7,254	-7,254	-7,254	-7,254	-7,254	-7,254	-7,254	-7,254	-7,254	-7,254
	Tree mortality from fires	4,372	1,456	1,497	1,538	1,579	1,620	1,660	1,701	1,742	1,783	1,824	1,865
	Forestland change	1,616,663	688,617	-1,726,153	-1,726,153	-1,726,153	-1,726,153	-1,726,153	-1,726,153	-1,726,153	-1,726,153	-1,726,153	-1,726,153
	Grassland change	-808,331	1,376,208	1,637,694	1,637,694	1,637,694	1,637,694	1,637,694	1,637,694	1,637,694	1,637,694	1,637,694	1,637,694
	Cropland change	-724,830	-1,880,826	94,292	94,292	94,292	94,292	94,292	94,292	94,292	94,292	94,292	94,292

Severe Hurricanes Scenario

Table B-62. Puerto Rico Forestry and Other Land Use Greenhouse Gas Emissions by Gas in MT CO_2e, 2019-2041 (Severe Hurricanes)

Severe Hurricanes Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Ref (No Sens)	Reference Total (in CO_2e)	105,057	202,851	-91,770	-91,782	-91,795	-91,807	-91,819	-91,831	-91,843	-91,856	-91,868	-91,880
	CO_2	105,003	202,832	-91,788	-91,800	-91,812	-91,824	-91,836	-91,848	-91,861	-91,873	-91,885	-91,897
	CH_4	9	3	3	3	3	3	3	3	3	3	3	3
	N_2O	45	15	15	15	15	15	14	14	14	14	14	14
High Economic	High Total (in CO_2e)	105,057	202,851	-91,770	-91,782	-91,795	-91,807	-91,819	-91,831	-91,843	-91,856	-91,868	-91,880
	CO_2	105,003	202,832	-91,788	-91,800	-91,812	-91,824	-91,836	-91,848	-91,861	-91,873	-91,885	-91,897
	CH_4	9	3	3	3	3	3	3	3	3	3	3	3
	N_2O	45	15	15	15	15	15	14	14	14	14	14	14
Low Economic	Low Total (in CO_2e)	105,057	202,851	-91,770	-91,782	-91,795	-91,807	-91,819	-91,831	-91,843	-91,856	-91,868	-91,880
	CO_2	105,003	202,832	-91,788	-91,800	-91,812	-91,824	-91,836	-91,848	-91,861	-91,873	-91,885	-91,897
	CH_4	9	3	3	3	3	3	3	3	3	3	3	3
	N_2O	45	15	15	15	15	15	14	14	14	14	14	14

Table B-63. Puerto Rico Forestry and Other Land Use Greenhouse Gas Emissions by Subsector in MT CO_2e, 2019-2041 (Severe Hurricanes)

Severe Hurricanes Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Reference (No Sensitivity)	Reference Total (in CO_2e)	105,057	202,851	-91,770	-91,782	-91,795	-91,807	-91,819	-91,831	-91,843	-91,856	-91,868	-91,880
	Tree carbon change (above-ground)	14,255	14,502	10,845	10,845	10,845	10,845	10,845	10,845	10,845	10,845	10,845	10,845
	Tree carbon change (below-ground)	2,929	2,894	2,164	2,164	2,164	2,164	2,164	2,164	2,164	2,164	2,164	2,164
	Tree mortality from fires	4,372	1,456	1,444	1,431	1,419	1,407	1,395	1,383	1,370	1,358	1,346	1,334
	Forestland change	1,616,663	688,617	514,971	514,971	514,971	514,971	514,971	514,971	514,971	514,971	514,971	514,971
	Grassland change	-808,331	1,376,208	-715,486	-715,486	-715,486	-715,486	-715,486	-715,486	-715,486	-715,486	-715,486	-715,486
	Cropland change	-724,830	-1,880,826	94,292	94,292	94,292	94,292	94,292	94,292	94,292	94,292	94,292	94,292
High Economic Growth	High Total (in CO_2e)	105,057	202,851	-91,770	-91,782	-91,795	-91,807	-91,819	-91,831	-91,843	-91,856	-91,868	-91,880
	Tree carbon change (above-ground)	14,255	14,502	10,845	10,845	10,845	10,845	10,845	10,845	10,845	10,845	10,845	10,845
	Tree carbon change (below-ground)	2,929	2,894	2,164	2,164	2,164	2,164	2,164	2,164	2,164	2,164	2,164	2,164
	Tree mortality from fires	4,372	1,456	1,444	1,431	1,419	1,407	1,395	1,383	1,370	1,358	1,346	1,334
	Forestland change	1,616,663	688,617	514,971	514,971	514,971	514,971	514,971	514,971	514,971	514,971	514,971	514,971
	Grassland change	-808,331	1,376,208	-715,486	-715,486	-715,486	-715,486	-715,486	-715,486	-715,486	-715,486	-715,486	-715,486
	Cropland change	-724,830	-1,880,826	94,292	94,292	94,292	94,292	94,292	94,292	94,292	94,292	94,292	94,292
Low Economic Growth	Low Total (in CO_2e)	105,057	202,851	-91,770	-91,782	-91,795	-91,807	-91,819	-91,831	-91,843	-91,856	-91,868	-91,880
	Tree carbon change (above-ground)	14,255	14,502	10,845	10,845	10,845	10,845	10,845	10,845	10,845	10,845	10,845	10,845
	Tree carbon change (below-ground)	2,929	2,894	2,164	2,164	2,164	2,164	2,164	2,164	2,164	2,164	2,164	2,164
	Tree mortality from fires	4,372	1,456	1,444	1,431	1,419	1,407	1,395	1,383	1,370	1,358	1,346	1,334
	Forestland change	1,616,663	688,617	514,971	514,971	514,971	514,971	514,971	514,971	514,971	514,971	514,971	514,971
	Grassland change	-808,331	1,376,208	-715,486	-715,486	-715,486	-715,486	-715,486	-715,486	-715,486	-715,486	-715,486	-715,486
	Cropland change	-724,830	-1,880,826	94,292	94,292	94,292	94,292	94,292	94,292	94,292	94,292	94,292	94,292

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Waste Management

Business-as-Usual Scenario

Table B-64. Puerto Rico Waste Management Greenhouse Gas Emissions by Gas in MT CO_2e, 2019-2041 (Business-as-Usual)

Business-as-Usual (BAU) Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Ref (No Sens)	Reference Total (in CO_2e)	2,925,188	2,994,121	2,912,696	2,843,654	2,780,684	2,717,106	2,652,657	2,587,241	2,520,985	2,453,906	2,386,380	2,319,109
	CO_2	0	0	0	0	0	0	0	0	0	0	0	0
	CH_4	2,888,736	2,956,099	2,875,708	2,807,543	2,745,373	2,682,602	2,618,971	2,554,387	2,488,972	2,422,745	2,356,076	2,289,659
	N_2O	36,452	38,022	36,988	36,111	35,311	34,504	33,685	32,855	32,013	31,162	30,304	29,450
	Biogenic CO_2	0	0	0	0	0	0	0	0	0	0	0	0
High Economic	High Total (in CO_2e)	2,925,188	2,994,121	2,912,696	2,843,654	2,780,684	2,717,106	2,652,657	2,587,241	2,520,985	2,453,906	2,386,380	2,319,109
	CO_2	0	0	0	0	0	0	0	0	0	0	0	0
	CH_4	2,888,736	2,956,099	2,875,708	2,807,543	2,745,373	2,682,602	2,618,971	2,554,387	2,488,972	2,422,745	2,356,076	2,289,659
	N_2O	36,452	38,022	36,988	36,111	35,311	34,504	33,685	32,855	32,013	31,162	30,304	29,450
	Biogenic CO_2	0	0	0	0	0	0	0	0	0	0	0	0
Low Economic	Low Total (in CO_2e)	2,925,188	2,994,121	2,912,696	2,843,654	2,780,684	2,717,106	2,652,657	2,587,241	2,520,985	2,453,906	2,386,380	2,319,109
	CO_2	0	0	0	0	0	0	0	0	0	0	0	0
	CH_4	2,888,736	2,956,099	2,875,708	2,807,543	2,745,373	2,682,602	2,618,971	2,554,387	2,488,972	2,422,745	2,356,076	2,289,659
	N_2O	36,452	38,022	36,988	36,111	35,311	34,504	33,685	32,855	32,013	31,162	30,304	29,450
	Biogenic CO_2	0	0	0	0	0	0	0	0	0	0	0	0

**Biogenic CO_2 has a global warming potential (GWP) of 0, meaning that it is not included in CO_2e calculations for greenhouse gas inventories, per IPCC guidelines.*

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Table B-65. Puerto Rico Waste Management Greenhouse Gas Emissions by Subsector in MT CO_2e, 2019-2041 (Business-as-Usual)

Business-as-Usual (BAU) Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Ref (No Sensitivity)	Reference Total (in CO_2e)	2,925,188	2,994,121	2,912,696	2,843,654	2,780,684	2,717,106	2,652,657	2,587,241	2,520,985	2,453,906	2,386,380	2,319,109
	Solid Waste (Landfills)	2,565,266	2,618,499	2,547,289	2,486,908	2,431,838	2,376,236	2,319,872	2,262,664	2,204,719	2,146,056	2,087,001	2,028,169
	Solid Waste (Compost)	2,877	2,877	2,799	2,732	2,672	2,611	2,549	2,486	2,422	2,358	2,293	2,228
	Wastewater (septic)	336,182	351,564	342,004	333,897	326,503	319,038	311,470	303,789	296,010	288,133	280,205	272,306
	Wastewater (aerobic)	12,965	13,137	12,780	12,477	12,201	11,922	11,639	11,352	11,061	10,767	10,471	10,176
	Wastewater (anaerobic)	7,793	7,941	7,725	7,542	7,375	7,206	7,035	6,862	6,686	6,508	6,329	6,150
	Wastewater (reactor)	105	103	100	97	95	93	91	89	86	84	82	79
High Economic Growth	High Total (in CO_2e)	2,925,188	2,994,121	2,912,696	2,843,654	2,780,684	2,717,106	2,652,657	2,587,241	2,520,985	2,453,906	2,386,380	2,319,109
	Solid Waste (Landfills)	2,565,266	2,618,499	2,547,289	2,486,908	2,431,838	2,376,236	2,319,872	2,262,664	2,204,719	2,146,056	2,087,001	2,028,169
	Solid Waste (Compost)	2,877	2,877	2,799	2,732	2,672	2,611	2,549	2,486	2,422	2,358	2,293	2,228
	Wastewater (septic)	336,182	351,564	342,004	333,897	326,503	319,038	311,470	303,789	296,010	288,133	280,205	272,306
	Wastewater (aerobic)	12,965	13,137	12,780	12,477	12,201	11,922	11,639	11,352	11,061	10,767	10,471	10,176
	Wastewater (anaerobic)	7,793	7,941	7,725	7,542	7,375	7,206	7,035	6,862	6,686	6,508	6,329	6,150
	Wastewater (reactor)	105	103	100	97	95	93	91	89	86	84	82	79
Low Economic Growth	Low Total (in CO_2e)	2,925,188	2,994,121	2,912,696	2,843,654	2,780,684	2,717,106	2,652,657	2,587,241	2,520,985	2,453,906	2,386,380	2,319,109
	Solid Waste (Landfills)	2,565,266	2,618,499	2,547,289	2,486,908	2,431,838	2,376,236	2,319,872	2,262,664	2,204,719	2,146,056	2,087,001	2,028,169
	Solid Waste (Compost)	2,877	2,877	2,799	2,732	2,672	2,611	2,549	2,486	2,422	2,358	2,293	2,228
	Wastewater (septic)	336,182	351,564	342,004	333,897	326,503	319,038	311,470	303,789	296,010	288,133	280,205	272,306
	Wastewater (aerobic)	12,965	13,137	12,780	12,477	12,201	11,922	11,639	11,352	11,061	10,767	10,471	10,176
	Wastewater (anaerobic)	7,793	7,941	7,725	7,542	7,375	7,206	7,035	6,862	6,686	6,508	6,329	6,150
	Wastewater (reactor)	105	103	100	97	95	93	91	89	86	84	82	79

Decarbonization Scenario

Table B-66. Puerto Rico Waste Management Greenhouse Gas Emissions by Gas in MT CO_2e, 2019-2041 (Decarbonization)

Decarbonization Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Ref (No Sens)	Reference Total (in CO_2e)	2,925,188	2,994,121	2,912,696	2,843,654	2,780,684	2,717,106	2,652,657	2,587,241	2,520,985	2,453,906	2,386,380	2,319,109
	CO_2	0	0	0	0	0	0	0	0	0	0	0	0
	CH_4	2,888,736	2,956,099	2,875,708	2,807,543	2,745,373	2,682,602	2,618,971	2,554,387	2,488,972	2,422,745	2,356,076	2,289,659
	N_2O	36,452	38,022	36,988	36,111	35,311	34,504	33,685	32,855	32,013	31,162	30,304	29,450
	Biogenic CO_2	0	0	0	0	0	0	0	0	0	0	0	0
High Economic	High Total (in CO_2e)	2,925,188	2,994,121	2,912,696	2,843,654	2,780,684	2,717,106	2,652,657	2,587,241	2,520,985	2,453,906	2,386,380	2,319,109
	CO_2	0	0	0	0	0	0	0	0	0	0	0	0
	CH_4	2,888,736	2,956,099	2,875,708	2,807,543	2,745,373	2,682,602	2,618,971	2,554,387	2,488,972	2,422,745	2,356,076	2,289,659
	N_2O	36,452	38,022	36,988	36,111	35,311	34,504	33,685	32,855	32,013	31,162	30,304	29,450
	Biogenic CO_2	0	0	0	0	0	0	0	0	0	0	0	0
Low Economic	Low Total (in CO_2e)	2,925,188	2,994,121	2,912,696	2,843,654	2,780,684	2,717,106	2,652,657	2,587,241	2,520,985	2,453,906	2,386,380	2,319,109
	CO_2	0	0	0	0	0	0	0	0	0	0	0	0
	CH_4	2,888,736	2,956,099	2,875,708	2,807,543	2,745,373	2,682,602	2,618,971	2,554,387	2,488,972	2,422,745	2,356,076	2,289,659
	N_2O	36,452	38,022	36,988	36,111	35,311	34,504	33,685	32,855	32,013	31,162	30,304	29,450
	Biogenic CO_2	0	0	0	0	0	0	0	0	0	0	0	0

**Biogenic CO_2 has a global warming potential (GWP) of 0, meaning that it is not included in CO_2e calculations for greenhouse gas inventories, per IPCC guidelines.*

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Table B-67. Puerto Rico Waste Management Greenhouse Gas Emissions by Subsector in MT CO_2e, 2019-2041 (Decarbonization)

Decarbonization Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Ref (No Sensitivity)	Reference Total (in CO_2e)	2,925,188	2,994,121	2,912,696	2,843,654	2,780,684	2,717,106	2,652,657	2,587,241	2,520,985	2,453,906	2,386,380	2,319,109
	Solid Waste (Landfills)	2,565,266	2,618,499	2,547,289	2,486,908	2,431,838	2,376,236	2,319,872	2,262,664	2,204,719	2,146,056	2,087,001	2,028,169
	Solid Waste (Compost)	2,877	2,877	2,799	2,732	2,672	2,611	2,549	2,486	2,422	2,358	2,293	2,228
	Wastewater (septic)	336,182	351,564	342,004	333,897	326,503	319,038	311,470	303,789	296,010	288,133	280,205	272,306
	Wastewater (aerobic)	12,965	13,137	12,780	12,477	12,201	11,922	11,639	11,352	11,061	10,767	10,471	10,176
	Wastewater (anaerobic)	7,793	7,941	7,725	7,542	7,375	7,206	7,035	6,862	6,686	6,508	6,329	6,150
	Wastewater (reactor)	105	103	100	97	95	93	91	89	86	84	82	79
High Economic Growth	High Total (in CO_2e)	2,925,188	2,994,121	2,912,696	2,843,654	2,780,684	2,717,106	2,652,657	2,587,241	2,520,985	2,453,906	2,386,380	2,319,109
	Solid Waste (Landfills)	2,565,266	2,618,499	2,547,289	2,486,908	2,431,838	2,376,236	2,319,872	2,262,664	2,204,719	2,146,056	2,087,001	2,028,169
	Solid Waste (Compost)	2,877	2,877	2,799	2,732	2,672	2,611	2,549	2,486	2,422	2,358	2,293	2,228
	Wastewater (septic)	336,182	351,564	342,004	333,897	326,503	319,038	311,470	303,789	296,010	288,133	280,205	272,306
	Wastewater (aerobic)	12,965	13,137	12,780	12,477	12,201	11,922	11,639	11,352	11,061	10,767	10,471	10,176
	Wastewater (anaerobic)	7,793	7,941	7,725	7,542	7,375	7,206	7,035	6,862	6,686	6,508	6,329	6,150
	Wastewater (reactor)	105	103	100	97	95	93	91	89	86	84	82	79
Low Economic Growth	Low Total (in CO_2e)	2,925,188	2,994,121	2,912,696	2,843,654	2,780,684	2,717,106	2,652,657	2,587,241	2,520,985	2,453,906	2,386,380	2,319,109
	Solid Waste (Landfills)	2,565,266	2,618,499	2,547,289	2,486,908	2,431,838	2,376,236	2,319,872	2,262,664	2,204,719	2,146,056	2,087,001	2,028,169
	Solid Waste (Compost)	2,877	2,877	2,799	2,732	2,672	2,611	2,549	2,486	2,422	2,358	2,293	2,228
	Wastewater (septic)	336,182	351,564	342,004	333,897	326,503	319,038	311,470	303,789	296,010	288,133	280,205	272,306
	Wastewater (aerobic)	12,965	13,137	12,780	12,477	12,201	11,922	11,639	11,352	11,061	10,767	10,471	10,176
	Wastewater (anaerobic)	7,793	7,941	7,725	7,542	7,375	7,206	7,035	6,862	6,686	6,508	6,329	6,150
	Wastewater (reactor)	105	103	100	97	95	93	91	89	86	84	82	79

Severe Hurricanes Scenario

Table B-68. Puerto Rico Waste Management Greenhouse Gas Emissions by Gas in MT CO_2e, 2019-2041 (Severe Hurricanes)

Severe Hurricanes Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Ref (No Sens)	Reference Total (in CO_2e)	2,925,188	2,994,121	2,912,696	2,843,654	2,780,684	2,717,106	2,652,657	2,587,241	2,520,985	2,453,906	2,386,380	2,319,109
	CO_2	0	0	0	0	0	0	0	0	0	0	0	0
	CH_4	2,888,736	2,956,099	2,875,708	2,807,543	2,745,373	2,682,602	2,618,971	2,554,387	2,488,972	2,422,745	2,356,076	2,289,659
	N_2O	36,452	38,022	36,988	36,111	35,311	34,504	33,685	32,855	32,013	31,162	30,304	29,450
	Biogenic CO_2	0	0	0	0	0	0	0	0	0	0	0	0
High Economic	High Total (in CO_2e)	2,925,188	2,994,121	2,912,696	2,843,654	2,780,684	2,717,106	2,652,657	2,587,241	2,520,985	2,453,906	2,386,380	2,319,109
	CO_2	0	0	0	0	0	0	0	0	0	0	0	0
	CH_4	2,888,736	2,956,099	2,875,708	2,807,543	2,745,373	2,682,602	2,618,971	2,554,387	2,488,972	2,422,745	2,356,076	2,289,659
	N_2O	36,452	38,022	36,988	36,111	35,311	34,504	33,685	32,855	32,013	31,162	30,304	29,450
	Biogenic CO_2	0	0	0	0	0	0	0	0	0	0	0	0
Low Economic	Low Total (in CO_2e)	2,925,188	2,994,121	2,912,696	2,843,654	2,780,684	2,717,106	2,652,657	2,587,241	2,520,985	2,453,906	2,386,380	2,319,109
	CO_2	0	0	0	0	0	0	0	0	0	0	0	0
	CH_4	2,888,736	2,956,099	2,875,708	2,807,543	2,745,373	2,682,602	2,618,971	2,554,387	2,488,972	2,422,745	2,356,076	2,289,659
	N_2O	36,452	38,022	36,988	36,111	35,311	34,504	33,685	32,855	32,013	31,162	30,304	29,450
	Biogenic CO_2	0	0	0	0	0	0	0	0	0	0	0	0

**Biogenic CO_2 has a global warming potential (GWP) of 0, meaning that it is not included in CO_2e calculations for greenhouse gas inventories, per IPCC guidelines.*

Table B-69. Puerto Rico Waste Management Greenhouse Gas Emissions by Subsector in MT CO_2e, 2019-2041 (Severe Hurricanes)

Severe Hurricanes Scenario		Inventory		Projections									
Metric Tons CO_2e		2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041
Ref (No Sensitivity)	Reference Total (in CO_2e)	2,925,188	2,994,121	2,912,696	2,843,654	2,780,684	2,717,106	2,652,657	2,587,241	2,520,985	2,453,906	2,386,380	2,319,109
	Solid Waste (Landfills)	2,565,266	2,618,499	2,547,289	2,486,908	2,431,838	2,376,236	2,319,872	2,262,664	2,204,719	2,146,056	2,087,001	2,028,169
	Solid Waste (Compost)	2,877	2,877	2,799	2,732	2,672	2,611	2,549	2,486	2,422	2,358	2,293	2,228
	Wastewater (septic)	336,182	351,564	342,004	333,897	326,503	319,038	311,470	303,789	296,010	288,133	280,205	272,306
	Wastewater (aerobic)	12,965	13,137	12,780	12,477	12,201	11,922	11,639	11,352	11,061	10,767	10,471	10,176
	Wastewater (anaerobic)	7,793	7,941	7,725	7,542	7,375	7,206	7,035	6,862	6,686	6,508	6,329	6,150
	Wastewater (reactor)	105	103	100	97	95	93	91	89	86	84	82	79
High Economic Growth	High Total (in CO_2e)	2,925,188	2,994,121	2,912,696	2,843,654	2,780,684	2,717,106	2,652,657	2,587,241	2,520,985	2,453,906	2,386,380	2,319,109
	Solid Waste (Landfills)	2,565,266	2,618,499	2,547,289	2,486,908	2,431,838	2,376,236	2,319,872	2,262,664	2,204,719	2,146,056	2,087,001	2,028,169
	Solid Waste (Compost)	2,877	2,877	2,799	2,732	2,672	2,611	2,549	2,486	2,422	2,358	2,293	2,228
	Wastewater (septic)	336,182	351,564	342,004	333,897	326,503	319,038	311,470	303,789	296,010	288,133	280,205	272,306
	Wastewater (aerobic)	12,965	13,137	12,780	12,477	12,201	11,922	11,639	11,352	11,061	10,767	10,471	10,176
	Wastewater (anaerobic)	7,793	7,941	7,725	7,542	7,375	7,206	7,035	6,862	6,686	6,508	6,329	6,150
	Wastewater (reactor)	105	103	100	97	95	93	91	89	86	84	82	79
Low Economic Growth	Low Total (in CO_2e)	2,925,188	2,994,121	2,912,696	2,843,654	2,780,684	2,717,106	2,652,657	2,587,241	2,520,985	2,453,906	2,386,380	2,319,109
	Solid Waste (Landfills)	2,565,266	2,618,499	2,547,289	2,486,908	2,431,838	2,376,236	2,319,872	2,262,664	2,204,719	2,146,056	2,087,001	2,028,169
	Solid Waste (Compost)	2,877	2,877	2,799	2,732	2,672	2,611	2,549	2,486	2,422	2,358	2,293	2,228
	Wastewater (septic)	336,182	351,564	342,004	333,897	326,503	319,038	311,470	303,789	296,010	288,133	280,205	272,306
	Wastewater (aerobic)	12,965	13,137	12,780	12,477	12,201	11,922	11,639	11,352	11,061	10,767	10,471	10,176
	Wastewater (anaerobic)	7,793	7,941	7,725	7,542	7,375	7,206	7,035	6,862	6,686	6,508	6,329	6,150
	Wastewater (reactor)	105	103	100	97	95	93	91	89	86	84	82	79