# NEW JERSEY'S GLOBAL WARMING RESPONSE ACT

# 80x50 REPORT

EVALUATING OUR PROGRESS
AND IDENTIFYING PATHWAYS TO
**REDUCE EMISSIONS 80% BY 2050**

CELEBRATING 1970 • 2020
STATE OF NEW JERSEY
DEPARTMENT OF ENVIRONMENTAL PROTECTION

Version 1.0


October 15, 2020

Dear Legislative Leaders and Fellow New Jerseyans,

Climate change is the defining issue of our time. Global atmospheric warming, caused largely by human activities, is leading to significant changes in climate patterns here in New Jersey, across the United States, and around the world. Due to our geography and population, New Jersey is uniquely vulnerable to climate change and is already experiencing its impacts, including rising sea-levels, increasing temperatures, chronic flooding, and more frequent and intense storms. Unfortunately, these impacts will worsen in the years ahead. The questions now before policymakers and the public are about the measures necessary to reduce the severity of these impacts.

The report released today by the Department of Environmental Protection (DEP) is another component of Governor Phil Murphy's comprehensive approach to meeting this critical moment by recommending a suite of legislative, regulatory and policy initiatives that will reduce the emissions of climate pollutants. Make no mistake: the changes New Jersey must make in the next thirty years are significant. But we know well the risks of inaction. Earlier this year, DEP released the *New Jersey Scientific Report on Climate Change* which, as just one example, explained the risk to New Jersey's coastal communities from sea-level rise, warning that under even a moderate emissions scenario, sea-levels could rise by as much as 5.1 feet by the year 2100 and 8.3 feet by the year 2150, eroding large land areas of the state, risking near total loss of our barrier islands, and devastating our tourism industry and larger economy.

Recognizing the need for climate action, New Jersey's legislature passed the Global Warming Response Act (GWRA) in 2007 and updated the law in 2019. Under this law, the DEP is responsible for assessing the state's greenhouse gas emissions and, in collaboration with other state agencies, presenting recommendations for reducing emissions by 20% below 2006 levels by 2020 and 80% by 2050—known as the 80x50 goal. Today, DEP delivers the 80x50 Report with newfound urgency and a call-to-action for legislators, policymakers, businesses and all New Jerseyans.

Fortunately, as a result of market and other forces that motivated power plants to transition from coal to natural gas over the last fifteen years, New Jersey has already successfully reduced emissions by 20% below 2006 levels. Meeting the considerably more challenging 80x50 goal, however, will require a further, seismic shift in how New Jersey does business. Over the next 30 years, New Jersey must implement an economy-wide transformation that steadily phases out the use of fossil fuels, expedites the deployment of renewable energy resources, electrifies new and existing buildings, and facilitates a swift and steady transition from gasoline-powered to electric vehicles, among other initiatives outlined in the 80x50 Report. We acknowledge that each of these initiatives are significant in themselves, but only an all-of-the-above approach adopted by all levels of government, economic sectors, communities and individuals will enable New Jersey to meet the 80x50 goal. If we do not make this transformation and instead remain on a business-as-usual course, New Jersey will lose the benefit of the progress we have already made, and our emissions will be *greater* than they are today.

Just as New Jersey is uniquely vulnerable to risks from climate change, so too is our great state uniquely positioned to turn this challenge into tremendous opportunity for our people, businesses and institutions. How we pursue climate action is indeed one more component of making New Jersey stronger and fairer for all people. By leveraging the talent and skill of our incomparable workforce, our trademark innovation, and our undeniable grit, New Jersey will meet this moment. Together, we will reduce the risks from climate change while making the meaningful and lasting changes that will protect the people and places we love, grow our economy, and preserve our natural treasures for generations to come. Let's get to work.

CELEBRATING
1970 • 2020
STATE OF NEW JERSEY
DEPARTMENT OF ENVIRONMENTAL PROTECTION

Sincerely,

Catherine R. McCabe, Commissioner
New Jersey Department of Environmental Protection

# ACKNOWLEDGMENTS

This report is issued with special thanks to Governor Phil Murphy and Department of Environmental Protection Commissioner Catherine R. McCabe for their vision and leadership, and with thanks to Board of Public Utilities President Joseph L. Fiordaliso, Lt. Governor and Department of Community Affairs Commissioner Sheila Oliver, Economic Development Authority CEO Tim Sullivan, Department of Labor Commissioner Robert Asaro-Angelo, State Treasurer Elizabeth Maher Muoio, Transportation Commissioner Diane Gutierrez-Scaccetti, NJ TRANSIT Executive Director Kevin Corbett, Motor Vehicle Commission Chair and Chief Administrator B. Sue Fulton and Secretary of Agriculture Douglas H. Fisher for each of their contributions and dedication of their respective staffs in the pursuit of this important work.

This report—and its role in contributing to the protection of our state, country and world from the adverse impacts of climate change—would not have been possible without the hard work and commitment of many people across the Executive Branch of New Jersey State Government.

## Primary Authors

**Department of Environmental Protection**
Helaine Barr
Paul Orlando
Robert Kettig
R. Christopher Barry
Rupa Karmarkar-Deshmukh
Marwa Kamel

## Special Contributors

**Department of Environmental Protection**
Kristen Brennan
Matthew Rivas

# Other Contributors

## Department of Environmental Protection
Shawn M. LaTourette,
Deputy Commissioner and Chief of Staff

Jane Rosenblatt,
Deputy Chief of Staff

**Air Quality, Energy & Sustainability**
*Assistant Commissioner Office*
Paul Baldauf
Jung Kim
Chris Salmi
Christine Schell

**Division of Climate, Clean Energy & Radiation Protection**
*Bureau of Climate Change and Clean Energy*
Jessica August
Joseph Carpenter
Elizabeth Carper
Ryan Gergely
Karl Hartkopf
Stephen Myers
Jorge Reyes

*Bureau of Sustainability*
Ky Asral
Steven Rinaldi

**Division of Air Quality**
Frank Steitz
Peg Hanna
Kenneth Ratzman
Rebecca Hobbs

*Bureau of Evaluation and Planning*
Sharon Davis
John Gorgol

*Bureau of Mobile Sources*
Robert Schell

**Climate and Flood Resilience Program**
*Bureau of Climate Resilience Planning*
Nicholas Angarone
Thomas Caggiano
David DuMont
Jessica Jahre
Rebecca Hill

**Division of Science and Research**
*Bureau of Environmental Assessment*
Metthea Yepsen

**Natural and Historic Resources**
**Parks and Forestry**
*Bureau of Forest Management*
Bernard Isaacson
Carrie Sargeant
William Zipse

**Site Remediation & Waste Management**
Division of Solid & Hazardous Waste
Mary Jo Aiello
Scott Brubaker

*Bureau of Planning & Licensing*
Fredrik Khayati

*Bureau of Recycling & Hazardous Waste*
Karen Kloo

*Bureau of Solid Waste Planning & Licensing*
Seth Hackman

## Board of Public Utilities
Cynthia Holland
Christine Sadovy
Hannah Thonet

## Economic Development Authority
Jonathan Ratner

## NJ Transit
Erin Hill
Steven Jenks

## Department of Transportation
James Lewis
Andrew Swords

## Department of Community Affairs
Maria Connolly
Robert Austin

## Department of Agriculture
Steven Bruder
Susan Payne
Monique Purcell

## Department of Treasury
William Golubinski

## Rutgers EcoComplex
Serpil Guran

## Rocky Mountain Institute

## Evolved Energy Research

# EXECUTIVE SUMMARY

# A CALL TO ACTION

Over the past three decades, the scientific community's understanding of the trends and underlying causes of climate change has evolved to the point where there is no credible doubt that significant and rapid warming of the earth's climate is occurring. Climate change is primarily caused by human activities, and it poses a severe threat to the environment, human health and welfare, security, and the economy—in New Jersey, across the United States, and around the world. New Jersey is especially vulnerable to the adverse effects of climate change due to its coastal location and population density. Minimizing these risks requires immediate, decisive, long-term commitments across all levels of government and sectors of the economy to facilitate the steep reductions of greenhouse gas (GHG) emissions that are necessary to protect New Jersey's economic, social, and environmental vitality.

Without steep and permanent reductions in global GHG emissions within the next several years, New Jersey's people and their property will experience significant adverse effects of climate change, including rising sea-levels, increases in temperature and precipitation causing periods of both intense storms and drought, and chronic inundation from flooding. These changes in climate will cause or exacerbate stress on the state's public health, ecological, social and economic systems. For example, leading climate scientists have projected that New Jersey is likely to experience sea-level rise by as much as 1.1 feet by the year 2030 and 2.1 feet by the year 2050 regardless of future reductions (Kopp, 2019), which will contributing to flooding across many areas of the state, and particularly along the coastline that hosts our vibrant tourism industry. While future emissions reductions cannot avoid these nearer-term impacts hastened by our past emissions, deeper and continuous GHG reductions will protect and improve the state's longer-term outlook by helping to avoid more drastic adverse impacts. Without steep reductions moving forward, for example, New Jersey's sea-levels could rise by as much as 5.1 feet by the year 2100 and 8.3 feet by the year 2150 under even a moderate emissions scenario (Kopp, 2019), with the potential to erode large land areas of the state. The risks to the continued success of New Jersey's economy, public health, and environment cannot be understated and the need for concerted action could not be clearer.

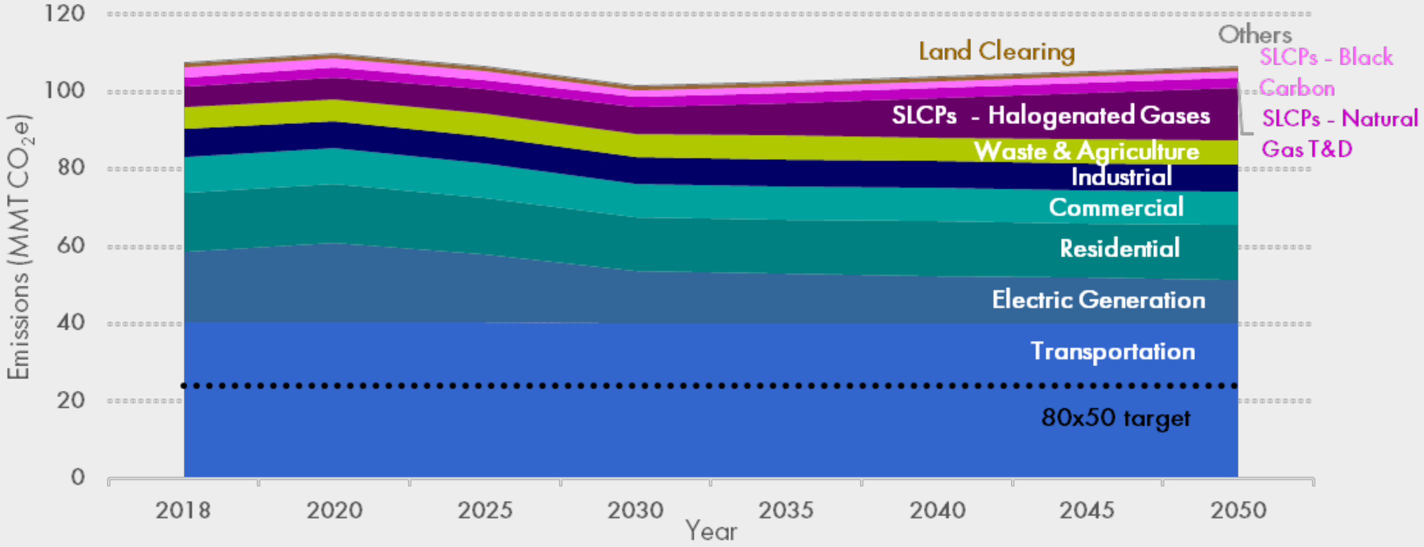
Recognizing the need for coordinated action in the public and private sectors, the New Jersey Global Warming Response Act (P.L. 2007 c.112; P.L. 2018 c.197) (GWRA) directed the New Jersey Department of Environmental Protection (DEP), in collaboration with other state agencies, to develop plans and make recommendations for reducing emissions of climate pollutants, represented throughout this report as carbon dioxide equivalent emissions or $CO_2e$, to 80% below their 2006 levels by the year 2050 (known as the "80x50" goal).[1] Building upon New Jersey's 2019 Energy Master Plan (2019 EMP) and Governor Phil Murphy's vision for 100% clean energy by 2050, this report analyzes New Jersey's emissions reductions to date, evaluates plans presently in place for further reducing emissions, and presents a set of strategies across seven emission sectors for policymakers to consider in formulating legislation, regulations, policy and programs to ensure that New Jersey achieves the 80x50 goal.

In 2006, net emissions totaled 120.6 MMT $CO_2e$, setting the 80x50 net emission goal at 24.1 MMT $CO_2e$ by 2050. New Jersey has made significant progress in reducing GHGs, in large part through a rapid transition from coal-powered energy generation to cleaner burning natural gas, with 2018 emissions estimated to be 97.0 MMT $CO_2e$—a 20% reduction below 2006 levels. Achieving the 80x50 goal, however, will require New Jersey to replace most current applications of fossil fuels with renewable energy alternatives within the next 30 years. Since the beginning of the Murphy Administration, the state has deployed policies and programs aimed at facilitating a transition to a clean energy economy, which are still in their early stages but will promote substantial emissions reductions. These efforts, however, cannot on their own achieve the 80x50 goal. On a "Business-as-Usual" course, which includes implementation of Murphy Administration initiatives as of 2019,[2] our 2050 GHG emissions would be *higher* than they are today estimated

[1] $CO_2e$ is a term for describing different greenhouse gases in a common unit. For any quantity and type of greenhouse gas, $CO_2e$ signifies the amount of carbon dioxide ($CO_2$) which would have the equivalent global warming impact, based on their relative global warming potential (GWP).
[2] Business-as-usual scenario includes current rate of electric vehicles adoption (8,000 annually) through 2050, 3.5 GW of offshore wind by 2030, in-state solar PV capacity growth at the observed rate of 152 MW/year, 2 GW of storage by 2030, 50% Renewable Portfolio Standard by 2030, energy efficiency improvements through 2030 and assuming growth in waste, natural gas transmission and distribution and halogenated gases.

to at best be 106.7 MMT $CO_2e$ or 12% below 2006 levels, undermining progress to-date and missing the 80x50 goal (Figure ES.1).

***Figure ES.1. New Jersey GHG and Black Carbon Emissions Business-as-Usual Projection for 2050 (MMT $CO_2e$).***
*Emissions will not decrease substantially unless alternative technologies are widely deployed, and renewable energy resources are greatly expanded.*

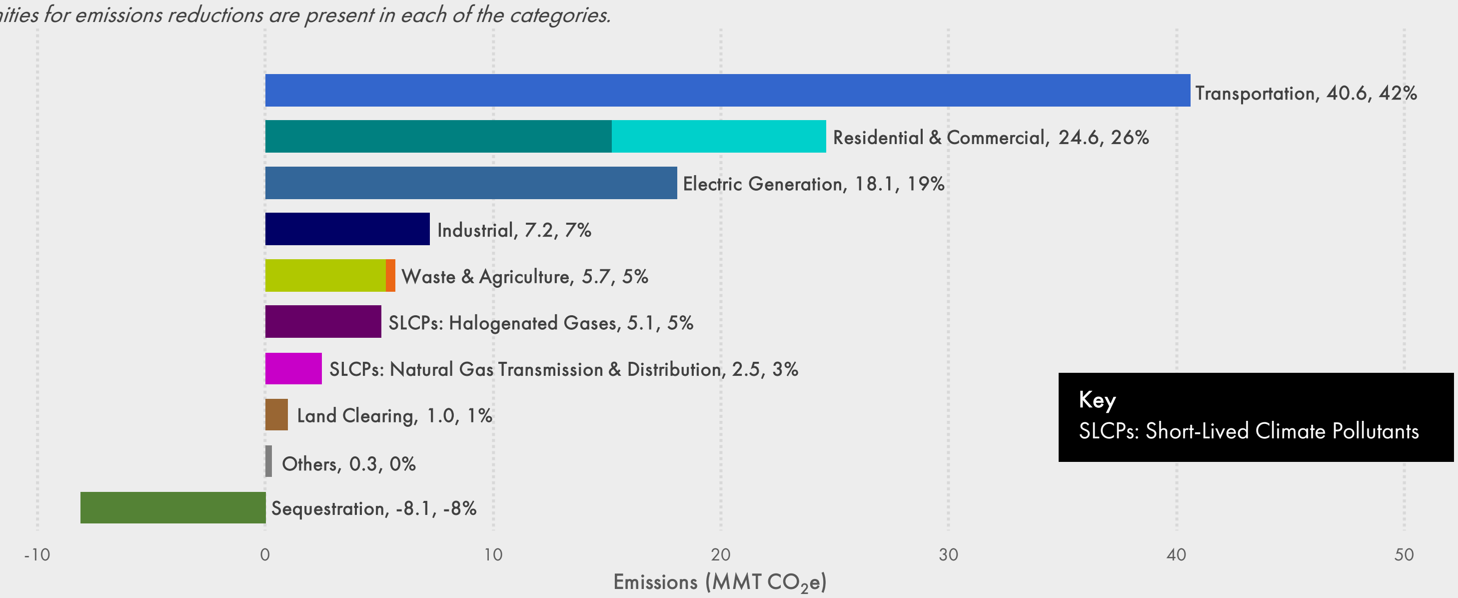



The goal of this report is to communicate the ability and limitations of existing policies and programs in reaching the 80x50 goal and to provide options that will assist policymakers in crafting new initiatives to bridge the emissions reductions gap. This report therefore summarizes the emission reduction potential of existing programs and identifies several strategies which, in combination, would enable New Jersey to achieve its 80x50 goal.

## NEW JERSEY'S CURRENT GHG EMISSIONS

The transportation sector represents the largest source of GHG emissions in New Jersey (42%), followed by the combined residential and commercial sectors (26%), and electric generation (19%). The industrial (7%), waste and agriculture (5%), halogenated gases (5%) and natural gas transmission and distribution (3%) sectors contribute most of the remaining emissions. New Jersey's 2018 GHG Inventory Report delineates the relative contributions of each of these sectors (Figure ES.2). Black carbon was not included in the 2018 GHG Inventory report as it is not a GHG. In 2018, black carbon accounted for an additional 2.7 MMT $CO_2e$ (3%) of climate pollutant emissions.

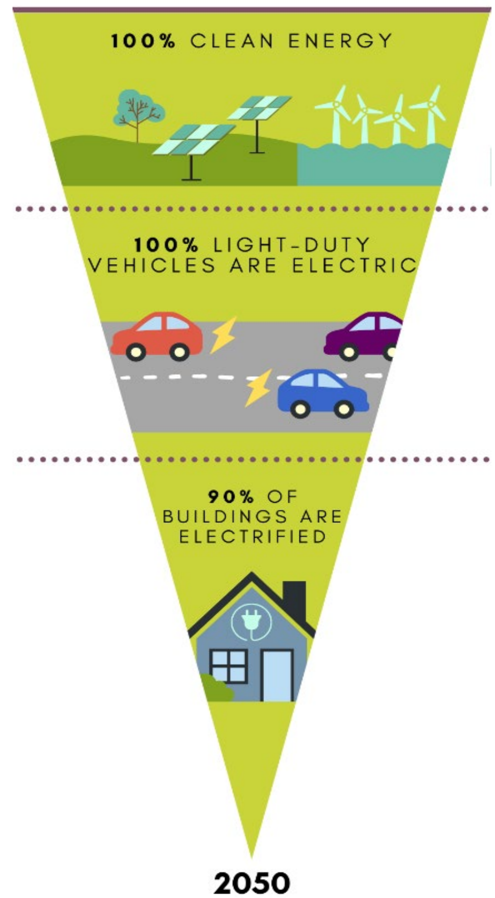
***Figure ES.2. New Jersey GHG Emissions Inventory for 2018 (MMT $CO_2e$ and Percentage).***
*Opportunities for emissions reductions are present in each of the categories.*



# NEW JERSEY'S PATH TO 80% REDUCTION BY 2050

Meeting the 80x50 goal will require very substantial reductions in GHG emissions in the transportation, residential and commercial, and electric generation sectors, given the predominant contributions of those sectors to New Jersey's total emissions. The modeling performed in developing the 2019 EMP shows that the least cost scenario can meet the 80x50 goal, as well as Governor Murphy's goal of 100% clean energy by 2050, through the rapid adoption of three key strategies: (1) replacing internal combustion vehicles with electric vehicles, (2) converting space and water heating in the residential and commercial buildings to electric heat, and (3) replacing fossil fuels in the electric generation sector with renewable energy sources. Presently, wind and solar photovoltaic (PV) technologies are available at competitive prices, which can reduce electric generation sector emissions and help meet the increased electricity demand due to growing use of electric vehicles and high-efficiency heat pumps used for space heating and cooling. While the industrial, waste and agriculture, and short-lived climate pollutants sectors contribute a comparatively smaller amount of New Jersey's overall GHG emissions, it is also important to stabilize emissions in these sectors and reduce them to the greatest extent possible.

Key Strategies to Achieve 80x50

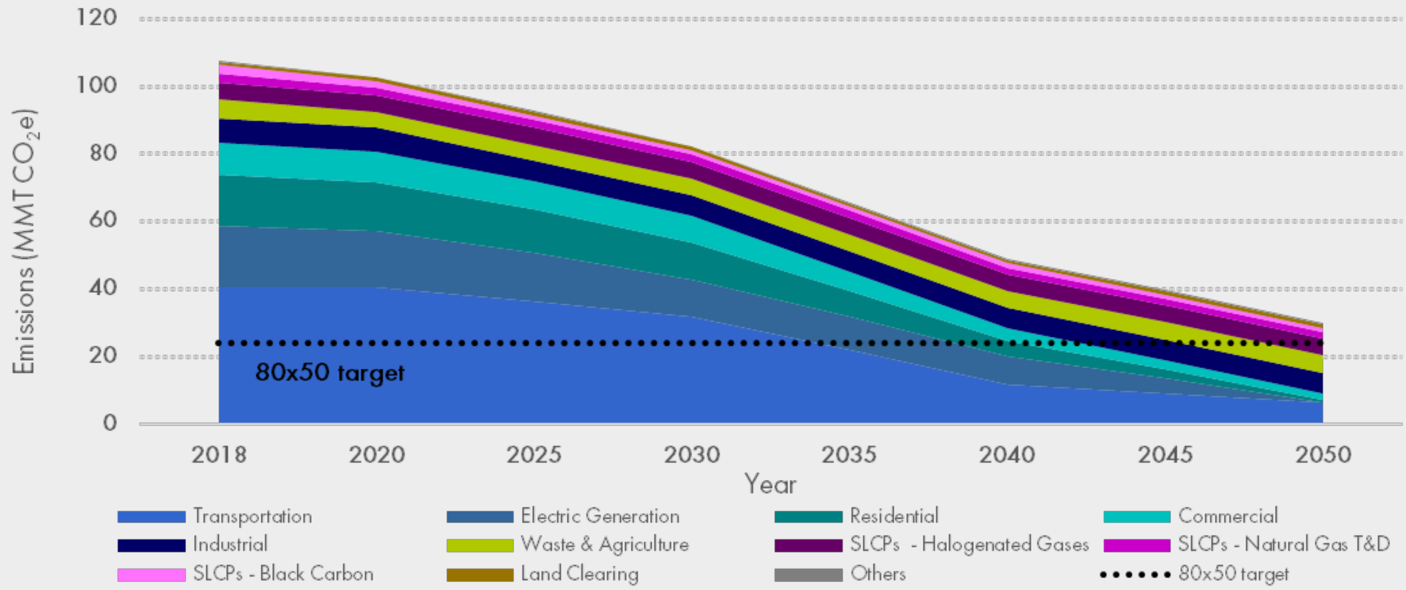



It is necessary for New Jersey to implement both a unified energy policy as set forth in the 2019 EMP and sector-specific policies to achieve the level of GHG reductions called for by the GWRA and envisioned in this report. For example, implementing the 2019 EMP and leveraging clean energy funding sources, including auction proceeds from the Regional Greenhouse Gas Initiative (RGGI), is one backbone mechanism that can be utilized to facilitate emissions reductions in several sectors discussed below while supporting investments in New Jersey companies who deploy clean energy technology, bolstering our economy and creating good jobs for New Jersey residents.

If New Jersey implements the pathways proposed in this report, which incorporates the strategies of the 2019 EMP, GHG emissions can be reduced to 29.8 MMT $CO_2e$ by 2050. This level of reductions, combined with a projected 10.8 MMT additional reduction from carbon sequestration, would bring net emissions in 2050 to 19 MMT $CO_2e$, achieving the 80x50 goal (Figure ES.3).

The following discussion summarizes each sector's current state of climate pollutant emissions and sets forth sector-specific strategies for reducing emissions.

*Figure ES.3. New Jersey GHG Emissions Pathway to 2050 (MMT $CO_2e$).*
*The 2019 EMP least cost pathway combined with non-energy sector strategies, and carbon sequestration (not shown) have the potential to reduce net emissions below the 80x50 target prior to 2050.*

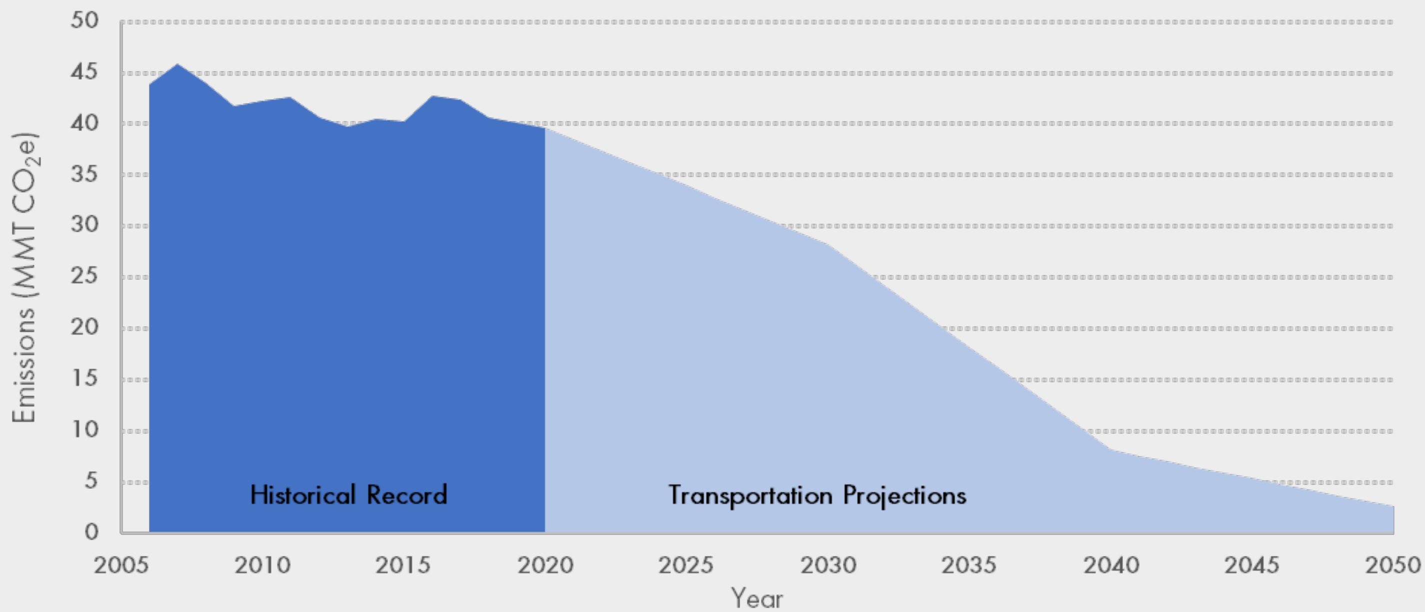



## TRANSPORTATION

The transportation sector is the largest source of New Jersey's GHG emissions. To achieve the 80x50 emissions reduction goal, significant electric vehicle adoption rates outlined in the 2019 EMP must be realized. DEP estimates that the 2019 EMP adoption rates will reduce transportation emissions by 87%, to 5.4 MMT $CO_2e$ by 2050.

Currently, gasoline-fueled vehicles account for over 70% of the transportation sector's emissions. The 2019 EMP's least cost scenario modeling calculated that 88% of new light-duty vehicle sales (passenger cars, SUVs and light-duty trucks) will need to be electric or hydrogen-powered by 2030, rising to 100% by 2035, in order to achieve the 80x50 goal (Figure ES.4).

*Figure ES.4. Transportation Sector Historical GHG Emissions & Projected Pathway to 2050 (MMT $CO_2e$).*
*Adopting electric vehicles can eliminate most emissions from the transportation sector.*



Currently, New Jerseyans purchase more than 500,000 fossil fuel powered passenger vehicles annually and existing policies and programs are not sufficient by themselves to achieve the levels of market penetration necessary to transform the transportation sector. The 330,000 light-duty electric vehicles on the road by 2025 that New Jersey set as its goal in the 2018 Multistate Memorandum of Understanding are expected to reduce the state's GHG emissions by 1.4 MMT $CO_2e$ by 2025. The 2019 Electric Vehicle Law (EV Law) (P.L. 2019, c.362) goal of 2 million light-duty electric vehicles by 2035 will achieve an additional reduction of 7.3 MMT $CO_2e$. While the EV Law provides incentives to jumpstart these efforts, the 2019 EMP indicates that electric vehicle adoption rates must dramatically increase from today's rate of 8,000 annual electric vehicle purchases to more than 111,000 annually, with significant continual increases until 2035, when all new light-duty vehicle sales will need to be electric in order to achieve the goal. As called for in the 2019 EMP, additional policies and initiatives are needed to achieve these objectives.

Continued orders-of-magnitude increases in electric vehicle adoption rates are critical for New Jersey to eliminate the 28 MMT $CO_2e$ emitted annually by light duty vehicles (cars, SUVs and light-duty trucks). While the 2019 EV Law has begun to carve a path for electric vehicle adoption, significant increases in subsidies and disincentives to reduce the consumption of gasoline will ultimately be necessary. Additional strategies for reducing the 7.4 MMT $CO_2e$ emitted annually from medium- and heavy-duty diesel vehicles must also be implemented. It will be necessary to support a combination of technologies—including electric batteries, hydrogen fuel and renewable biofuels—that best address the end use and purpose of medium- and heavy-duty vehicles. One such example is the strategies currently being developed by the New Jersey Economic Development Authority (EDA) for facilitating new investments in medium- and heavy-duty vehicle electrification using the state's proceeds from RGGI.

In order to promote and support the increased adoption of electric vehicles, it is urgent that New Jersey pursue a significant and visible buildout of public electric vehicle charging stations. Electric vehicle chargers must become as commonplace as gasoline refueling stations to enable widescale acceptance and adoption of electric vehicles. The 2019 EV Law requirement for the installation of 200 public fast charging stations (employing 400 chargers) over the next five years is a significant step towards that goal. The law also calls for 1,000 public Level Two chargers in the state by 2025 and sets targets for chargers in multifamily and overnight lodging establishments.

Several electric vehicle infrastructure initiatives are already underway or in planning stages including efforts to streamline the local approval process, prioritizing funding for Direct Current Fast Chargers, as well as the New Jersey Board of Public Utilities (BPU) Board Order for a charging ecosystem which outlines the role of utilities and advancing public private partnerships. To build on this momentum, state agencies, local governments, utilities and private companies must work together to identify public electrification density needs and implement a long-term infrastructure development program to build-out a statewide electric vehicle charging network. In addition to other resources that policymakers could make available, existing funding sources such as the Clean Energy Fund and RGGI auction proceeds can continue to be allocated to advance these goals. Importantly, deeper investment in this effort will also create hundreds of new jobs, resulting in growth in New Jersey's clean energy economy, and the reduction of co-pollutants that can disproportionately impact public health in low-income and minority environmental justice communities.

In addition to a significant effort to electrify vehicles, other innovative solutions must be explored to reduce GHG emissions from the transportation sector. The recent experience of many New Jerseyans during the COVID-19 pandemic has served as a proof of concept for the long-theorized ability of institutions and businesses to integrate remote work programs while maintaining productivity. This paradigm has provided an opportunity to realize significant short term, emission reductions in the transportation sector. To the extent that it supports a healthy economy, more permanent remote work solutions should be explored.

In sum, to reduce the transportation sector's overwhelming contribution to New Jersey's GHG emissions and meet our the 80x50 goal, New Jersey must:

1. Implement legislative, regulatory and programmatic reforms to facilitate a rapid and complete transition away from fossil-powered vehicles, ensuring average adoption rates of at least 111,000 new electric vehicles annually through 2025 with continued increasing adoption rates until all new sales of light-duty cars, SUVs, and trucks are electric by 2035.

2. Implement a long-term infrastructure development program dedicated to constructing a statewide electric vehicle charging network.

3. Transition to complete electrification of the state government vehicle fleet and incentivize county and local governments to lead by example by electrifying their vehicle fleets.

4. Identify regulatory, funding and financing mechanisms to convert medium- and heavy-duty vehicles to electric, renewable biodiesel and hydrogen fuel sources.

In addition to electrification, complementary policies should be pursued to reduce emissions from the transportation sector as quickly as possible, including:

1. Increase ridership on mass transit.

2. Expand transit-oriented development such as Transit Villages and Rural Town Centers.

3. Incentivize work-from-home programs and flexible work weeks, in order to reduce single-occupancy vehicle trips.

4. Collaborate with other states through regional partnerships and strategies to further reduce emissions from fossil-fueled vehicles.

These complementary policies can achieve near-term, cost-effective emissions reductions while electric transportation infrastructure is built out and technologies mature.

## RESIDENTIAL AND COMMERCIAL

Residential and commercial buildings account for the second largest share (26%) of the state's GHG emissions, accounting for 24.6 MMT $CO_2e$ in 2018. In order to achieve the 80x50 goal, emissions from the residential and commercial building sectors must be reduced by 89% to 2.7 MMT $CO_2e$ by 2050. Space and water heating account for the majority of emissions from these sectors, with 87% of residential buildings and 82% of commercial buildings relying predominantly on natural gas. The least cost scenario modeling performed for the 2019 EMP calculated that 90% of buildings must be converted to 100% clean energy systems to meet the 2050 emission goals (see Figures ES.5 and ES.6).

***Figure ES.5. Residential Sector Historical GHG Emissions & Projected Pathway to 2050 (MMT $CO_2e$).***
*Converting space heating and hot water applications to electricity, using electric appliances, and improving energy efficiency will bring substantial reductions to the residential sector's emissions.*

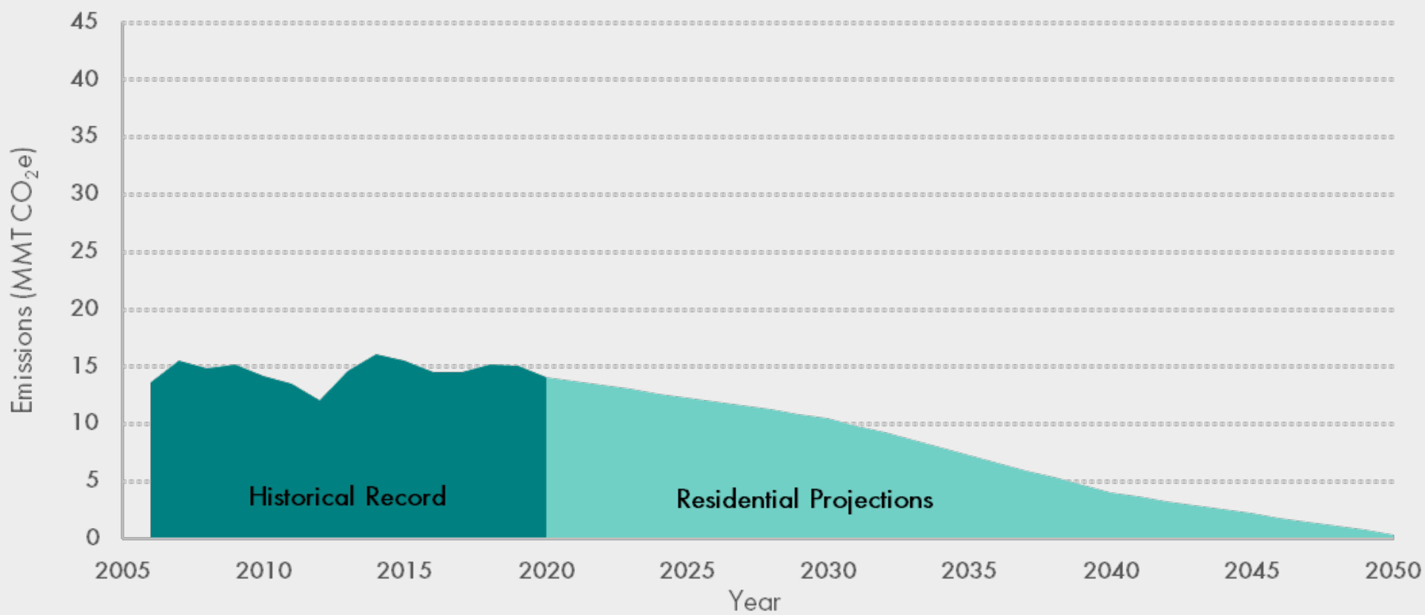
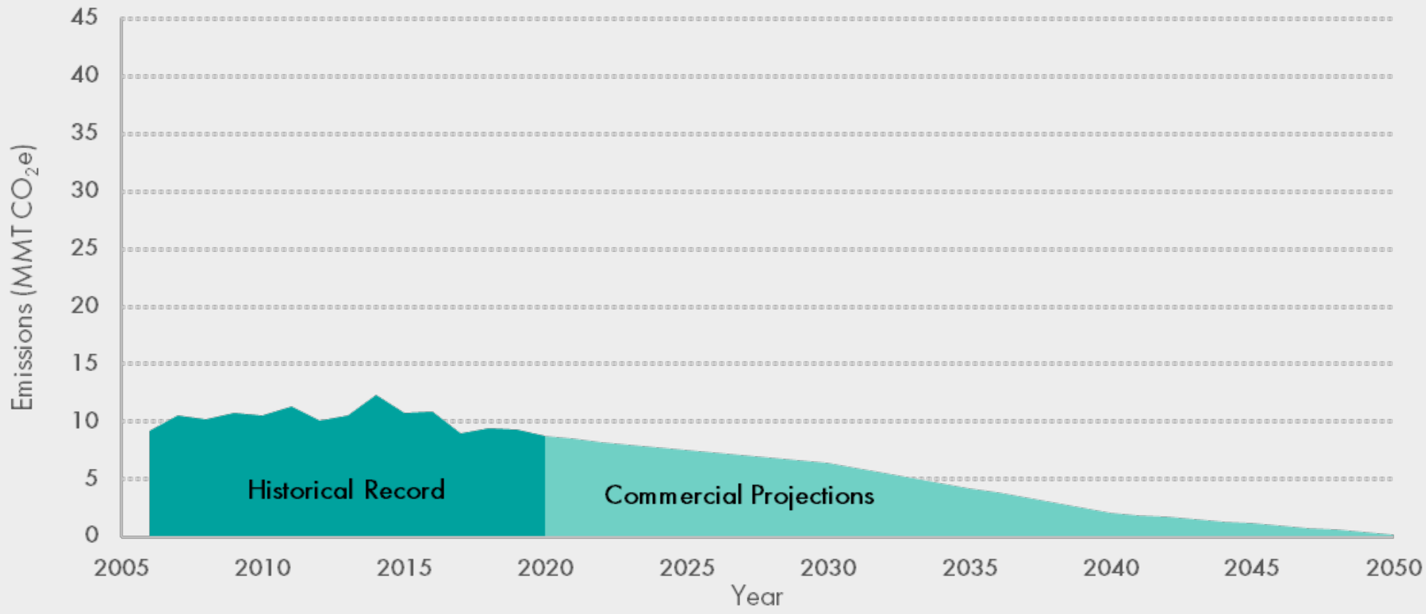


***Figure ES.6. Commercial Sector Historical GHG Emissions & Projected Pathway to 2050 (MMT $CO_2e$).***
*Applying similar strategies as the residential sector will bring substantial reductions to the commercial sector's emissions.*




Achieving the steep reductions of emissions from residential and commercial buildings necessary to meet the 80x50 goal is among New Jersey's most complex challenges, particularly in light of the age of the state's building inventory and its existing fossil fuel-based infrastructure. The 2019 EMP recognizes this complexity, proposing that pilot projects first be used to demonstrate the viability of new technologies, in order to build consumer confidence. Full scale conversion must begin by 2030. To achieve the level of reductions needed, policies requiring net-zero emissions for new construction must be paired with aggressive requirements for electrification of older residential and commercial buildings as soon as practicable. The latter plan should begin with conversion of buildings that currently rely on propane and heating oil (approximately 10% of New Jersey residences). To support a steady conversion of the building inventory, legislation or BPU directives could be pursued to meet the building conversion rates in the 2019 EMP of 22% conversion by 2030, 64% by 2040 and 90% by 2050.

Four primary strategies to reduce GHG emissions in this sector are needed:

1. Develop a Buildings Electrification Roadmap, which provides strategies and concrete timelines for achieving widespread electrification.
2. Prioritize near-term conversion of buildings relying on propane and heating oil, starting no later than 2021.
3. In coordination with the New Jersey Department of Community Affairs (DCA), consider legislation governing all new construction and upgrades to facilitate the transition to a decarbonized building sector.
4. Mandate energy audits in state buildings and encourage/incentivize energy audits in county and municipal buildings.
5. Adopt new construction net zero carbon goals for commercial and residential buildings.

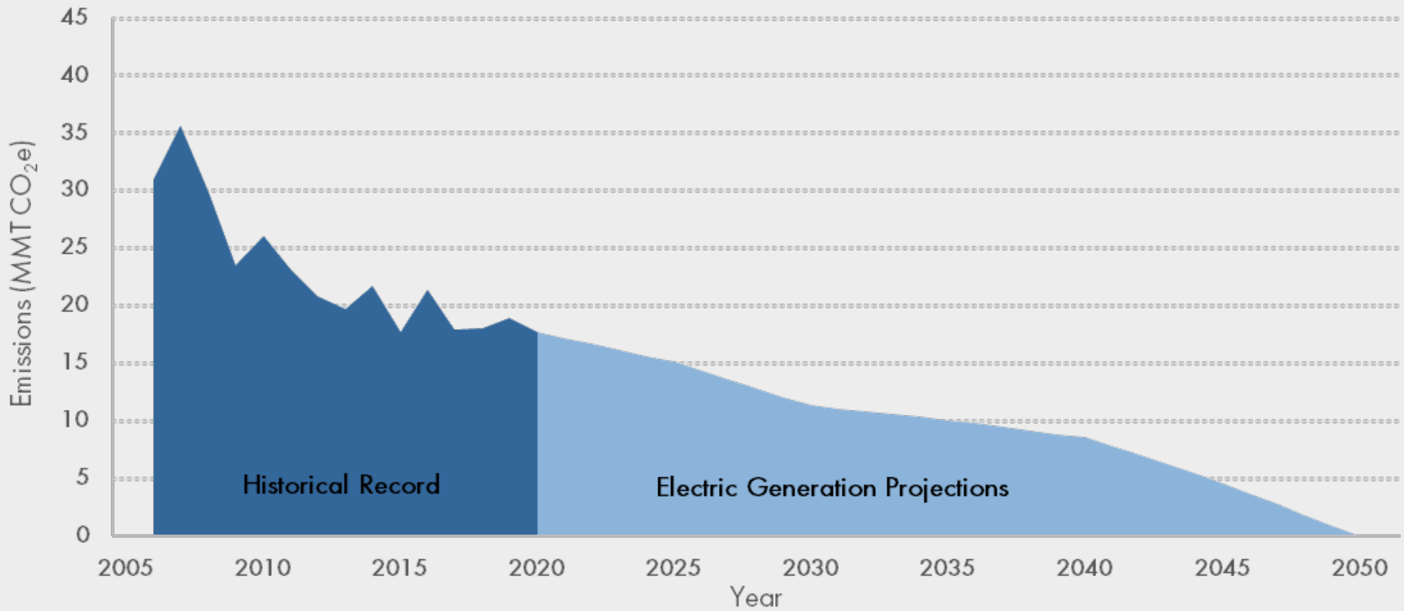
An additional, complementary policy to reduce GHG emissions from the building sector includes the installation of solar thermal technology to increase efficiency in water heating.

# ELECTRIC GENERATION

While historically higher emissions from the electric generation sector have been significantly reduced since enactment of the GWRA (largely due to replacement of coal generation with natural gas), this sector remains the third largest contributor to the state's total $CO_2e$ emissions (19%), accounting for 18.1 MMT $CO_2e$ in 2018 (see Figure ES.7). The majority of these emissions are from natural gas fired electric generating units (83%), with coal fired units contributing 11%, and waste-to-energy facilities contributing 6% of the total emissions from this sector.

***Figure ES.7. Electric Generation Sector Historical GHG Emissions & Pathway to 2050 (MMT $CO_2e$).***

*Deployment of renewable electric generation in tandem with electrification of other sectors will ensure emission reductions are realized against the backdrop of increased electric demand.*




To meet both the 80x50 goal and Governor Murphy's goal of 100% net-zero electric generation, emissions from electric generation must be fully decarbonized, dropping to 0 MMT $CO_2e$ by 2050, as described in the 2019 EMP. The EMP projects that renewable power supply must increase from a present-day level of 3.3 GW (Gigawatts) to almost 16 GW by 2030, through an additional 12.4 GW of renewable energy. It is anticipated this will come from development of 3.5 GW of offshore wind and the balance will be supplied from 8.9 GW of in-state solar and renewable energy resources from the PJM region. By 2050 total state renewable energy capacity must reach approximately 60.5 GW, comprised of 32 GW of solar, nearly 11 GW of offshore wind, and almost 18 GW of firm capacity (e.g., low-carbon or carbon neutral fuels) to meet reliability requirements. New Jersey must also adapt and manage its electric grid through the deployment of distributed energy resources, battery storage and other strategies to accommodate the growing demand from the sectors undergoing electrification.

An additional mechanism for limiting $CO_2$ emissions is the adoption of a Clean Energy Standard, as explained in the 2019 EMP. Given DEP's existing legal authority to regulate the emission of $CO_2$ as an air pollutant, DEP is currently in the process of evaluating the potential adoption of $CO_2$ emissions limits for fossil electric generating units, as well as certain segments of the commercial sector. Regulatory options include carbon emission standards or carbon intensity standards ($CO_2$ per MWh), where emission limits decrease over time.

In sum, in order to meet its 80x50 GHG reduction goals, New Jersey must act swiftly to reduce emissions from the electric power generation sector through a number of actions, including:

1. Pursue the rapid development of renewable electric generation.

2. Implement regulatory limitations on $CO_2$ emissions.

3. Limit reliance upon and development of new fossil fuel-powered electric generating units and transition existing natural gas infrastructure for deployment of alternative low-carbon or carbon neutral fuels.

4. Adapt the electric grid to accommodate distributed energy resources such as solar PV and battery storage, and to support the increasing demand from energy sectors undergoing electrification.

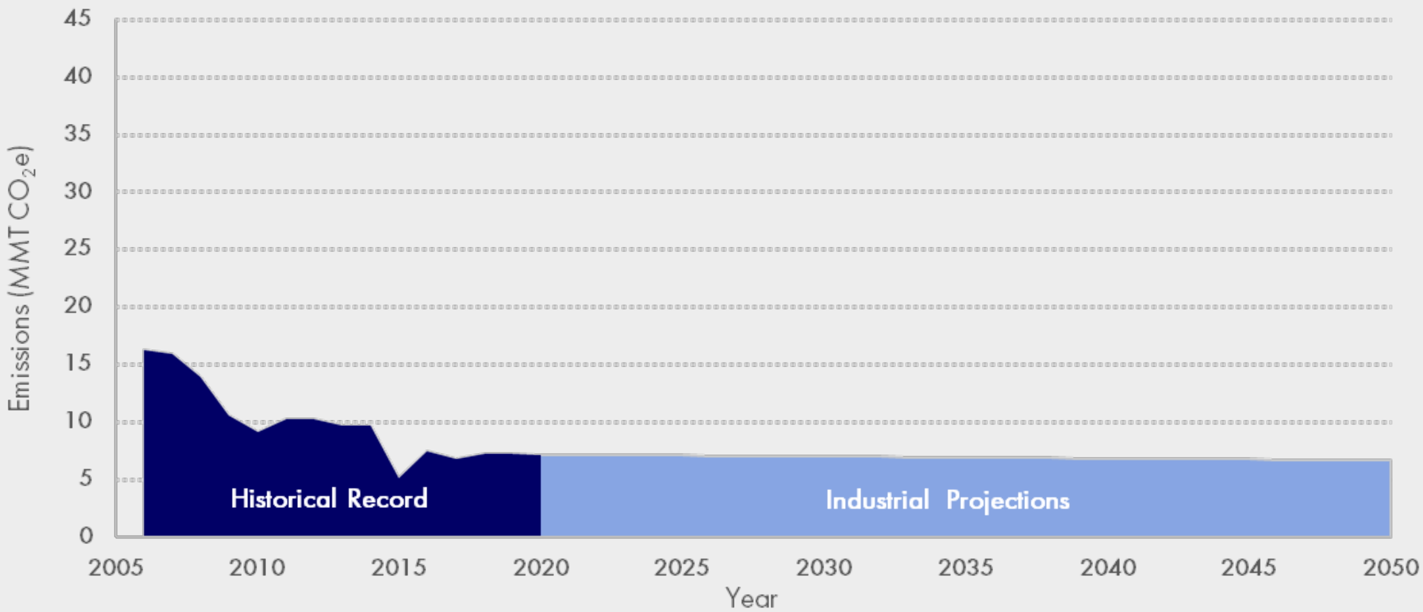
5. Carefully manage loads and improve efficiency to reduce demand and optimize energy use.

6. Retain existing carbon-free resources, including the state's three nuclear power plants.

## INDUSTRIAL

Despite its smaller emissions profile as compared to other sectors, New Jersey's industrial sector is still a significant source of GHG emissions. In 2018, New Jersey industries emitted 7.2 MMT $CO_2$e, accounting for 7% of the state's GHG emissions. Industry can reduce emissions through increased energy efficiency and electrification strategies, as outlined in the 2019 EMP for all energy users. DEP estimated reductions based on energy efficiency of non-process emissions consistent with the Clean Energy Act. These estimates project a 7% reduction of emissions from this sector, to 6.7 MMT $CO_2$e by 2050 (Figure ES.8).

***Figure ES.8. Industrial Sector Historical GHG Emissions & Projected Pathway to 2050 (MMT $CO_2$e).***
*Modest industrial emission reductions are projected due to energy efficiency improvements.*




Reductions can be achieved through expanded adoption of energy efficiency and renewable energy measures, as well as conversion to electrified alternatives. In 2019, a BPU study found that process and non-process measures related to motor systems, interior lighting, process heating, and space heating represented opportunities for energy efficiency (Optimal Energy, 2019).

Effective emissions reduction strategies for the industrial sector include:

1. Facility-wide energy audits, benchmarking and commitments to energy efficiency upgrades and practices.

2. Investigate opportunities to reduce industrial $CO_2$ emissions through regulations.

Complementary policies should also be pursued to facilitate near term emission reductions while supporting economic growth, including:

1. Expand distributed renewable energy. DEP estimates suggest that 29,800 acres of rooftop and non-impervious land area is available at industrial facilities to host approximately 10 GW of solar capacity—enough to power up to 1 million homes. These emissions reductions would be accounted for in the electric generation sector.

2. Upgrade diesel vehicle and equipment fleet to reduce onsite emissions of fine particulate and black carbon.

## WASTE AND AGRICULTURE

The waste and agriculture sectors together make up 5% of the state's GHG emissions, totaling 5.7 MMT $CO_2$e in 2018. Waste management generated 5.3 MMT $CO_2$e, while agricultural activities contribute a modest 0.4 MMT $CO_2$e. Emissions from the waste sector primarily consist of methane and $CO_2$ emissions from the decomposition of organic matter from landfills and wastewater treatment facilities. Without near term policy action, emissions from waste and wastewater are projected to increase at a rate of 0.43% annually, to 6.0 MMT $CO_2$e in 2030, and up to 6.5 MMT $CO_2$e by 2050.

To fulfill the 80x50 mandate, emissions from these sectors must be reduced by 15% (0.9 MMT $CO_2$e) to 4.9 MMT $CO_2$e by 2050, based on projections developed by the DEP. While small emissions reductions can be gained by implementing effective agricultural land management practices, the bulk of emissions reductions from this sector can be realized by enhanced waste management practices through development of a circular economy of waste handling. This process incorporates food waste separation at the source, introducing that waste as a feedstock for renewable biogas production, to produce net zero electricity. Collectively these strategies can reduce 2050 waste emissions by 1.6 MMT $CO_2$e (Figure ES.9).

***Figure ES.9. Waste Sector Historical GHG Emissions & Projected Pathway to 2050 (MMT $CO_2$e).***
*Emissions from waste management decline through food waste reduction and recovery.*

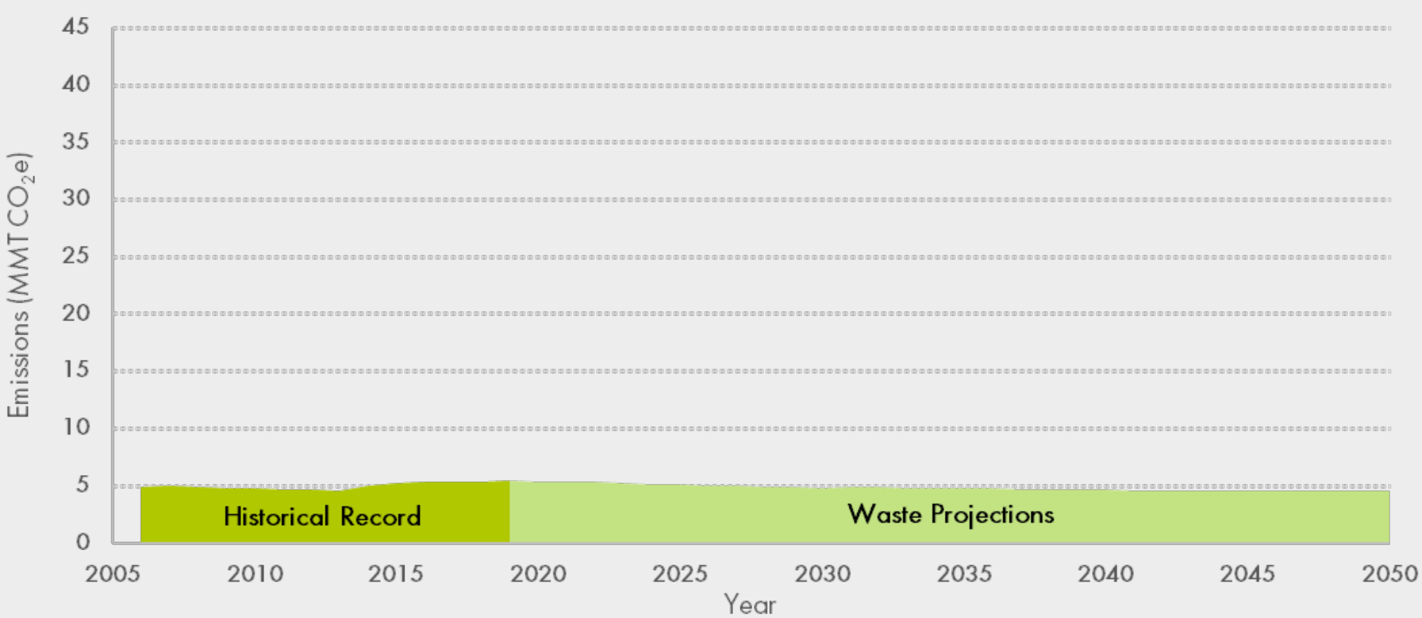
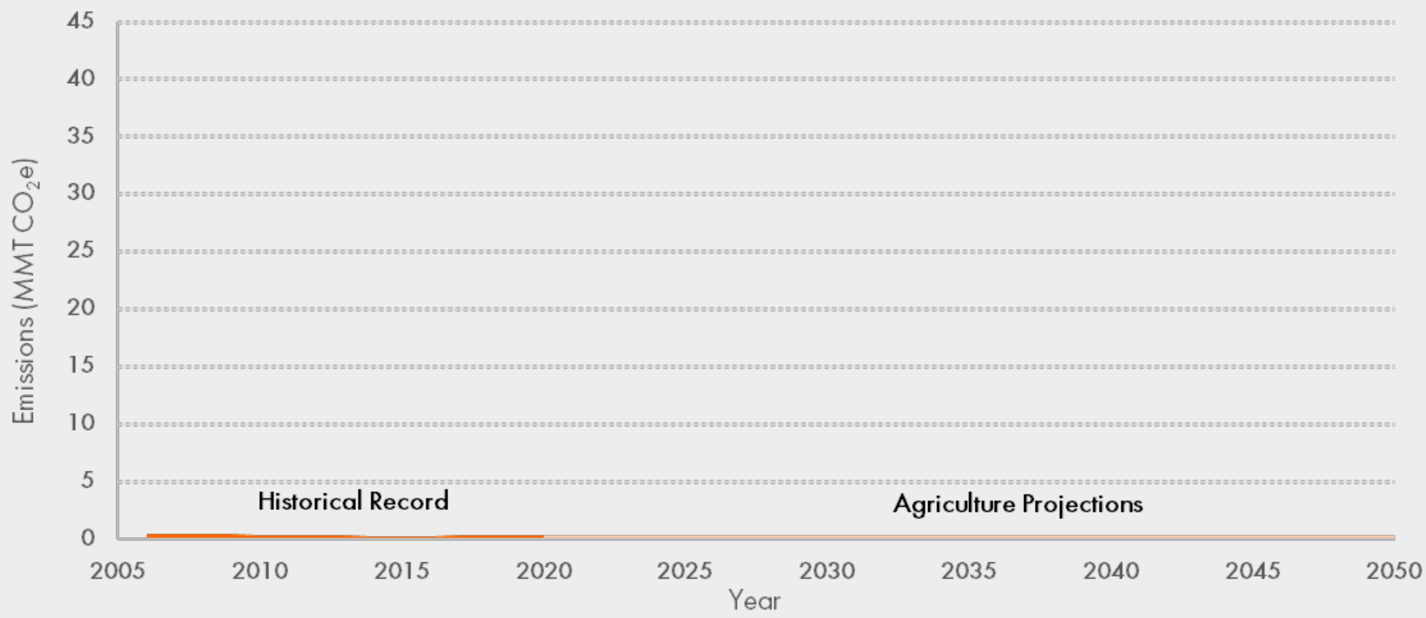


*Figure ES.10. Agricultural Sector Historical GHG Emissions & Projected Pathway to 2050 (MMT $CO_2e$).*
*Emission benefits may be realized through improved land management.*




To reduce and prevent future growth of emissions from the waste and agriculture sectors:

1. Adopt regulations to implement requirements of the Food Waste Recycling and Waste-to-Energy Production Act (P.L.2020, c.24.).
2. Promote the development of food waste processing facilities and the development of markets and best practices for sectors of the economy generating food waste.
3. Promote and support energy recovery efforts from wastewater treatment operations. Expand on successful demonstration projects that introduce food organic wastes into the wastewater treatment process, which enhances energy content of digester gas that is then utilized for onsite energy and process heat.
4. Expand education and outreach efforts about climate friendly agricultural practices, which enhance soils and reduce the production of GHGs.

## SHORT-LIVED CLIMATE POLLUTANTS

Short-lived climate pollutants (SLCPs) are a category of gaseous and particulate materials that remain in the atmosphere and effect climate for a short period of time (weeks to years) compared to $CO_2$ but have potent climate impacts. When released into the atmosphere, SLCPs have extremely high global warming effects, even when released in relatively small amounts. The short-lived climate pollutants discussed in this report are the largest contributors to GHG emissions and include two gaseous pollutant subcategories (methane and halogenated gases) and one particulate subcategory (black carbon). Methane from waste, agriculture and natural gas pipelines along with halogenated gases combine to a total of 13.3 MMT $CO_2e$ or 12.7% of the state's total climate pollutant emissions in 2018. Black carbon emissions contributed another 2.7 MMT $CO_2e$ or 2.5%.

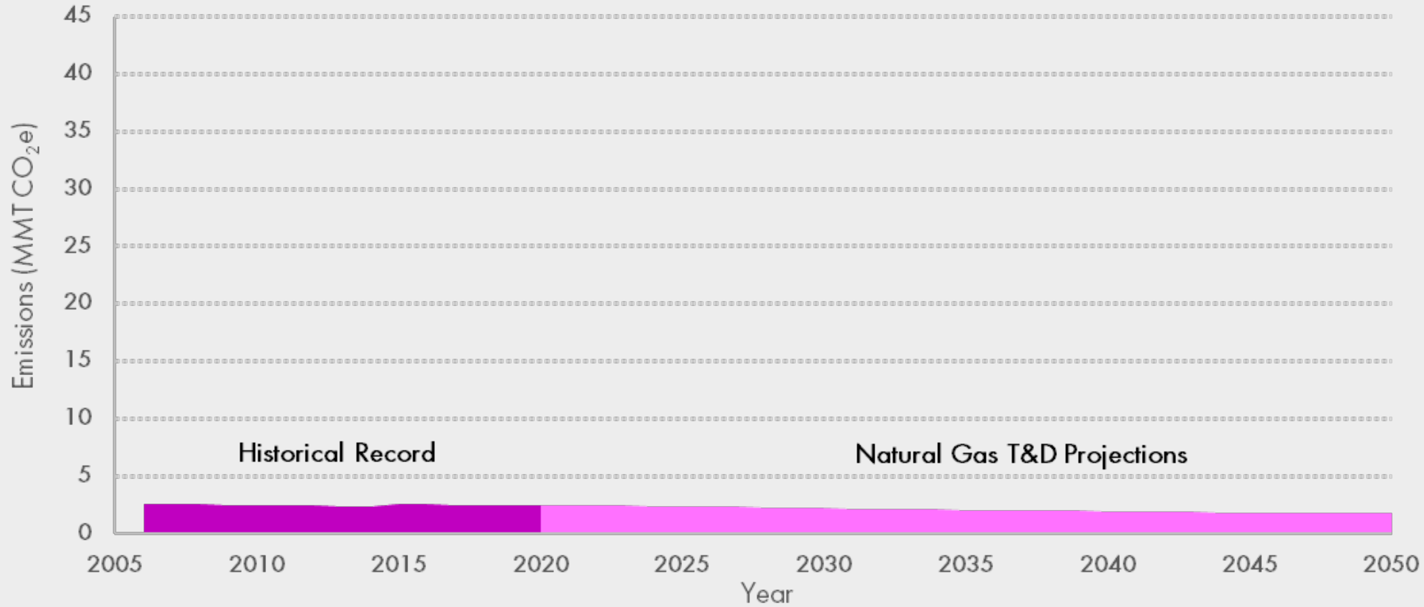
SLCPs consist of methane gas from transmission and distribution of fossil fuels, halogenated gases (mostly HFCs) from refrigeration and heating/cooling equipment, and black carbon from biomass and fossil fuel burning. Under the "Business-as-Usual" scenario, emissions growth due to increased use of these products is predicted for the two gaseous subcategories (methane from natural gas transmission and distribution and HFCs) unless action is taken to reduce emissions.

Black carbon emissions are projected to decline as a result of New Jersey's successful efforts to reduce fine particulate emissions (PM2.5) from various diesel vehicle types. However, additional targeted strategies to reduce black carbon emissions from the transportation sector are appropriate, especially in low-income and minority communities located along traffic corridors, nearby ports and other sources of black carbon emissions.

While New Jersey has made progress in reducing SLCP emissions, more actions are needed within each emission subsector.

Methane reductions can be achieved by requiring advanced leak detection in natural gas distribution systems and upgrading such infrastructure as appropriate as New Jersey transitions away from its dependency on natural gas. DEP projects that a 0.6 MMT $CO_2$e reduction in methane emissions can occur by 2050 (Figure ES.11).

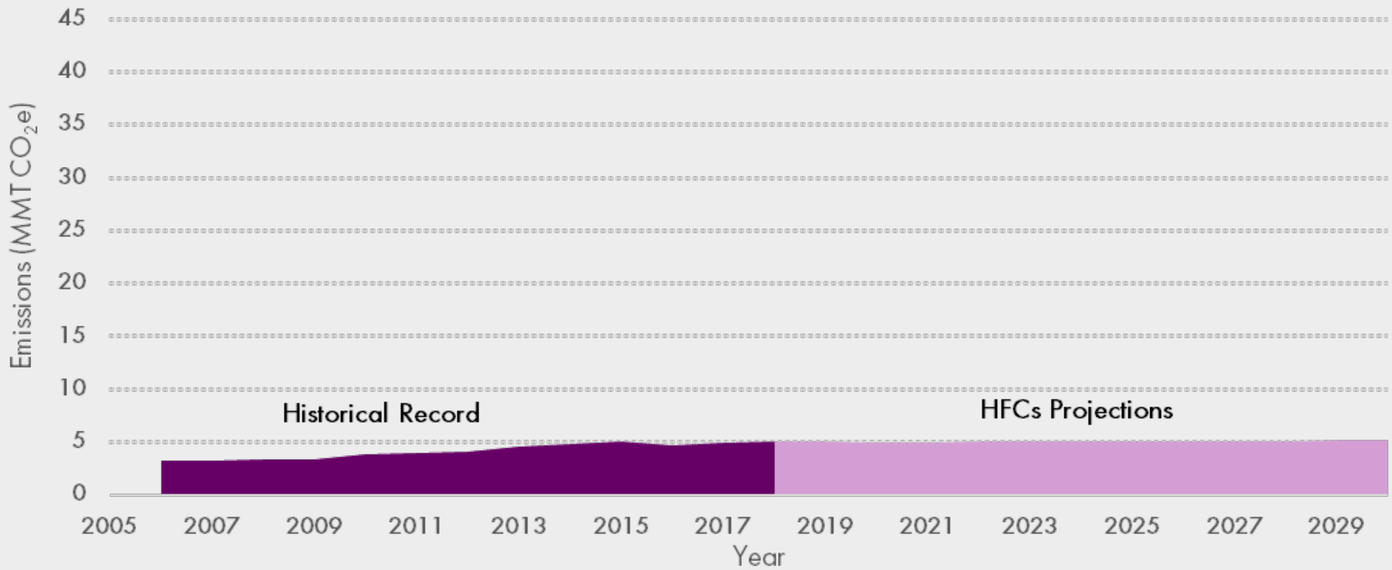
***Figure ES.11. Natural Gas T&D Historical GHG Emissions & Projected Pathway to 2050 (MMT $CO_2$e).***
*Emissions from natural gas transmission and distribution systems can be lowered through pipeline modernization and non-pipeline solutions.*




Emissions from HFC's will remain a challenge as New Jersey works to electrify residential and commercial buildings, as equipment that utilizes these gases for electric powered heating and cooling increases.

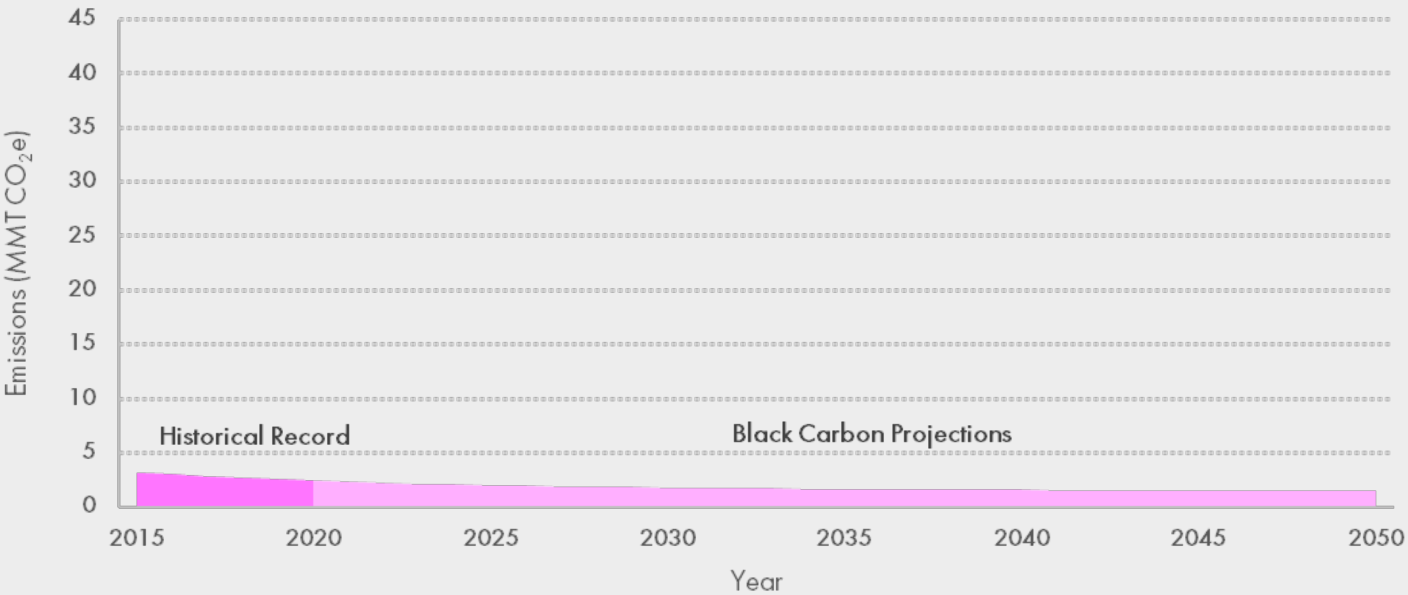
Without new strategies to control halogenated gases, DEP projects that HFC emissions could reach 13.7 MMT $CO_2$e by 2050. However, due to recent legislative action and industry efforts to identify and implement lower global warming potential product replacements, DEP projects 8.6 MMT $CO_2$e of HFC emissions can be avoided by 2050 through the adoption of a Refrigeration Management Program and the implementation of the HFC Law (P.L. 2019, c.507) (Figure ES.12).

*Figure ES.12. Halogenated Gases Historical Emissions & Projected Pathway to 2030 (MMT $CO_2e$).*
*HFCs are the fastest growing source of GHGs emissions in the state, strategies to eliminate releases and finding low global warming potential substitutes will hold emissions in check through 2030.*




New Jersey will continue to reduce black carbon emissions as cleaner combustion engines enter the market and as the state transitions away from fossil fuels. During this transition, New Jersey should also pursue the regulation of captive non-road sources of black carbon; for example, construction equipment and other on-site vehicles that support operations, which would address localized concerns of PM2.5 and black carbon. Undertaking these transitions, DEP projects that black carbon emissions would total 0.75 MMT $CO_2e$ by 2050 (Figure ES.13).

*Figure ES.13. Black Carbon Historical Data & Projected Pathway to 2050 (MMT $CO_2e$).*
*Black carbon emissions will continue to decline due to as a result of cleaner burning diesel engine deployment and vehicle electrification. Some other sources such as wildfires are difficult to predict and were assumed constant.*




In sum, to reduce short-lived climate pollutants, New Jersey should:

1. Reduce methane emissions from natural gas distribution systems through an aggressive transition away from the use of fossil fuels in the transportation, buildings, electric generation and industrial sectors.

2. Implement regulations that phase-out the use of high global warming potential halogenated products, while requiring enhanced leak detection and end of life recycling.

3. Implement programs and policies that prioritize utility efforts to upgrade or, where practical, retire leaking natural gas distribution infrastructure and expand the use of leak detection capabilities to identify, prioritize and replace leaking equipment to reduce methane leaks.

4. Pursue regulations that require expedited replacement or retirement of the most polluting off-road diesel equipment to reduce fine particulate (and black carbon) emissions.

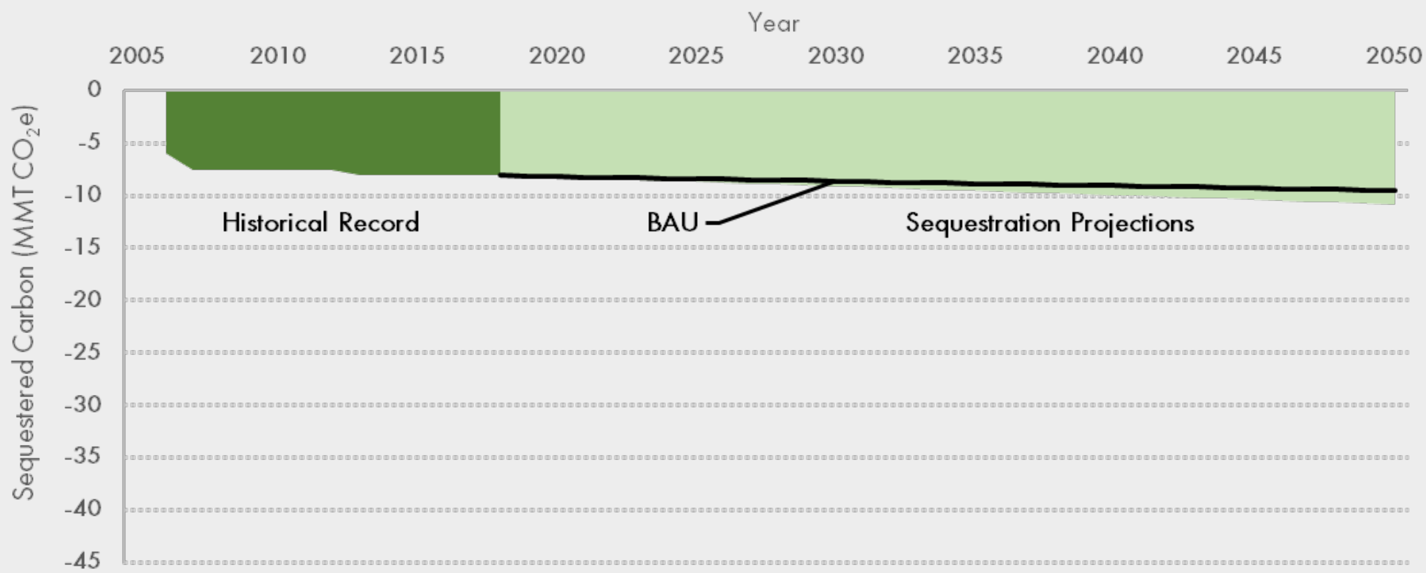
## CARBON SEQUESTRATION

Natural carbon sinks are an important component of New Jersey's GHG inventory and management system. Removal of carbon from the atmosphere and storing it in natural sinks, a process referred to as carbon sequestration, can help to offset existing emissions. New Jersey's land sector sequestered the equivalent of 8.1 MMT $CO_2e$ (8% of New Jersey's net emissions) in 2018. During the nearly 30-year period from 1986 to 2015, DEP land cover data shows a loss of over 360,000 acres to development consisting mostly of agricultural lands, wetlands, forests and woodlands. Continued development of these natural resources will reduce the state's existing carbon sinks.

Carbon sequestration can be enhanced through improved land management practices, including managing forest health, promoting reforestation, restocking woodlands, growing cover crops, and introducing tidal flows back into salt marsh systems. New Jersey must also protect its existing carbon pools by taking action to avoid the loss of natural lands, preserve marsh migration pathways, and defend existing carbon sinks from the dangers of wildlife, disease, pests and inundation.

Collectively, DEP projects that strategies to conserve and protect the state's natural carbon sinks could increase carbon sequestration up to 33% to 10.8 MMT $CO_2e$ by 2050 (Figure ES.14). This optimistic projection, however, would require the use of all currently available open space for sequestration, requiring a major transition in New Jersey's current land use laws and practices. To better inform sequestration and related land use planning, a statewide carbon sequestration plan is needed to establish a 2030 and 2050 target for carbon sequestration and identify priority actions for achieving this goal. Program and policy changes, such as the creation of a privately held woodlands and forest conservation program and expansion of urban and community forestry programs could be primary components of a sequestration plan. These efforts could also be enhanced through legislative initiatives to minimize forest loss during land development by making forest identification and protection an integral part of the site planning process.

***Figure ES.14: Historical Sequestration Data & Projected Pathway to 2050 (MMT $CO_2e$).***
*Natural sinks remove climate pollutants from the air, lowering the state's net emissions. Protecting and maintaining these sinks is vital to achieving the 80x50 goal.*



The following strategies would protect and enhance New Jersey's natural ability to sequester carbon, furthering the state's progress in meeting the 80x50 goal:

1. Develop a statewide carbon sequestration plan that establishes a 2030 and 2050 target for both blue carbon and terrestrial carbon sequestration.
2. Develop and adopt minimum forest cover objectives for land development, including requirements for forest stand delineations and implementation of forest conservation plans.
3. Develop a conservation program for privately held woodlands and forests.
4. Expand the Urban and Community Forestry program by increasing accreditation for all municipalities and boards of education.
5. Provide additional incentives and technical tools to assist communities in forestry management and climate friendly agricultural practices.
6. Monitor sequestration results of current pilot blue carbon projects and utilize data to inform future project selection criteria.

## CONCLUSION

New Jersey can meet its goal of reducing GHG emissions to 80% below 2006 levels by 2050—protecting our people, economy, and environment from the worsening impacts of climate change to which our state is uniquely vulnerable. Reaching our 80x50 goal requires planning and collaboration across all economic sectors, levels of government, political boundaries, and administrations, all fixed on a carbon neutral future. Achieving this goal depends upon a swift and decisive transition away from our reliance on fossil fuels, accomplished through adaptive policies that also ensure reliability and remain responsive to the scope and pace of efforts to electrify the transportation and building sectors while expanding renewable energy sources. However, only by working in concert across time and economic sectors can we implement the long-term, structural changes to how we generate and use energy, build our homes and businesses, operate our industries, develop and preserve our land, grow our food, manage our waste, and transport our people and products.

The following chapters assess New Jersey's GHG reduction progress by emissions sector and provides recommendations for how we can continue this important work together in the years to come. While these recommendations are not intended to be exhaustive, they represent the latest thinking of the New Jersey Department of Environmental Protection, whose people and programs remain committed to reducing and responding to climate change as a core component of the Department's mission of protecting public health and the environment.

# WORKS CITED

Kopp, R. C. (2019). *New Jersey's Rising Seas and Changing Coastal Storms: Report of the 2019 Science and Technical Advisory Panel.* Trenton, New Jersey: Rutgers, The State University of New Jersey. Prepared for the New Jersey Department of Environmental Protection.

Optimal Energy. (2019). *Energy Efficiency Potential in New Jersey.* New Jersey Board of Public Utilities. Retrieved from https://s3.amazonaws.com/CandI/NJ+EE+Potential+Report+-+FINAL+with+App+A-H+-+5.24.19.pdf

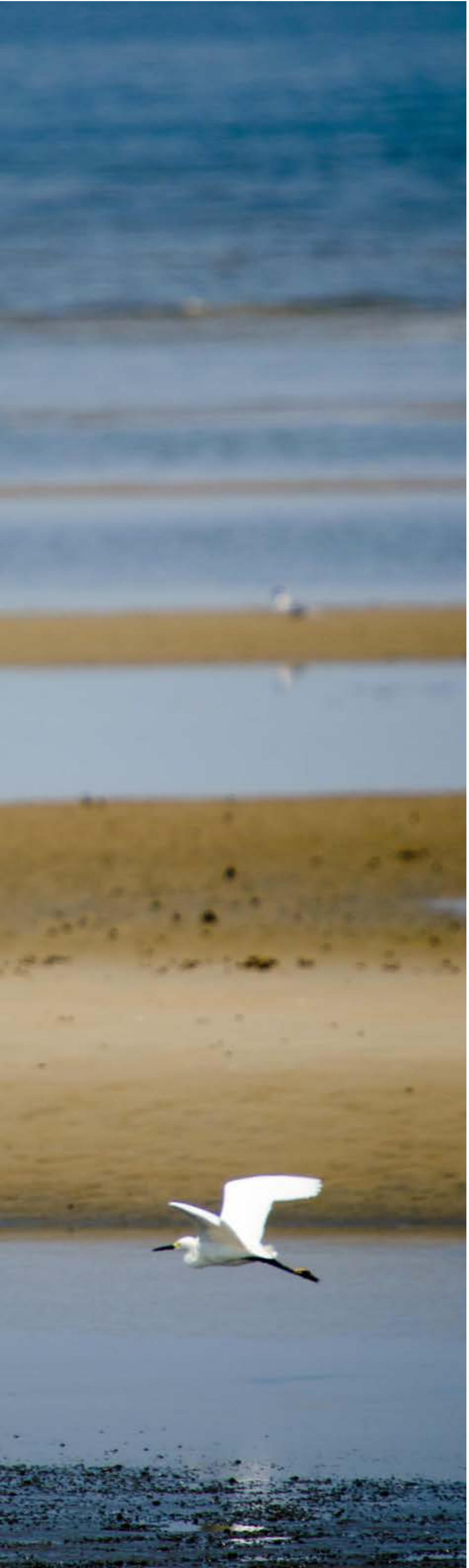
P.L. 2007 c.112; P.L. 2018 c.197. (2018). *Global Warming Response Act.* Retrieved from https://lis.njleg.state.nj.us/nxt/gateway.dll?f=templates&fn=default.htm&vid=Publish:10.1048/Enu

P.L. 2019 c.362. (2020). *An Act Concerning the Use of Plug-In Vehicles.* Retrieved from State of New Jersey: https://www.njleg.state.nj.us/2018/Bills/PL19/362_.HTM

# TABLE OF CONTENTS

# INTRODUCTION

*Source: Steve Jacobus*



## BACKGROUND

Climate change is the defining issue of our time. The actions that policy- and decision-makers in New Jersey state government take, or fail to take, will affect the future of our state, country and world in profound ways. Climate scientists agree that global warming trends and other shifts in the climate system observed over the past century are caused by human activities, specifically the emissions of heat-trapping greenhouse gases (GHG) from fossil fuel production and combustion, deforestation and land degradation. Further, the consequences of climate change make clear the urgency of decarbonizing our economy so as to protect and improve upon the quality of life of all New Jerseyans.

Due to its geography, population, and other factors, New Jersey is especially vulnerable to the adverse impacts of climate change. In distilling the most current climate science and its particular relevance to the Garden State, the 2020 New Jersey Scientific Report on Climate Change explains the worsening impacts to our state under low-, moderate-, and high-emission scenarios (NJDEP, 2020). Key findings of the report underline the urgency of this report, and the need for concerted action across all levels of government:

- New Jersey is warming faster than the rest of the Northeast region and the world. Since 1895, New Jersey's annual temperature has increased by 3.5° F.
- Annual precipitation in New Jersey is expected to increase by 4% to 11% by 2050.
- Sea-levels are rising at a greater rate in New Jersey than other parts of the world.
- New Jersey is likely to experience sea-level rise by as much as 1.1 feet by the year 2030 and 2.1 feet by the year 2050 due to climate pollutants we have already emitted.
- Sea-levels could rise by as much as 5.1 feet by the year 2100 and 8.3 feet by the year 2150 under a moderate emissions scenario.
- New Jersey's billion-dollar commercial fishing industry—the fifth largest in the country—will be adversely impacted by increased ocean acidification and "dead zones" from hypoxic events
- The effects of climate change are likely to contribute to an increase in air pollution, lead to increased respiratory and cardiovascular health problems, like asthma and hay fever, and a greater number of premature deaths.
- Water supplies will be stressed from the increase in the growing season and extreme temperatures expected due to climate change.
- New Jersey could become unsuitable for one of our greatest exports—blueberries—by the middle of this century.

- The frequency and intensity of harmful algal blooms are likely to increase, disrupting swimming and fishing in NJ's lakes, and posing risks to drinking water reservoirs.
- Wildfire seasons could be lengthened, and the frequency of large fires increased due to the hot, dry periods that will result from increased temperatures.
- New Jersey could even loose its state bird—the American Goldfinch—as it may become too hot for the species to nest here.

Fortunately, New Jersey's leadership has recognized the need for bold action to address climate change. In July 2019, Governor Murphy signed into law amendments to the Global Warming Response Act (GWRA) reaffirming New Jersey's commitment to climate action. First passed in 2007 and since amended to enhance the state's response, the GWRA introduced a fixed goal of reducing GHG emissions by 80% from their 2006 levels by 2050. Today, state policies directed at reducing climate impacts revolve around this "80x50" objective. Included among the mandates of the GWRA,

> *"The department [DEP], in consultation with the Board of Public Utilities and any other state agencies, as appropriate, shall prepare a report recommending the measures necessary to reduce greenhouse gas emissions, including short-lived climate pollutants, to achieve the 2050 limit. The report shall include specific recommendations for legislative and regulatory action that will be necessary to achieve the 2050 limit and any established interim benchmarks." (N.J.S.A. 16:2C-42.6.c)*

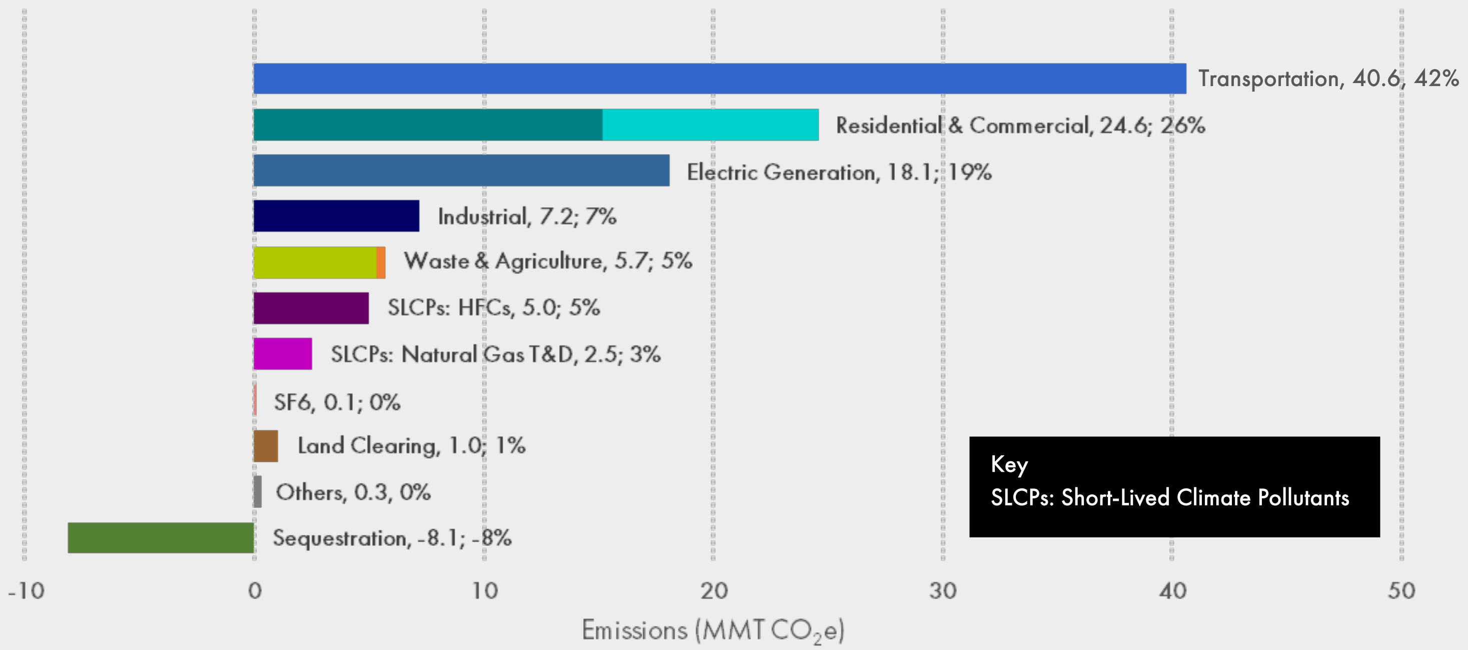
This "80x50 Report" was created in response to this mandate and integrates and builds upon efforts already underway to reduce the state's GHG emissions. Indeed, the last two years has seen many climate policy accomplishments. Enhancements to the state's longstanding support for solar and offshore wind have been adopted (P.L. 2018, c.17, 2018; EO-92, 2019). Detailed computer modeling of energy use, a pathway for reaching the 80x50 goal at lowest cost, and a comprehensive proposal for transforming how electricity is generated and used in the state were presented in the 2019 Energy Master Plan (2019 EMP) (NJBPU, 2020). Cross-jurisdictional cooperation by way of the Regional Greenhouse Gas Initiative, United States Climate Alliance, Zero Emissions Vehicle Alliance, and other organizations has multiplied the effectiveness of New Jersey's policies (NESCAUM, 2018; P.L. 2019 c.328, 2019; USCA, 2018). And, considerations directed specifically at improving the lives of the state's most vulnerable communities now represent core elements of the state's initiatives at multiple levels (EO-23, 2018; NJBPU, 2020; 51 NJR 232, 2019). Many other regulatory and statutory efforts have been proposed and adopted, all directed at facilitating the state's response to climate change. However, as this report will present in more detail, these important policy gains are by themselves not sufficient for New Jersey to meet its 80x50 goal.

This report builds on these previous efforts and as stated at the launch of the 2019 EMP, serves as the third element of a comprehensive plan that evaluates New Jersey's GHG emissions from both energy and non-energy systems, providing guidance, policies, and regulatory and legislative recommendations to meet our GHG emission reduction goals. The calculations presented here are intended to provide comparisons of policy alternatives to understand where the greatest gains could be realized and are not intended to represent precise estimates of future emissions. Almost every topic reviewed could itself be the subject of deep investigation and more exhaustive appraisal. Such efforts would take considerable time, and yet, would not alter this report's recommendations. This report therefore seeks to initiate action without introducing further delay. Rather, this report recommends that individual, sector-specific topics be selected for future study where additional details are needed during the legislative, regulatory and policy development that this report seeks to facilitate. Meanwhile, the DEP intends to release an updated report every three years so that emissions reduction recommendations may be continually reassessed, remodeled, and reprioritized as early objectives are achieved and newly emerging pathways mature.

## Sources of Greenhouse Gases in New Jersey

Emissions of GHGs are documented in the New Jersey Statewide Greenhouse Gas Inventory Report, prepared every two years pursuant to the mandate of the GWRA. The most recent report estimated emissions for 2016 and developed projections for 2017 and 2018.[1] Net emissions for 2018 were estimated to be 97.0 million metric tons (MMT) of carbon dioxide equivalent ($CO_2e$).[2] As shown in Figure 1, transportation dominated the state's emissions profile at 40.6 MMT $CO_2e$, which is 42% of the net total. Electric generation, residential, commercial and the industrial sectors rounded out the top five. Combined, these categories added 90.5 MMT $CO_2e$ to the atmosphere, or 93% of the state's total net emissions. Other sources contributed 14.6 MMT $CO_2e$ while sequestration removed 8.1 MMT $CO_2e$ (Figure 1).

***Figure 1. New Jersey GHG Emission Inventory for 2018 (MMT $CO_2e$ and Percentage).***
*Opportunities for emissions reductions are present in each of the categories.*



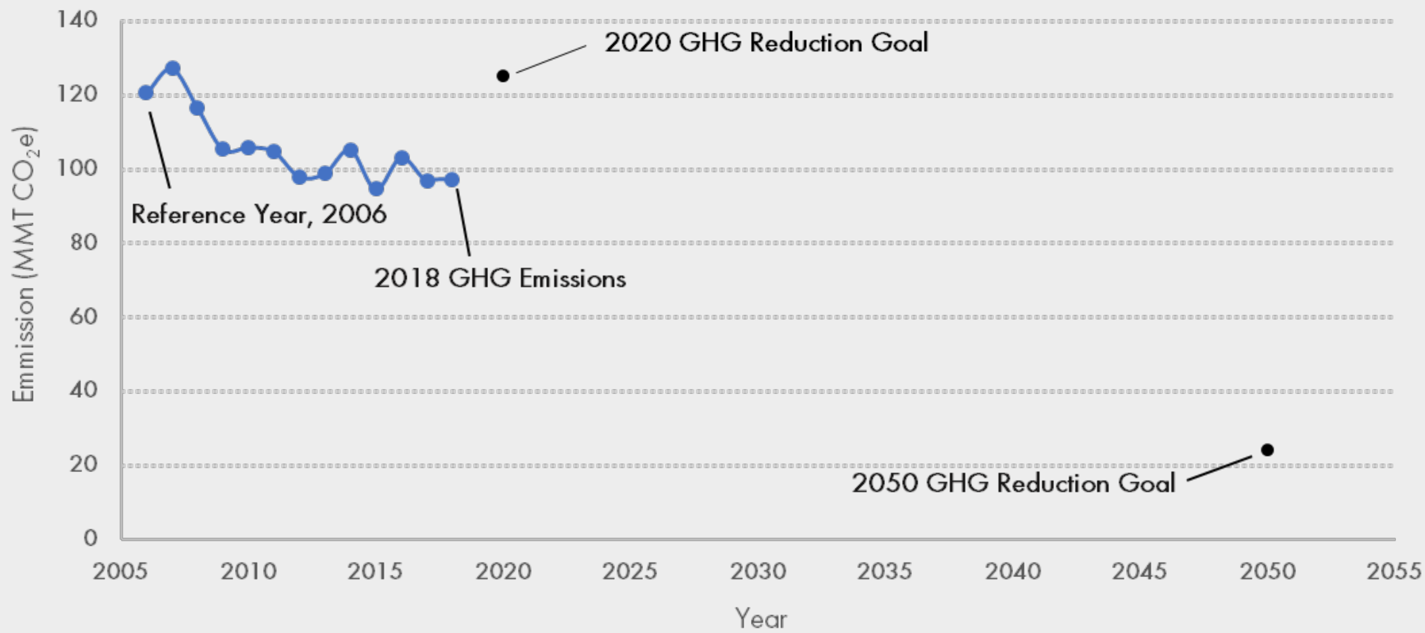

For the baseline year of 2006, net emissions totaled 120.6 MMT $CO_2e$, setting the 80x50 goal at a maximum net emissions rate of 24.1 MMT $CO_2e$ by 2050 (Figure 2). Achieving this emission limit will require transformation across all corners of New Jersey's economy from electric generation, buildings, transportation, waste management, and land use.

[1] The US Energy Information Agency data used to prepare the State Inventory Reports is released 18 months after the end of the calendar year for which it applies, and additional time may be taken by USEPA to incorporate that data into emissions assessment tools. To avoid delays, New Jersey prepares emissions projections for years where federal data is not yet available and then revises those figures based on final data during subsequent inventory assessments.

[2] Various gases in addition to carbon dioxide contribute to global warming, and each behaves differently in the atmosphere. Carbon dioxide equivalent, or $CO_2e$, puts each gas on an equal footing so the effects of different gases can be directly compared. For a given gas, the mass is multiplied by its Global Warming Potential (GWP), a factor representing how many times stronger the gas is in terms of warming compared to carbon dioxide. Different gases persist in the atmosphere for different lengths of time, so GWP values have specific time frames associated with them; when adding $CO_2e$ values together in a unified inventory, all gases must be measured across the same time duration. Many institutions and organizations, including the United States Environmental Protection Agency, utilize the 100-year GWP values from the International Panel on Climate Change (IPCC) Fourth Assessment (2007) ("AR4"). Accordingly, New Jersey's 2018 Statewide Greenhouse Gas Emissions Inventory Report utilizes AR4 GWP values. For consistency with the AR4 and 2018 inventory, estimates in this report utilize the same GWP values, based upon a 100-year time horizon. Additional discussion is provided where applicable throughout this report. The authors acknowledge that recent legislation (P.L. 2019, c. 319) requires that the state consider a 20-year time horizon when assessing the global warming impact of a greenhouse gases and current IPCC criteria (which utilizes the 100-year time horizon). As this legislation was enacted after completion of the 2018 inventory upon which calculations in this report and the 2019 Energy Master Plan are based, DEP has utilized the 100-year time horizon throughout this report and intends to perform the 20-year time horizon assessment in future inventories. DEP anticipates that future inventories will include assessments based upon both time horizons and subsequent updates to this report will be based upon the inventory results.

*Figure 2. New Jersey GHG Emission Reduction Targets.*

*The GWRA established both a 2020 and 2050 GHG reduction goal for the state. The 2020 target required the state to reduce its GHG emissions to the 1990 level or below by 2020, New Jersey has exceeded this goal by more than 20 MMT $CO_2e$. The 2050 goal (referred to as "80x50") is much more ambitious and will require coordinated action across all sectors of the economy.*




## Structure of the GWRA 2050 Report

The chapters in this report are broadly aligned with sector categories as defined by the US Energy Information Agency (USEIA) (USEIA, 2020). However, because the mission of the USEIA centers on energy production and use, not climate impact, a number of important greenhouse pollutants are discussed as separate topics or are otherwise incorporated into related chapters. Examples include short-lived climate pollutants (SLCPs) such as refrigerant gases, which are covered in the Short-Lived Climate Pollutants Chapter; and agricultural soil management practices, which are covered in the Waste and Agriculture Chapter.

The arrangement of topics also differs from how an emissions source is addressed in governing regulations. Notably, construction equipment that uses diesel fuel is categorized by the USEIA as belonging to the industrial sector, but within the regulatory sphere it is often considered with mobile sources like diesel trucks. For the most part, construction equipment is included in the industrial sector within the 80x50 report, but black carbon emissions are addressed separately in the SLCP Chapter. The list below briefly summarizes the topics covered in each chapter.

**Transportation**: Includes emissions from on-road and non-road transportation. Non-road transportation includes locomotives, marine transport, and aviation, but does not include construction equipment or commercial warehouse equipment like forklifts.

**Electric Generation**: Includes emissions from grid supplied electric generation. Emissions from distributed electric generation is included with the host site and or facility in the Industrial and Commercial Chapters.

**Residential and Commercial**: Includes emissions associated with structures such as homes, apartment buildings, stores, and warehouses. Also included are emissions from activities that take place within or around these structures, for example forklifts at warehouses. Energy consuming activities associated with water treatment are included in the commercial sector. However, non-energy emissions from wastewater treatment is addressed in the Waste and Agriculture Chapter.

**Industrial Sector**: Includes manufacturing and creation of marketable products, including petroleum refining. Agricultural energy consumption, for example powering tractors and irrigation pumps, is included here. However, release of climate pollutants from soil is discussed in the Waste and Agriculture Chapter, and sequestration of carbon in soils is discussed in the Carbon Sequestration chapter. Gaseous emissions from non-road construction equipment are included, but black carbon is discussed in the SLCP Chapter.

**Waste and Agriculture**: Includes solid waste management, wastewater treatment, and those agricultural emissions associated with soil management, manure management, and enteric fermentation.

**Short-Lived Climate Pollutants**: Includes emissions associated with halogenated gases, methane from natural gas transmission and distribution, and black carbon.

**Carbon Sequestration**: Considers incorporation of atmospheric carbon into agricultural croplands and grasslands, forests, wetlands, salt marshes, and developed lands.

### *Reference Cases and "Business-as-Usual" Conditions*

Throughout the 80x50 report each emission sector presents a set of conditions as a baseline representing what might happen if no action were taken, or if only a limited range of actions were pursued. These reference cases are frequently referred to as "Business-as-Usual" conditions. It should be noted that these are only hypothetical circumstances chosen to highlight the alternatives being examined. As discussed in the individual chapters, some of these reference cases were designed to parallel those in the 2019 EMP, while others were based on current trajectories and policies. There is no one single "Business-as-Usual" set of conditions, and the reference cases do not represent certainties were there were no legislative, regulatory, or policy intervention.

### *Emissions Reduction Pathways and Recommendations*

The 80x50 report compares policy alternatives within each sector chapter, referred to as emissions reduction pathways. This serves to identify the most effective strategies for emissions reductions and, where practicable, estimate potential reductions through 2050. It is important to note that the methodology used in these estimates varied by sector and availability of data. The energy consuming sectors relied on 2019 EMP modeling outputs developed by the Rocky Mountain Institute. The non-energy sectors utilized various tools and techniques to quantify potential emissions reductions. Like the Business-as-Usual baseline, these pathways do not represent certainties, and are intended only to provide policy makers with emission reduction scenarios to pertinent to their evaluations of legislative, regulatory, and policy initiatives.

Finally, achieving the scale of emission reductions called for in the GWRA will require continuous adaptive management as new technologies, and societal changes occur over the next thirty years. The recommendations proposed in the following chapters are not intended as the final word on how to achieve New Jersey's 80x50 goal but are meant to inform the immediate next steps that should be urgently undertaken to transform each sector.

# WORKS CITED

51 NJR 232. (2019). *Board of Public Utilities Community Solar Energy Pilot Program Rules (N.J.A.C. 14:8-9).* Retrieved from NJ Clean Energy: https://www.njcleanenergy.com/files/file/R_2019%20d_021%20(51%20N_J_R_%20232(a)).pdf

EO-23. (2018, April 18). *Environmental Justice Issues in New Jersey's Urban Communities.* Retrieved from State of New Jersey: https://nj.gov/infobank/eo/056murphy/pdf/EO-23.pdf

EO-92. (2019). *Murphy Executive Order 92, Expansion of Offshore Wind Capacity to 7500 MW by 2035.* Retrieved from State of New Jersey: https://nj.gov/infobank/eo/056murphy/pdf/EO-92.pdf

NESCAUM. (2018). *Multi-State ZEV Action Plan 2018-2021.* Retrieved from http://www.nescaum.org/documents/2018-zev-action-plan.pdf/

NJBPU. (2019). *2019 New Jersey Energy Master Plan, Pathway to 2050.* Trenton, NJ: State of New Jersey.

NJDEP. (2020). *New Jersey Scientific Report on Climate Change.* Trenton, NJ. Retrieved from https://www.nj.gov/dep/climatechange/docs/nj-scientific-report-2020.pdf

P.L. 2007 c.112; P.L. 2018 c.197. (2018). *Global Warming Response Act.* Retrieved from https://lis.njleg.state.nj.us/nxt/gateway.dll?f=templates&fn=default.htm&vid=Publish:10.1048/Enu

P.L. 2018, c.17. (2018). *Clean Energy Act.* Retrieved from https://www.njleg.state.nj.us/2018/Bills/PL18/17_.PDF

P.L. 2019 c.328. (2019). *An Act Concerning Greenhouse Gas Emissions (RGGI), Amending P.L. 2007, c.340.* Retrieved from https://www.njleg.state.nj.us/2018/Bills/PL19/328_.PDF

USCA. (2018, February 22). *New Jersey Governor Phil Murphy Joins U.S. Climate Alliance (Press Release).* Retrieved from United States Climate Alliance: http://www.usclimatealliance.org/publications/2018/2/22/new-jersey-governor-phil-murphy-joins-us-climate-alliance

USEIA. (2020). *Glossary: Energy-Use Sector.* Retrieved August 10, 2020, from https://www.eia.gov/tools/glossary/index.php?id=E#en_use_sector

CHAPTER 1

# TRANSPORTATION

## TRANSPORTATION SECTOR SNAPSHOT

### 2018 EMISSIONS DATA

- The transportation sector emitted **40.6 MMT $CO_2$e** in 2018.

### EMISSIONS ACTIVITIES

New Jersey's transportation sector emissions come from land, air, and sea and were 42% of New Jersey's net total emissions in 2018.

### GHGs OF CONCERN

- Carbon Dioxide ($CO_2$)
- Nitrous Oxide ($N_2O$)

### EMISSIONS REDUCTION PATHWAYS

1. Electrify Light Duty Vehicles
2. Decarbonize medium- and heavy-duty vehicles
3. Increase NJ Transit ridership and expansion of transit villages
4. Incentivize work-from-home policies, ridesharing, home delivery and other strategies
5. Support regional and national efforts to improve fuel economy of light-duty fossil-fuel powered new vehicles sales

### RECOMMENDATIONS

1. Implement legislative, regulatory and programmatic reforms to facilitate a rapid and complete transition away from fossil-powered vehicles, ensuring average adoption rates of at least 111,000 new electric vehicles annually through 2025 with continued increasing adoption rates until all new sales of light-duty cars, SUVs, and trucks are electric by 2035.
2. Implement a long-term infrastructure program dedicated to constructing a statewide electric vehicle charging network.
3. Develop incentives for county and local governments to lead by example by electrifying their vehicle fleets.
4. Identify funding and financing mechanisms to convert medium- and heavy-duty vehicles to electric.
5. Pursue increased ridership on NJ Transit, expansion of transit villages and work-from-home policies to reduce vehicle miles traveled.

### AGENCY STAKEHOLDERS

- New Jersey Board of Public Utilities
- New Jersey Department of Community Affairs
- New Jersey Economic Development Authority
- New Jersey Department of Environmental Protection
- New Jersey Department of Transportation
- New Jersey Transit
- New Jersey Department of Treasury
- New Jersey Motor Vehicle Commission



# OVERVIEW

The transportation sector is comprised of on-road motor vehicles such as light-duty cars, trucks and sports utility vehicles (SUVs), and medium- and heavy-duty vehicles used for commercial operations such as buses, goods transport and delivery services. It also includes non-road modes of transportation such as trains, boats, and airplanes.[1] Construction equipment such as backhoes and cranes, and materials handling equipment such as forklifts at warehouses, are not, strictly speaking, modes of transportation and are therefore considered as sources of industrial and commercial emissions. Carbon dioxide ($CO_2$) is the primary climate pollutant of concern from transportation.[2]

The transportation sector, the largest source of New Jersey's greenhouse gas (GHG) emissions, must be the foremost focus of efforts to reduce emissions. To achieve the 80x50 goal, the New Jersey Department of Environmental Protection (DEP) estimated emission reductions based on the vehicle adoption rates outlined in the 2019 Energy Master Plan (2019 EMP), and projects that transportation emissions must be reduced by 87%, to 5.4 MMT $CO_2e$ by 2050. Achieving these emissions reductions is predicated on decarbonizing electric generation. In the absence of the emissions reductions discussed in the Electric Generation Chapter, realized by the deployment of renewable energy, the net emissions reductions projected from transportation will be much less. This is compounded by the significant increase in electric demand that will result from the electrification of transportation and the building sector. The 2019 EMP modeled an increase in New Jersey's electric demand from the current 75 GWh to 168 GWh by 2050.

Currently, gasoline-fueled vehicles account for over 70% of the transportation sector's emissions. The 2019 EMP least cost scenario modeling, which assumed a fifteen year lifecycle, calculated that 88% of new light-duty vehicle sales (passenger cars, SUVs and light-duty trucks) will need to be battery electric or hydrogen-powered by 2030, rising to 100% by 2035, in order to achieve the 80x50 goal. This strategy coupled with complementary social strategies, such as working from home and the growth of livable, walkable communities, reduce the need for transportation, ensuring the New Jersey can significantly reduce its emissions profile.

[1] Emissions from aviation and marine are a small contributor to the inventory and are influenced by a broader market and subject to interstate commerce laws. In-state purchase data for jet and marine residual fuels reported to the United States Energy Information Agency are not closely linked to in-state emissions. As a result, New Jersey uses approximations as described in the New Jersey GHG Inventory Reports to estimate these components (NJDEP, 2008; NJDEP, 2009). Emission reduction strategies for these modes of transportation are not investigated in this report.
[2] Nitrous oxides, although present in very small quantities, are not addressed in this chapter. Further, black carbon is recognized as an important climate pollutant related to transportation and is addressed in the Short-Lived Climate Pollutants Chapter of this report.

## WHERE WE STAND

Each mode of transportation has different characteristics that determine how climate emissions are estimated. With respect to on-road transportation, New Jersey used the United State Environmental Protection Agency (USEPA) MOVES model (USEPA, 2014) to calculate emissions for its most recent GHG inventories (2016-2018). MOVES uses information on fleet composition, vehicle miles traveled, and fuel efficiency to calculate highly detailed assessments of GHG, on-road black carbon and conventional air pollutants. For estimates prior to 2016, New Jersey used fuel consumption data from the United States Energy Information Agency (USEIA) to estimate on-road emissions, which only allowed for broad categorization by fuel type. Previously-published results from this older fuel-based method were slightly higher (typically about 11%) than estimates based on MOVES. Data presented here for 2006, 2016, 2017 and 2018 is based directly on MOVES output. Data for years 2007-2015 were adjusted by 11% for consistency with the MOVES methodology.

Contributions from New Jersey's transportation sector dominate the state's overall emissions profile. For 2018, the sector is estimated to have released 40.6 million metric tons (MMT) of $CO_2e$.[3] This represented about 42% of the state's net emissions of 97.0 MMT (NJDEP, 2019). Proportionally, this percentage is higher than in most other states, because a large portion of New Jersey's electric generation is comprised of carbon free nuclear energy and efficient combined cycle natural gas plants. The steadily growing development of solar photovoltaic electricity has made the state's electricity sector even cleaner.

Historical estimates (Table 1.1 and Figure 1.1) show a very slight downward trend in transportation emissions since 2006, largely attributable to modest reductions from on-road gasoline-powered vehicles. In 2018, on-road gasoline accounted for 72% of the state's transportation-related emissions (Figure 1.2). Distillate fuel, which is largely on-road diesel, contributed an additional 19%. These two fuels are therefore responsible for 91% of the sector's total emissions. Residual fuel, which consists of the heavy petroleum products left over after distillation (that is, after removal of gasoline and diesel), contributed about 5%. Jet fuel contributed 2%.

***In 2018, the Transportation sector was estimated to release 40.6 million metric tons of $CO_2e$. This represents 42% of New Jersey's net emissions***

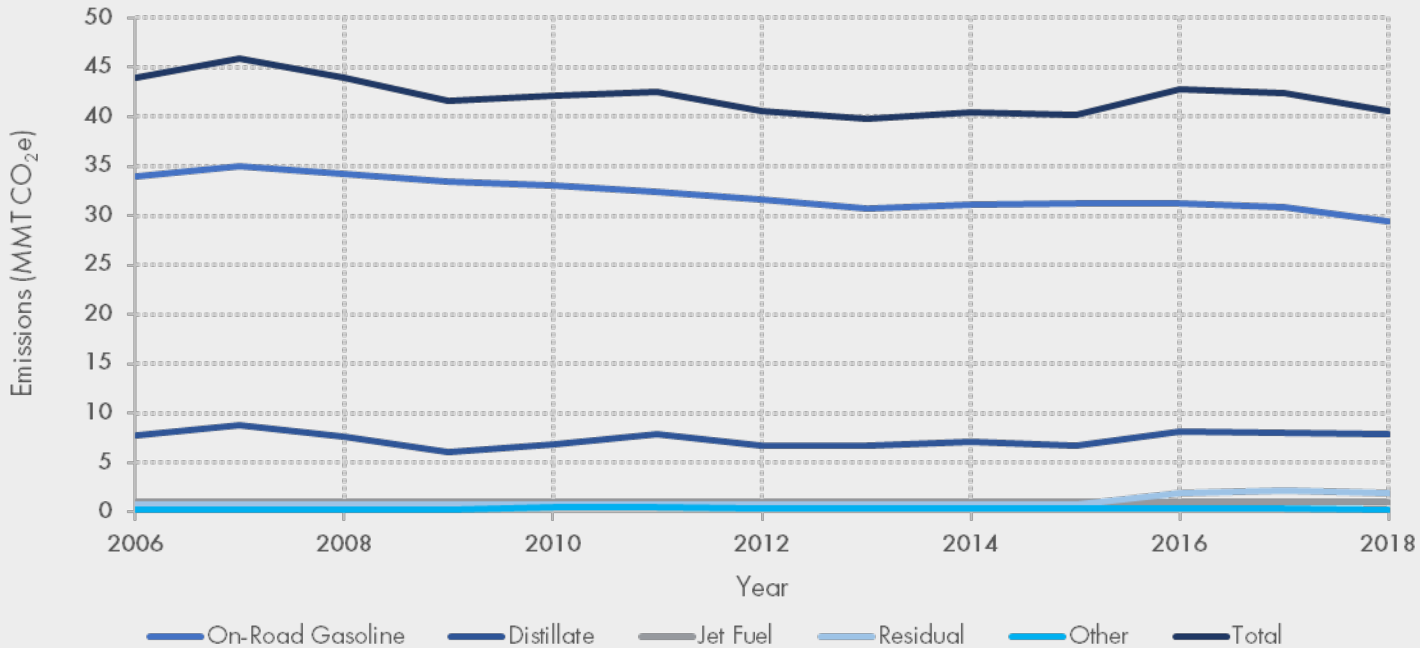
***Table 1.1. Annual Transportation Sector Greenhouse Gas Emissions 2006 – 2018 (MMT $CO_2e$).***

| 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 43.9 | 45.9 | 44.0 | 41.7 | 42.2 | 42.6 | 40.6 | 39.8 | 40.5 | 40.2 | 42.8 | 42.4 | 40.6 |

[3] $CO_2e$ stands for carbon dioxide equivalent, which also accounts for the effects of related gases such as methane and nitrous oxide.

***Figure 1.1. Historical Emissions from New Jersey's Transportation Sector, by Fuel Type.***

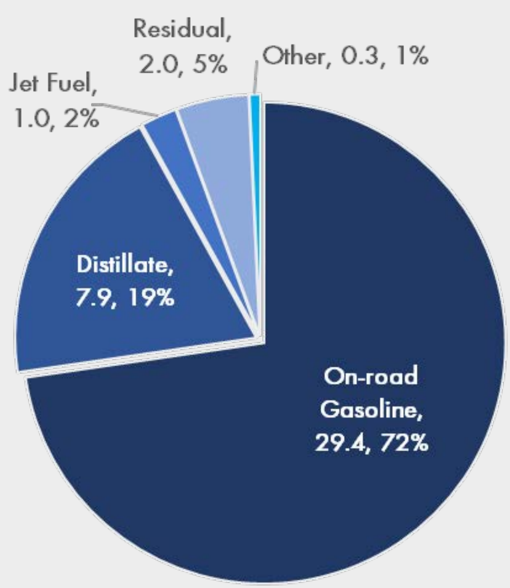
*Emission from the transportation sector have decreased by about 8% since 2006, due primarily to modest reductions in on-road gasoline consumption.*




On closer inspection, 86% of vehicle miles traveled (VMT) arose from just two vehicle types: gasoline-powered light-duty trucks, such as pickups and SUVs, and gasoline-powered passenger cars (Figure 1.3). Combined, these two modes of transport accounted for 72% of on-road emissions, or about 27 MMT $CO_2e$ (Figure 1.4). Commercial trucks[4] contributed 18.6% of on road emissions while only making up 5.9% of vehicle miles traveled (Table 1.2).

***Figure 1.2. 2018 NJ Transportation Emissions by Fuel Type (MMT $CO_2e$ and Percent).***

*On-road gasoline represents the greatest source of emissions in the transportation sector, with distillates (mostly on-road diesel) also making a sizeable contribution. Together, these two fuels account for about 91% of the sector's emissions.*




[4] The Commercial truck category includes the following: Gas Single Unit Short-Haul Truck, Gas Single Unit Long-Haul Truck and Gas Combination Short-Haul Trucks, Diesel Combination Short-Haul Truck, Diesel Combination Long-Haul Truck, Diesel Single Unit Short Haul, and Diesel Single Unit Long Haul.

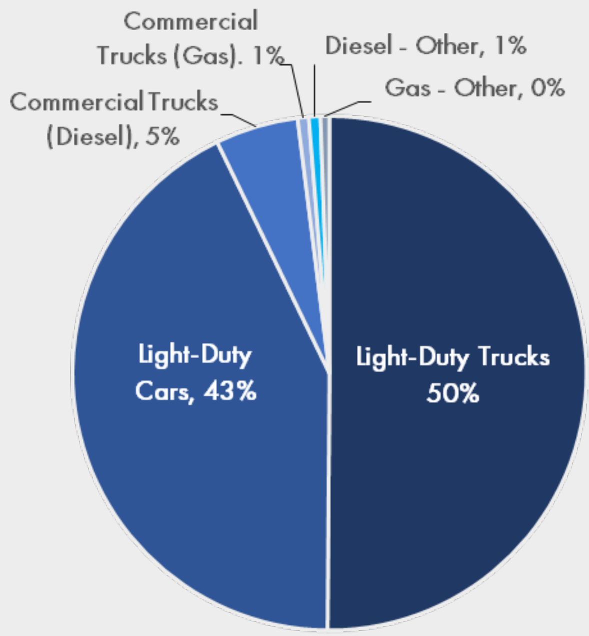



*Figure 1.3. 2018 Vehicle Miles Traveled (77.7 billion miles total).*
*Passenger cars and light-duty trucks together accounted for 93% of roadway miles traveled in the state. The light-duty truck category in this Figure includes light-duty commercial trucks.*

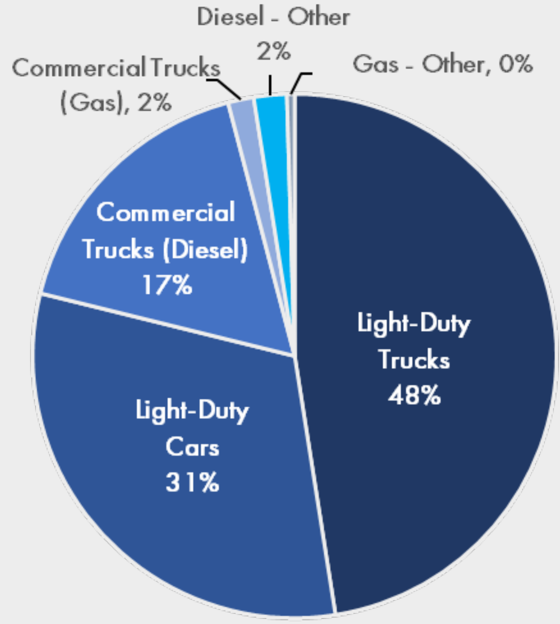



*Figure 1.4. 2018 On-Road Emissions by Vehicle Category (37.8 MMT $CO_2e$ total).*
*Passenger cars and light-duty trucks together emitted 79% of the greenhouse gases that come from on-road vehicles. The light duty truck category in this Figure includes light-duty commercial trucks.*

*Table 1.2. Estimated New Jersey On-Road Emissions for 2018 (USEPA MOVES Model Output).*[5]
*The MOVES model provides detailed estimates of emissions for a wide range of on-road vehicles. Motor vehicles using fuel that is 85% ethanol (E-85) are included in the estimates for gasoline vehicles, while vehicles using compressed natural gas (CNG) are included in the diesel estimates. Vehicles using E-85 and CNG only account for about 0.6% of total on-road emissions.*

| OVERALL GAS AND DIESEL CONSUMPTION | | | | |
|---|---|---|---|---|
| Fuel Type | $CO_2e$ Metric Tons | VMT | Percent Total of Emissions | |
| Gasoline | 29,735,766 | 71,483,253,632 | 78.6% | |
| Diesel Fuel | 7,897,614 | 5,779,762,367 | 20.9% | |
| E-85 | 175,436 | 426,480,144 | 0.46% | |
| CNG | 35,510 | 24,813,914 | 0.094% | |
| | | | | |
| **Gas + Diesel Total** | **37,844,326** | **77,714,310,057** | **100%** | |
| **BREAKDOWN BY VEHICLE TYPE** | | | | |
| Gasoline Vehicles | $CO_2e$ Metric Tons | VMT | Emissions As % Of Gas + Diesel Total | VMT As % Of Gas + Diesel Total |
| Passenger Truck | 15,545,598 | 34,048,028,358 | 41.1% | 43.81% |
| Passenger Car | 11,759,410 | 32,872,317,445 | 31.1% | 42.30% |
| Light Commercial Truck | 1,827,632 | 4,012,583,065 | 4.8% | 5.16% |
| Single Unit Short-Haul Truck | 591,024 | 532,758,833 | 1.6% | 0.69% |

[5] This Table does not include off-road modes of transport such as rail, aviation and marine.

| | | | | |
|---|---|---|---|---|
| Motorcycle | 160,639 | 420,627,305 | 0.42% | 0.54% |
| Motor Home | 10,404 | 9,403,258 | 0.027% | 0.012% |
| Single Unit Long-Haul Truck | 8,883 | 7,900,963 | 0.023% | 0.010% |
| Transit Bus | 4,082 | 3,178,315 | 0.011% | 0.004% |
| School Bus | 1,989 | 2,073,016 | 0.005% | 0.003% |
| Refuse Truck | 1,448 | 811,136 | 0.004% | 0.0010% |
| Combination Short-Haul Truck | 93 | 52,082 | 0.0002% | 0.00007% |
| | | | | |
| **Gasoline Total** | **29,911,202** | **71,909,733,776** | **79%** | **92.5%** |
| Diesel Vehicles | $CO_2e$ Metric Tons | VMT | Emissions As % Of Gas + Diesel Total | VMT As % Of Gas + Diesel Total |
| Combination Long-Haul Truck | 3,231,379 | 1,593,899,633 | 8.54% | 2.05% |
| Combination Short-Haul Truck | 1,416,286 | 811,961,488 | 3.74% | 1.04% |
| Single Unit Short-Haul Truck | 1,321,452 | 1,186,672,385 | 3.49% | 1.53% |
| Single Unit Long-Haul Truck | 487,690 | 461,397,139 | 1.29% | 0.59% |
| Passenger Truck | 459,128 | 668,574,209 | 1.21% | 0.86% |
| Transit Bus | 237,961 | 179,509,342 | 0.63% | 0.23% |
| Intercity Bus | 205,244 | 113,081,138 | 0.54% | 0.15% |
| School Bus | 197,963 | 202,928,032 | 0.52% | 0.26% |
| Light Commercial Truck | 146,398 | 225,763,731 | 0.39% | 0.29% |
| Refuse Truck | 121,787 | 67,512,811 | 0.32% | 0.09% |
| Passenger Car | 100,904 | 287,030,657 | 0.27% | 0.37% |
| Motor Home | 6,932 | 6,245,716 | 0.018% | 0.008% |
| | | | | |
| **Diesel Total** | **7,933,124** | **5,804,576,281** | **21%** | **7.5%** |

## Existing Emissions Reduction Policies

Under the administration of Governor Phil Murphy, New Jersey has amplified its efforts to reduce emissions from the transportation sector, focusing on expanding electrification of in-state transportation and ensuring reciprocal build-out of electric vehicle (EV) charging infrastructure. State agencies are coordinating their efforts to pursue these goals in support of mass adoption.

### *Zero Emission Vehicle Program Memorandum of Understanding*

On May 3, 2018, Governor Phil Murphy signed the State Zero Emission Vehicle Program Memorandum of Understanding, formally committing New Jersey to join eight (now nine) other states to place a combined 3.3 million zero-emission vehicles (ZEV) on the road by 2025 (NESCAUM, 2018a). Collectively, the ten signatory states represent 27% of the United States auto market. Further, New Jersey participates in the multi-state ZEV Task Force, which contributed to the development of the ZEV Action Plan (NESCAUM, 2018b) and supports related initiatives such as electrification of medium- and heavy-duty trucks and buses (NESCAUM, 2019). New Jersey has also joined the International ZEV Alliance, a partnership of states and nations, including Norway, Germany, Canada, and the United Kingdom, that seeks to reduce global GHG emissions by one billion metric tonnes per year by 2050 (International ZEV Alliance, 2020).

### *Medium-and Heavy-Duty Memorandum of Understanding*

In July 2020, New Jersey signed onto a multi-state Memorandum of Understanding, committing to work collaboratively to advance and accelerate the market for electric medium- and heavy-duty vehicles. This effort establishes an interim target of 30% zero-emission vehicles sales by 2030 and 100% of all new medium-and heavy-duty vehicles sales be zero emission vehicles by 2050.

### *The Partnership to Plug In*

Achieving the state's electrification goals will rely on the Partnership to Plug In, a collaboration between the New Jersey Department of Environmental Protection (DEP), New Jersey Economic Development Authority (EDA), and New Jersey Board of Public Utilities (BPU) designed to encourage large scale adoption of electric vehicles, with goals to increase total registrations in New Jersey to 330,000 electric vehicles by 2025 (NJDEP, 2020a). Examples of activities undertaken by the program to date include providing support for charging infrastructure development and identifying strategic locations for fast charging stations. Establishing an attractive corporate environment for businesses working in the electric vehicle sector is also a core objective. "It Pay$ to Plug In" is a complementary grant program designed to offset the costs of installing charging equipment, with $7.6 million available now (NJDEP, 2020b).

### *Electric Vehicle Law, P.L. 2019, c.362*

In January 2020, the New Jersey Legislature intensified the state's electrification efforts by setting specific statutory goals for future adoption of plug-in battery-powered vehicles and plug-in hybrid electric vehicles under P.L. 2019 c.362, herein referred to as the Electric Vehicle Law (EV Law). Among the goals, by December 31, 2025, the total number of registered light-duty plug-in electric vehicles (including battery-only and plug-in hybrids) should reach 330,000 units, and by the end of 2035 two million will be registered. By the end of 2040, 85% of new light-duty vehicles sold in the state should be plug-in electrics. The law also sets targets for installation of charging infrastructure at public locations, multifamily residential properties, overnight lodging facilities and similar settings. The law further requires that 25% of state-owned, non-emergency light-duty vehicles be plug-in electrics or hybrids by the end of 2025, and 100% by the end of 2035. The law requires that the DEP submit a report to the Governor and Legislature by December 31, 2020, and every five years thereafter until 2040, reviewing the current state of the plug-in electric vehicle market and summarizing progress towards achieving these goals. The report may also make specific recommendations for legislative and regulatory action that will be useful in overcoming any identified challenges to meeting the goals. In addition to these structural considerations, the law also creates financial incentives to encourage purchases, and allocates certain proceeds from the state's participation in the Regional Greenhouse Gas Initiative (RGGI) towards meeting the state's electrification goals.

To place these objectives in perspective, the total number of registered electric vehicles as of December 2019 equaled just over 30,000 (0.48%) of New Jersey's 6.3 million registered light-duty vehicles. It should be noted that the mandates in the EV Law (Table 1.3) differ from the assumptions used in the 2019 EMP.

***Table 1.3. Key Goals of Electric Vehicle Law (P.L. 2019 c.362, 2020).***

| Goal | Date |
|---|---|
| Statewide EV Goals | |
| 330,000 registered plug-in electric light duty vehicles | December 31, 2025 |
| 2 million registered plug-in electric light duty vehicles | December 31, 2035 |
| 85% of all new light-duty vehicles sold or leased in the state are plug-in electric vehicles - *(note that 2019 EMP assumes 100% of sales are electric in 2035)* | December 31, 2040 |
| State Fleet EV Goals | |
| 25% of state-owned non-emergency light-duty vehicles are plug-in electric vehicles | December 31, 2025 |
| 100% of state-owned non-emergency light duty vehicles are plug-in electric vehicles | December 31, 2035 |
| Electric Vehicle Charging Infrastructure Goals | |
| 400 public fast charging stations at 200 locations in the state | December 31, 2025 |
| 1,000 public Level Two chargers in the state | December 31, 2025 |

| | |
|---|---|
| 15% of all multi-family residential properties in the state are equipped for electric vehicle charging | December 31, 2025 |
| 30% of all multi-family properties are equipped for electric vehicle charging | December 31, 2030 |
| 20% of all franchised overnight lodging establishments are equipped for electric vehicle charging | December 31, 2025 |
| 50% of all franchised overnight lodging establishments are equipped for electric vehicle charging | December 31, 2030 |
| Bus Goals | |
| 10% of NJ TRANSIT new bus purchases are zero emission buses. | December 31, 2024 |
| 50% of NJ TRANSIT new bus purchases are zero emission buses. | December 31, 2026 |
| 100% of NJ TRANSIT new bus purchases are zero emission buses. | December 31, 2032 and thereafter |

### *National fuel economy standards*

Corporate Average Fuel Economy (CAFE) standards reduce energy consumption by increasing the fuel economy of light-duty cars and trucks. The CAFE standards are fleet-wide fuel economy standards that must be achieved annually by each automaker for its car and light-duty truck fleet. When these standards are raised, automakers respond by creating a more fuel-efficient fleet, which improves our nation's energy security and saves consumers money at the pump, while also reducing GHG emissions and other pollutants. CAFE standards are regulated by United States Department of Transportation's National Highway Traffic and Safety Administration (NHTSA). NHTSA sets and enforces the CAFE standards.

### *National greenhouse gas emissions standards*

Under the Clean Air Act, the USEPA sets GHG emission standards for motor vehicles, expressed as grams of $CO_2$ released per mile driven. USEPA previously granted California's request for a waiver for GHG standards for light-duty vehicles, which authorized California to set and enforce its own more stringent standards. USEPA and California then agreed to align their respective GHG emission standards, with which NHTSA would harmonize its fuel economy standards. In 2019 and 2020, however, the Trump administration withdrew the waiver granted to California and separately, rolled back the Model Year 2021 through 2026 standards such that improvements of only 1.5% per year would be achieved rather than the 5% per year improvements put into place by the Obama administration. New Jersey, and many other states, have adopted California's GHG standards. New Jersey should continue to advocate for the most stringent GHG standards for light-duty vehicles.

### *Complementary Programs*

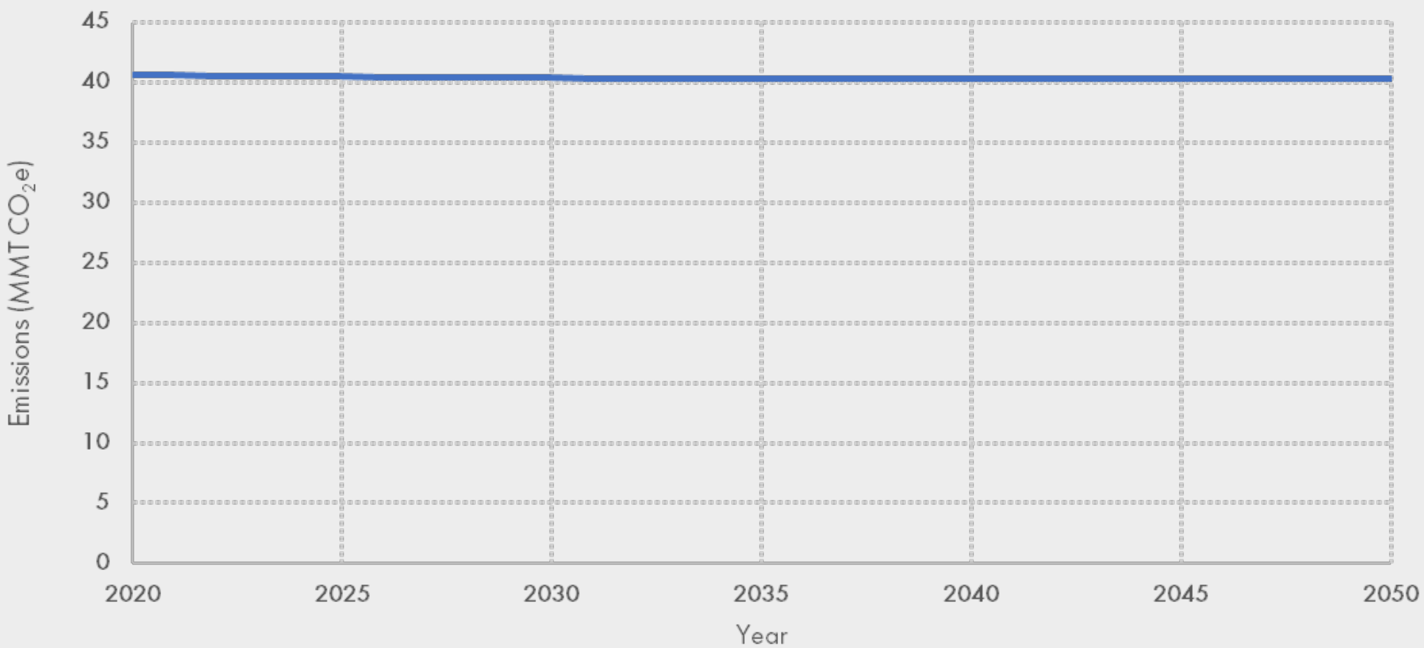
Other programs exist that support New Jersey's efforts to reduce climate and air pollutants from fossil-fuel powered vehicles. One example is New Jersey's Diesel Retrofit Law of 2005 (P.L. 2005 c.219), which required installation of modern retrofit technology. In addition to reducing criteria pollutants, the cleaner technology led to significant reductions in black carbon (a climate pollutant) from both on-road and off-road equipment. More recently, the DEP announced the allocation of $61 million to convert old diesel trucks, buses, port equipment, marine vessels and trains to electric alternatives, using funds arising from the national Volkswagen diesel emissions settlement (NJDEP, 2020c).

Broader initiatives can also reduce climate impacts while creating social benefits that directly improve residents' quality of life. In particular, the Transit Village program, supported by New Jersey Department of Transportation (NJDOT) and NJ TRANSIT, promotes centralized development in neighborhoods surrounding transit hubs (NJDOT, 2019). These pedestrian-friendly communities reduce reliance on single-passenger vehicles by encouraging use of mass transit, and at the same time bring commercial and residential resources closer together to eliminate the need for many trips.

## Business-as-Usual Projection

In order to compare the relative impacts of various policy alternatives it is useful to establish a baseline that separates out as many confounding factors as possible, thereby permitting alternatives to be considered on their own. For the purposes of this chapter the Business-as-Usual projection reflects current circumstances with minimal changes introduced over time. For example, the number of vehicles registered in the state is held constant, as are the total number of vehicle miles traveled. The composition and emissions profile of the fleet is also held constant to reflect 2018 conditions, and the electric vehicle sales rate is maintained at the recently observed level of 8,000 units per year. Under these conditions, GHG emissions from the transportation sector would remain largely unchanged through 2050 (Figure 1.5).

***Figure 1.5. New Jersey Transportation Sector 2020-2050 Business-as-Usual Projection (MMT $CO_2e$).***
*Under the Business-as-Usual scenario, without widespread adoption of electric vehicles, transportation sector emissions are nearly unchanged though 2050.*




# ASSESMENT STRATEGY

DEP calculated electric vehicle emission projections utilizing a policy comparison model that evaluated emissions based on the 2018 registered fleet. The transportation sector pathway analyses assumed vehicle fleet size will remain constant through 2050 and does not consider changes in vehicle fleet makeup including distribution of vehicle types, efficiency improvements and changes in the number of vehicles on the road (Table 1.4). From this, the emissions were calculated by applying the 2019 EMP least cost projected fraction of fossil-powered vehicles in a given year. In the 2019 EMP and DEP's policy comparison model, the existing fleet of fossil-powered vehicles is gradually retired over thirty years, replaced with similar numbers of registered electric vehicles (Figure 1.6). To demonstrate the scope of agreement between the two approaches, emission projections for both models were plotted (Figure 1.7).

***Table 1.4. New Jersey Vehicle Registration, December 2019.***

| Vehicle Category | Registered Vehicles |
|---|---|
| Light-Duty Cars and Trucks | 6,336,154 |
| Medium-Duty Trucks, Heavy Duty-Trucks, and Buses | 389,605 |
| Total | 6,726,059 |

***Figure 1.6. Fossil light-duty vehicle registrations projected in the 2019 EMP and the DEP's policy comparison model.***

*The retirement of fossil vehicles projected in the 2019 EMP agrees closely with the DEP's policy comparison model. The 2019 EMP assumed that fleet size would grow through 2050, but that almost all new vehicles would be electric vehicles. The DEP policy comparison model assumed constant fleet size to avoid introducing additional uncertainty, but the retirement of existing fossil vehicles is almost identical.*

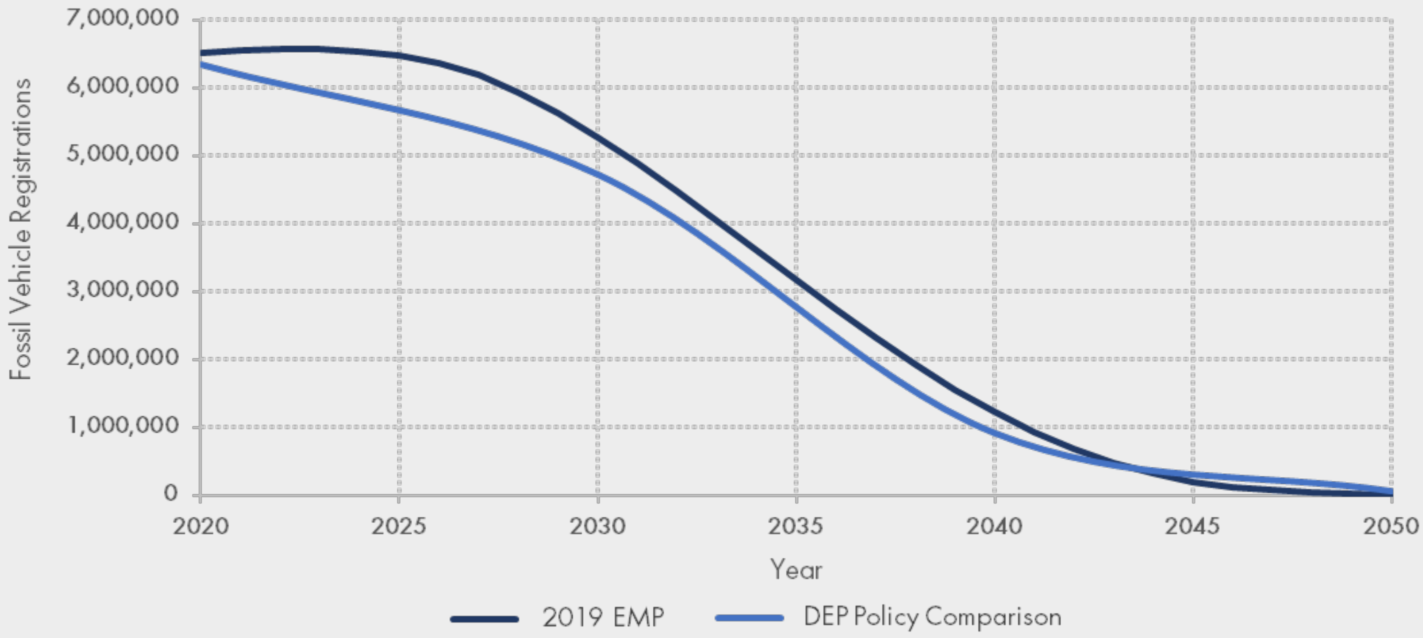
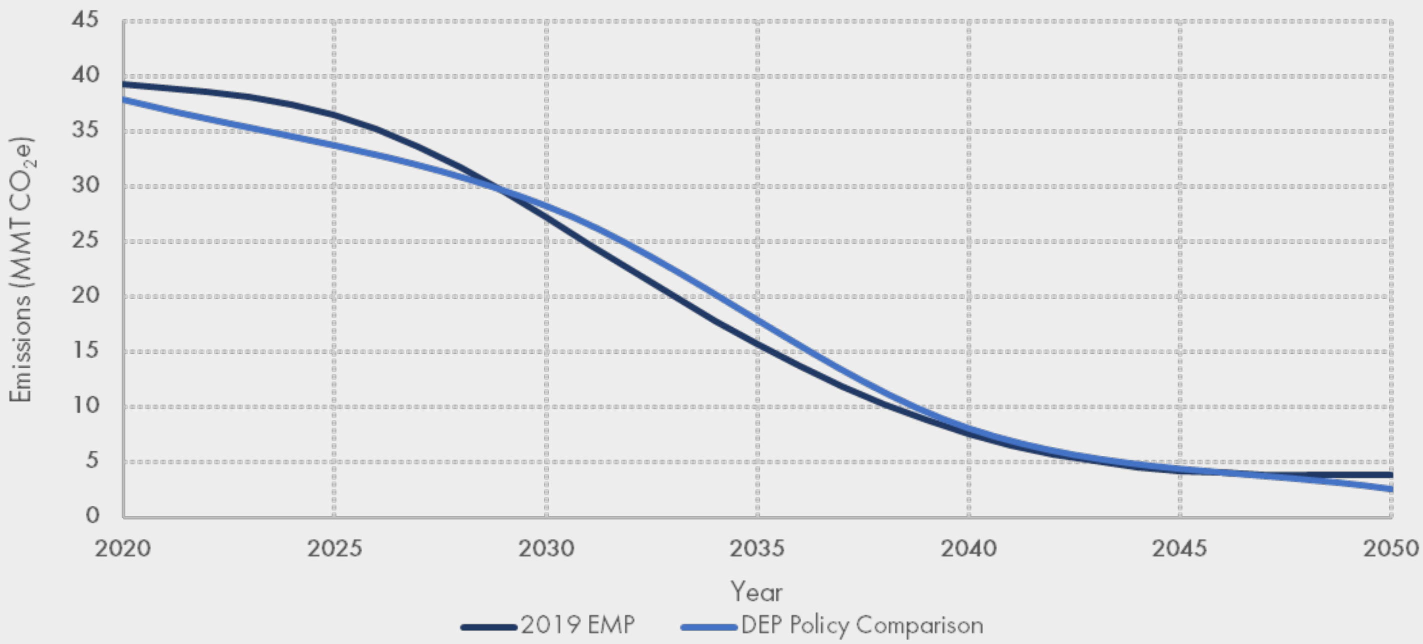



***Figure 1.7. Emissions estimates based on 2019 EMP and the DEP policy comparison model.***

*Emissions resulting from consumption of gasoline and diesel in the 2019 EMP track closely with the DEP policy comparison model.*



Source: Port Authority of NY and NJ

## THE PATH FORWARD

As illustrated in the 2019 EMP, the least cost scenario calls for the transportation sector to transition to electric vehicles, reaching 100% of new passenger car sales by 2035 in order to meet the state's 80% emissions reduction goal. The 2019 EMP preferred least cost scenario relies on achieving GHG reductions by electrifying nearly all light-duty vehicles while simultaneously decarbonizing the electric generation sector. This approach calls for aggressive electric vehicle adoption rates that will be very challenging in the near term due to market limitations. However, over the next two years, more than 100 new electric vehicle models are expected to be introduced (Automotive News, 2018). While the electric vehicle market matures and consumer confidence grows, New Jersey should look to achieve near term emissions reductions through additional transportation strategies that can bring early gains.

Five pathways have been identified that can achieve emissions reductions, including two pathways that target electrification of vehicles (Pathways 1 and 2) and three pathways that rely on other transportation regulatory strategies (Pathways 3, 4, and 5).

- Pathway 1, Electrify Light-Duty Vehicles, evaluates the EV Law and mirrors the strategies outlined in the Energy Master Plan;
- Pathway 2, Decarbonize medium- and heavy-duty vehicles, evaluates emission reductions from categories of vehicles on the road besides light-duty passenger vehicles;
- Pathway 3, Increase NJ TRANSIT ridership and expansion of transit villages, considers the advantages of expanded public transportation;
- Pathway 4, Incentivize work-from-home policies, ridesharing, home delivery and other strategies, examines additional ways to reduce the demand for travel;
- Pathway 5, Support regional and national efforts to reduce GHG emissions of light-duty fossil-fuel powered new vehicles, looks at the role of improved emissions policies as the energy transition becomes established.

Collectively, a combination of policies based on the above strategies can accelerate reduction of transportation sector emissions towards the goal of 5.4 MMT $CO_2e$ emissions by 2050. The individual pathways are interactive, meaning that a strong success in one category can enhance or detract from the potential gains in another. It is therefore necessary to consider each pathway separately before studying how they can be combined to create optimal benefits.

### EMISSIONS ACTIVITES

- Moving people using fossil-fuel powered vehicles
- Shipping goods using fossil-fuel powered transportation

### EMISSIONS REDUCTION PATHWAYS

1. Electrify light-duty vehicles
2. Decarbonize medium- and heavy-duty vehicles
3. Increase NJ Transit ridership and expansion of transit villages
4. Incentivize work-from-home policies, ridesharing, home delivery and other strategies
5. Support regional and national efforts to reduce greenhouse gas emissions of light-duty fossil-fuel powered new vehicles

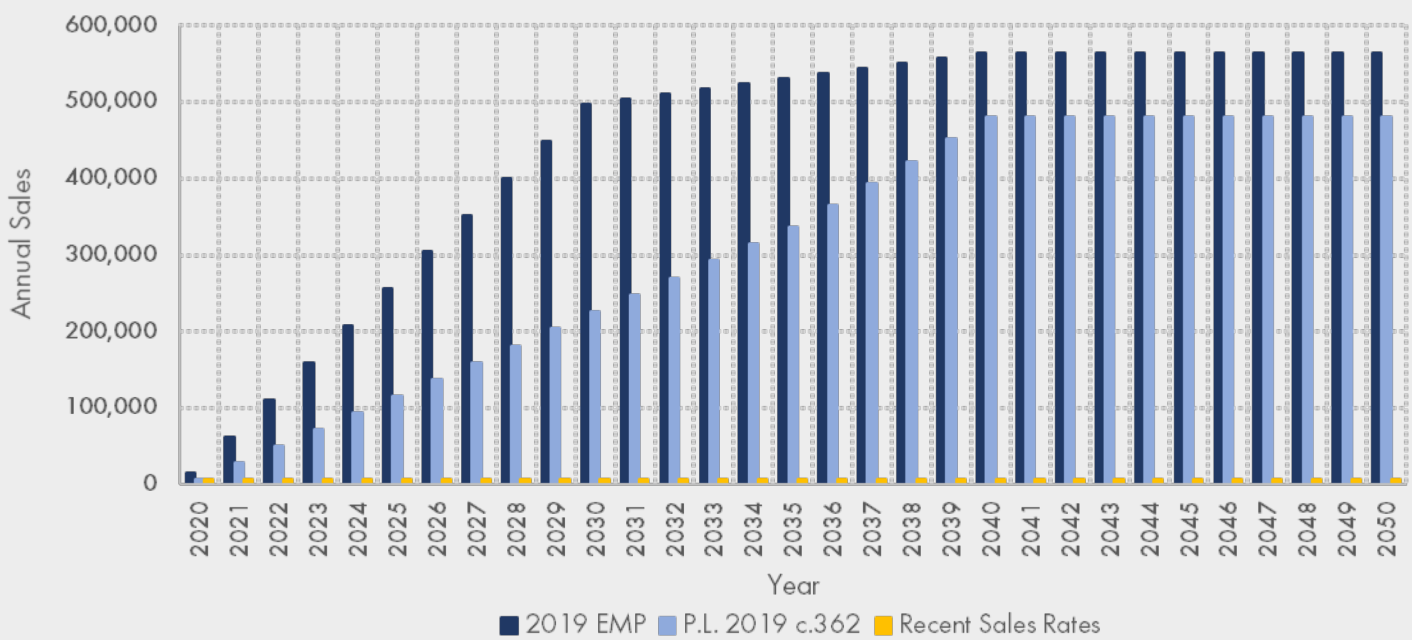
## **Emissions Reduction Pathway 1:** Electrify light-duty vehicles

For the transportation sector, the single greatest force that will drive emissions reductions is the transition from fossil fuel vehicles to those powered by clean, renewable electricity. As noted above, light-duty passenger vehicles (cars, light-duty trucks and SUVs) represent the lion's share of both VMT and emissions produced. The 2019 EMP calls for a nearly complete replacement of gasoline-powered vehicles by 2050, which requires 100% electric vehicle sales by 2035, assuming a 15-year vehicle life. Further, failing to electrify the vehicle fleet increases the cost of decarbonization from 2035 to 2050 by an average of $1.6 billion per year, according to the research underlying the 2019 EMP (NJBPU, 2020).[6]

The increase in adoption of electric vehicles will result in a corresponding increase in the state demand for electric generation. The 2019 EMP modeling predicted a more than doubling of the state's current electric demand due to electrification across multiple energy sectors, including vehicles and building heating and cooling. To realize the full emissions reduction potential of vehicle electrification, the rate of net-zero carbon electric generation must grow proportionately with the increased electric demand created by electric vehicle adoption. This topic is further discussed in the Electric Generation Chapter of this report.

Meeting the 2019 EMP's light-duty conversion goals would result in an annual 8.3 MMT $CO_2e$ emissions reduction by 2030 and 30.0 MMT $CO_2e$ by 2050.[7] In order to achieve this, the 2019 EMP modeling calls for the light-duty auto and truck market to quickly shift to electric vehicles, with 88% of new vehicle sales being electric by 2030, and by 2035 100% of new vehicles sales being electric. In quantitative terms, the number of electric vehicles registered must increase from approximately 30,000 vehicles today to 1.8 million by 2030, 5.4 million by 2040 and over 6 million by 2050, even before accounting for any potential growth in the total number of vehicles. This requires significant increases from the current 8,000 annual electric vehicle sales and even greater growth than that set by the EV Law (P.L.2019, c.362) to upwards of half a million sales annually by 2030 (Figure 1.8).

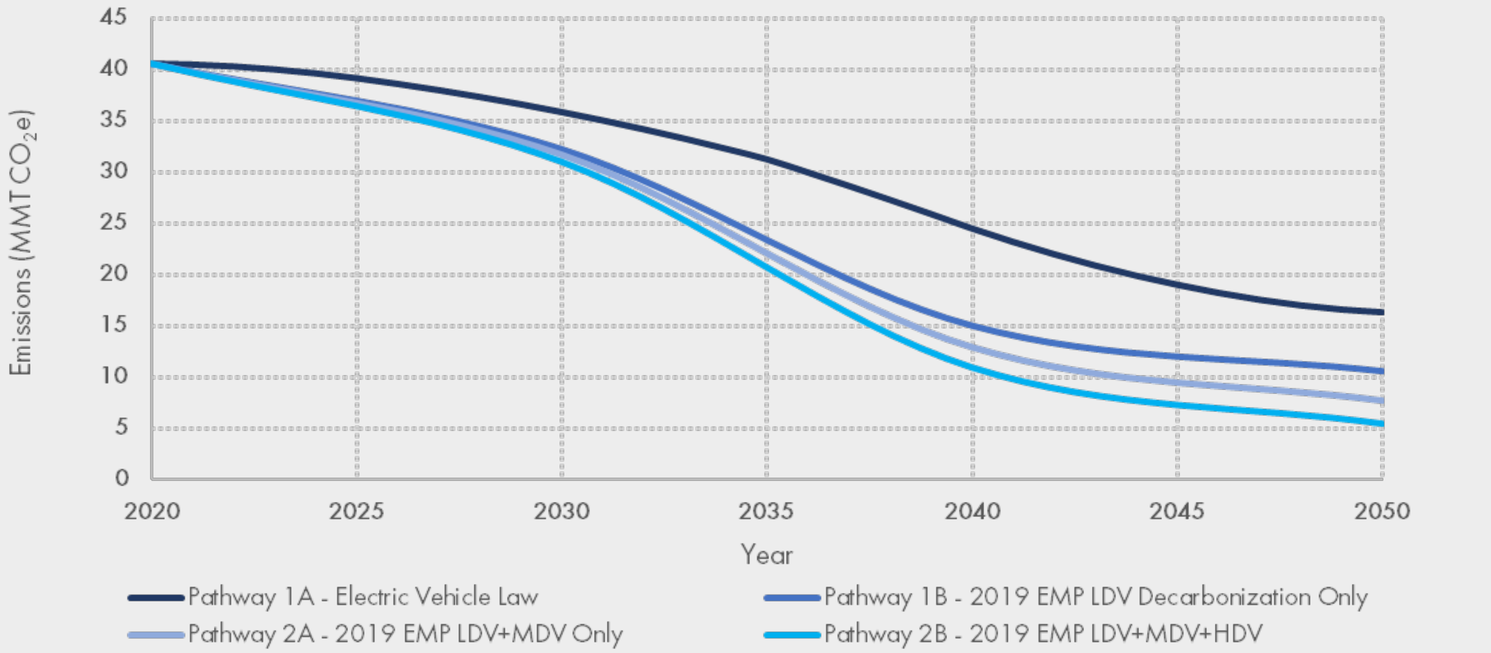
***Figure 1.8. Comparison of Required Annual Sales of Light-duty Electric Vehicles to Meet the Goals of P.L. 2019 c.362 and the 2019 EMP.***
*The 2019 EMP projects that electric vehicle sales will need to reach approximately 500,000 units per year by 2030. Sales under the electric vehicle law are anticipated to reach only about half that rate by 2030. These projections assume that the total number of passenger vehicles remains constant through 2050.*




[6] As compared to Variation Six of the 2019 EMP.
[7] For the purposes of these calculations, 2020 transportation sector emissions are assumed equal to the 2018 estimate of 40.6 MMT $CO_2e$ (NJDEP, 2019).

Various initiatives have been broken down into emission reduction projections (Figure 1.9). Pathway 1A models emission reductions associated with the EV Law (P.L. 2019, c.362). Pathway 1B illustrates the emission reductions from light-duty vehicle provisions of the 2019 EMP. The gap between light-duty vehicle emissions projections for the EV Law and the 2019 EMP reaches 5.8 MMT $CO_2$e by 2050, even before considering the 2019 EMP's further reductions in emissions from medium- and heavy- duty vehicles discussed below in Pathway 2. Achieving nearly 100% electric vehicle new passenger car sales by 2035 is therefore an important strategy for meeting the 80x50 mandate.

***Figure. 1.9. Transportation Sector Emissions under the NJ Electric Vehicle Law and the 2019 EMP Least Cost Scenario.***
*Electrification of light-duty vehicles can reduce transportation sector emissions below 11 MMT $CO_2$e by 2050, and electrification of medium- and heavy-duty vehicles as specified in the 2019 EMP can further reduce emissions to below 6 MMT $CO_2$e.*




## **Emissions Reduction Pathway 2:** Decarbonize medium- and heavy-duty vehicles

There are many categories of vehicles on the road besides light-duty cars and trucks, and these represent opportunities for further reductions. In particular, the 2019 EMP least cost scenario calls for 75% of medium-duty trucks and 50% of heavy-duty trucks to be decarbonized by 2050. Pathway 2A (Figure 1.9) considers the impact of fully decarbonizing light-duty vehicles and 75% of medium-duty vehicles, for a combined emissions reduction of 33 MMT $CO_2$e in 2050. Pathway 2B reflects decarbonization of 50% of heavy-duty vehicles and buses, in addition to the light- and medium-duty vehicle reductions discussed above. This pathway represents the full on-road reductions called for in the 2019 EMP and would reduce the sector's total emissions by 35 MMT $CO_2$e in 2050. Transportation sector total emissions in 2050 would therefore be approximately 5.4 MMT $CO_2$e. This is 11 MMT $CO_2$e below the level that would be achieved through the EV Law alone.

Prioritizing technology for this sector will depend on the state of the technology, implementation cost, achievable emission reductions, and other factors. For example, diesel powered long-haul trucks (semis) represent the third largest category in terms of on-road emissions, but the technology for electrifying this sector is still developing. Renewable diesel or renewable natural gas can be considered as interim strategies until full electrification is possible. Hydrogen fuel cell vehicles may also be a viable option. These technologies are at earlier stages of evolution and therefore will benefit from research and development support. To the extent that they are successful, a significant fraction of the remaining 5.4 MMT $CO_2$e after achievement of Pathway 2B could be eliminated.

Decarbonizing medium- and heavy-duty vehicles provide additional benefits by locally reducing criteria pollutants and carcinogens such as black carbon, which are released in greater concentrations in heavily trafficked corridors that are typically in or near environmental justice communities. Complementary medium- and heavy-duty vehicle strategies are further discussed in the Short-Lived Climate Pollutant Chapter of this report.

## **Emissions Reduction Pathway 3:** Increase NJ TRANSIT ridership and expansion of transit villages

NJ TRANSIT provides vital transportation services for the state's residents, delivering over three billion passenger miles of mobility annually (NJ TRANSIT, 2020). With each added passenger, the opportunity exists to reduce reliance on light-duty cars and trucks and thereby reduce GHGs. NJ TRANSIT provided an analysis of the potential emissions reductions that could be achieved through increased ridership through 2040 on both buses and trains under low and high ridership scenarios. These projections were developed using the standard method of the American Public Transportation Association (APTA) (APTA, 2019), and only consider emissions avoided through transportation efficiency. The DEP extrapolated these estimates out to 2050 and also evaluated aspirational goals of doubling current ridership, as summarized in Table 1.5. In all cases, ridership was assumed to gradually increase over thirty years until achieving the noted ridership goals in 2050 of between 13.5% and 54% above a 2020 baseline, or in the case of aspirational goals 200%.

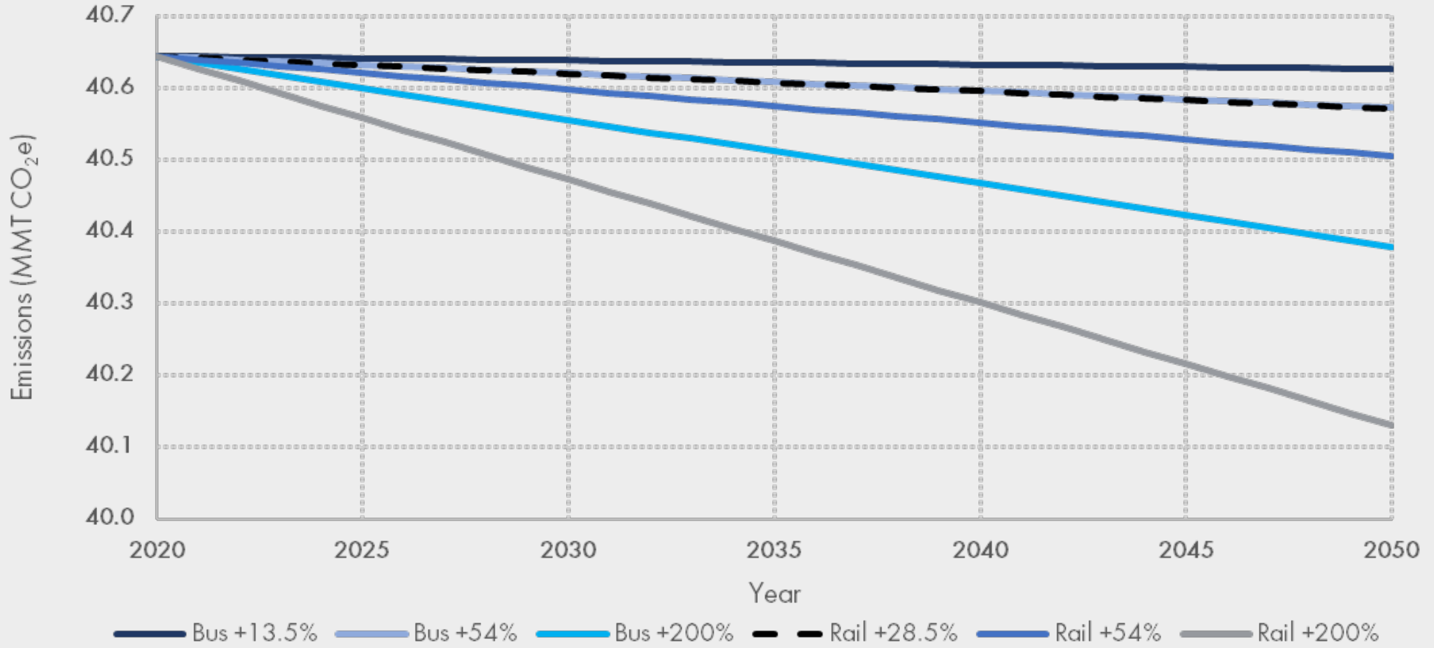
***Table 1.5. Emission Reductions from Increased Public Transit Ridership[8].***
*Public transportation has the potential to reduce reliance on personal vehicles and thereby lower emissions, but ridership must expand significantly beyond current levels to achieve the full benefit.*

| Scenario | Ridership Increase in 2050 (Percent) | 2050 Annual Avoided Emissions (MMT $CO_2e$) | Cumulative Avoided Emissions through 2050 (MMT $CO_2e$) |
|---|---|---|---|
| Bus Ridership Low | 13.5% | 0.02 | 0.28 |
| Bus Ridership High | 54% | 0.07 | 1.11 |
| Bus Ridership Aspirational | 200% | 0.26 | 4.11 |
| | | | |
| Rail Ridership Low | 28.5% | 0.07 | 1.14 |
| Rail Ridership High | 54% | 0.14 | 2.15 |
| Rail Ridership Aspirational | 200% | 0.51 | 7.97 |

Emissions reductions under these scenarios were small, with annual avoided emissions ranging between 0.02 and 0.51 MMT $CO_2e$ in 2050, and with cumulative reductions over the thirty year period of between 0.3 and 8.0 MMT $CO_2e$ (Figure 1.10; Table 1.5). These levels pale in comparison with the transportation sector's overall annual emissions of 40.6 MMT $CO_2e$. However, the findings do not indicate a lack of potential for public transit. Instead, they reflect the fact that the 3 billion passenger miles traveled each year on NJ TRANSIT are dwarfed by the 68 billion miles traveled in passenger vehicles (Table 1.2). When ridership increases by much greater factors, for example by two to ten fold, substantial reductions in cumulative emissions can be expected. In absolute terms, the necessary number of increased passengers to achieve this is not out of reach and may be accomplished as other decarbonization strategies of the 2019 EMP and this report are realized.

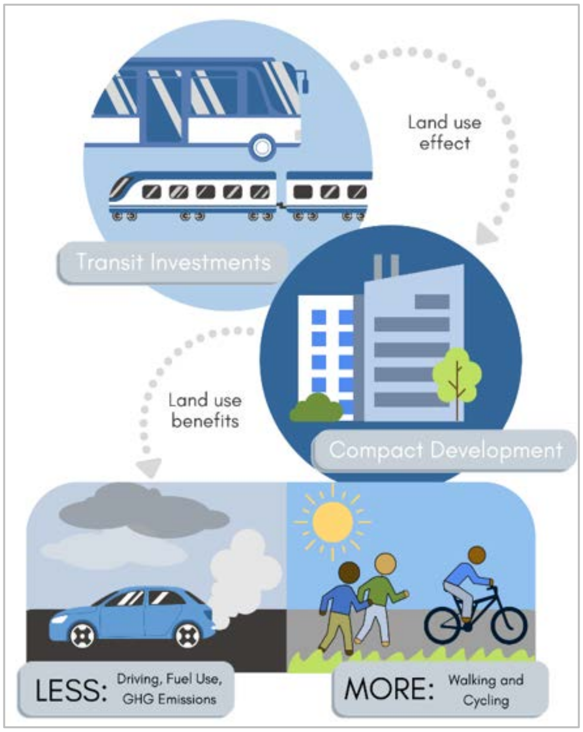
[8] Adapted from NJ TRANSIT-provided data. The NJ TRANSIT projections were through 2040. DEP extrapolated these estimates to 2050 to allow comparative analysis with other projections in the 80x50 report.

***Figure 1.10. Transportation Sector Emissions Under Public Transit Ridership Scenarios.***
*Combined gains in ridership on rail and bus are largely additive and can be combined to estimate overall impact. The demographic trend towards living in cities and towns will also likely increase ridership but it is not considered in these projections.*




Development of new, and expansion of existing transit villages facilitates lifestyle changes that provide additional climate benefits. For example, bringing communities together and relying less on sprawl can lead to substantial reductions in GHG emissions. Expansion of the transit village concept, and the rejuvenation of rural town centers and urban neighborhoods, yield climate benefits by reducing the need for travel and consequently GHG emissions. The close proximity to services and transportation options other than a personal car, denser population and infrastructure result in increased land use efficiency. This land use paradigm highlights the importance of public transportation, compact development and their role in decarbonizing the economy (Figure 1.11) (APTA, 2019).

***Figure 1.11. The Land Use Effect of Public Transportation.***
*Investments in transit village expansion provide benefits that further reduce emissions beyond those associated with public transit ridership alone. (APTA, 2019)*




According to the APTA Report, people who live in transit villages but do not use transit were found to drive less and walk and bike more. Furthermore, APTA identified four ways in which the land use efficiency of transit villages reduces reliance on light-duty vehicles:

- **Reduced trip lengths**. Transit villages enable higher-density development that in many cases would not be possible without the existence of transit.

- **Facilitation of bicycle and pedestrian travel**. As well as reducing trip lengths, the higher densities and mix of uses supported by transit enable mode shift from the private auto to walking and cycling, which requires less energy and generates lower emissions per unit of travel. For example, pedestrian oriented shops and services may not be economically viable without the density and foot traffic that transit supports.

- **Trip chaining**. Transit can facilitate the combination of trips into a single tour, which eliminates duplicative travel among multiple two-way trips. For example, a commuter may pick up groceries or dry cleaning on the way home from the station.

- **Impacts through vehicle ownership**. Households living close to transit tend to own fewer vehicles, partly because a vehicle may not be needed for commuting, and partly because of the reduced availability and higher cost of parking. In turn, reduced vehicle availability tends to lead to reduced auto use, and the private car may cease to become the habitual choice for every trip.

## **Emissions Reduction Pathway 4:** Incentivize work-from-home policies, ridesharing, home delivery, and other strategies

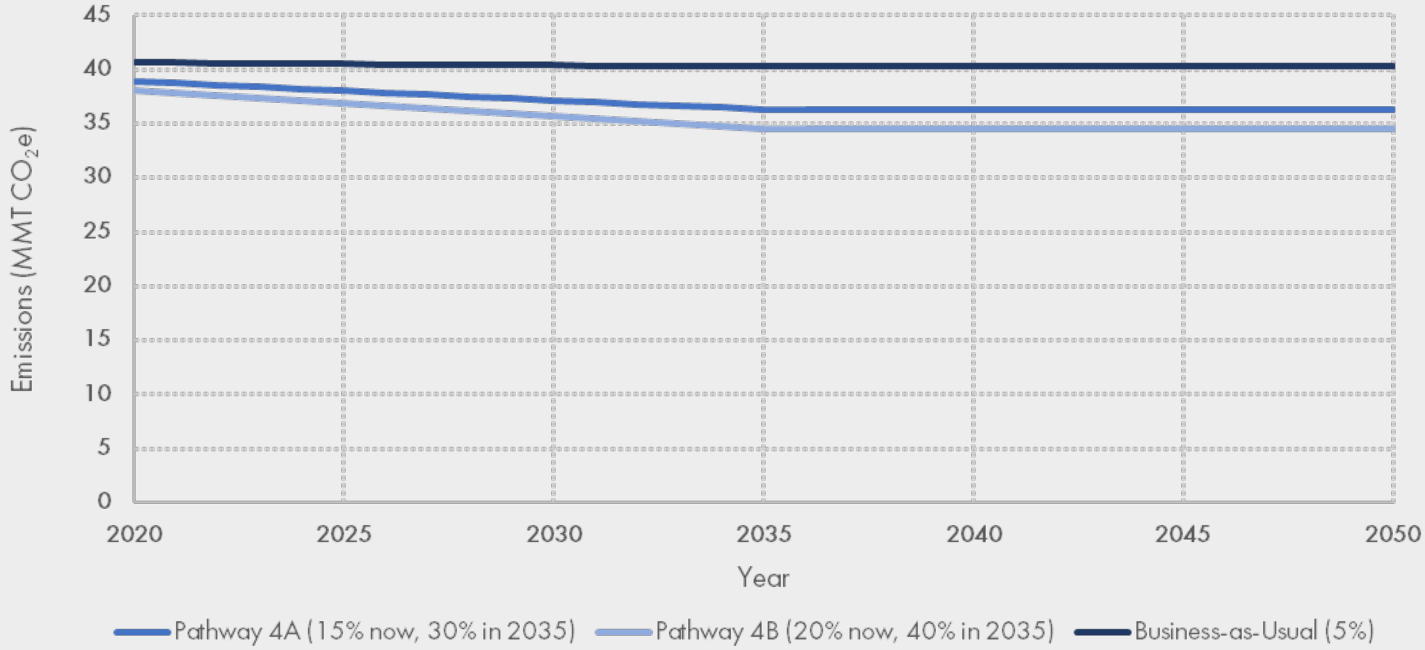
GHG emissions can be reduced through transportation strategies such as working from home, ridesharing, and utilizing home delivery services, collectively reducing VMT. Even jobs not conducive to these strategies can realize GHG emission reductions through the adoption of flexible work hours, reducing the number of weekly commutes and benefiting from improved traffic flow while commuting.

The DEP has evaluated different work-from-home scenarios to determine their viability in achieving near and long-term emissions reductions. During 2019, about 5% of New Jersey's population worked from home three or more days a week, but about 30% of jobs could be performed from home (Dingel & Neiman, 2020a; Dingel & Neiman, 2020b; US Bureau of Labor Statistics, 2019). Pathway 4A models 15% of the state's workforce working from home in 2020, increasing to 30% in 2035, and then holding at 30% through 2050. When compared to the BAU, emissions decrease by 1.7 MMT $CO_2e$ in 2020 and by 4.3 MMT $CO_2e$ in 2035 (Figure 1.12).[9] At the end of the thirty-year period, cumulative emissions would be reduced by 114 MMT $CO_2e$, or more than an entire year's worth of the state's emissions for all sectors combined at the current rate. Pathway 4B is a more aggressive work-from-home scenario, where 20% of the state's workforce start to work from home in 2020, increasing to 40% in 2035, and holding steady at 40% through 2050. Initial emission reductions are 2.6 MMT $CO_2e$, and 6.1 MMT $CO_2e$ by 2035. Cumulative emissions reductions in this case reach 161 MMT $CO_2e$ by the end of the period. Adoption of policies to encourage working from home could therefore lead to cost-effective emissions reductions early in the energy transition process. These strategies can result in immediate, early emissions reductions while vehicle electrification and a transition to renewable electric generation progress. Work-from-home policies also deliver social and environmental benefits beyond their usefulness in reducing GHG emissions (Guyot & Sawhill, 2020). For example, DEP analysis of air quality during the spring of 2020 showed significant improvements during the COVID-19 stay at home order. Monthly average nitrogen oxide concentrations measured by DEP monitoring stations in urban areas of New Jersey decreased by 31% to 51% in April and May 2020 when compared with monthly average nitrogen oxide concentrations from 2014-2019. Monthly average fine particle (PM2.5) levels from the same urban areas decreased 21% to 34% in April and May 2020 when compared to data from 2014-2019. During April 2020, light-duty vehicle traffic volume decreased 50%, and in May decreased about 35% compared to respective light-duty traffic volumes in April and May 2019. Heavy-duty vehicle traffic volume decreased by about 30% for both April and May 2020 when compared with corresponding volumes in 2019 (NJDEP, 2020d).

[9] Calculations are based on average one-way New Jersey commute time of 32.4 min (US Census Bureau, 2018); 4,291,282 average monthly employment 2018-2019 (US Bureau of Labor Statistics, 2020); and assumed travel speed of 35 mph. Emissions are based on USEPA MOVES output data for 2018, reduced in proportion to travel miles avoided.

***Figure 1.12. Transportation Sector Emissions Under Three Work-from-Home Scenarios.***

*The work-from-home scenarios shown here would reduce cumulative emissions through 2050 by 114 to 161 MMT $CO_2e$, more than the state currently emits in an entire year from all sectors combined.*



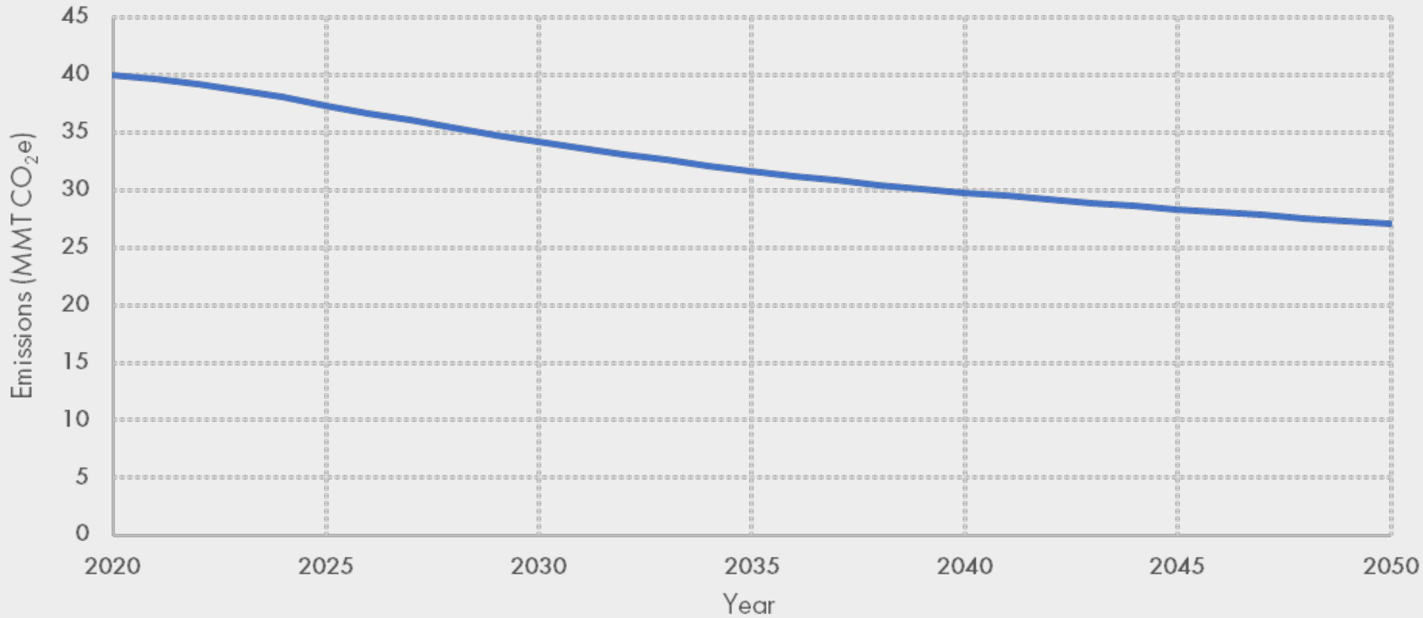

Beyond work-from-home policies, other transportation strategies may provide climate benefits. For example, ride sharing, van pooling and home delivery are also strategies that should be further evaluated for their potential to reduce emissions. Online shopping services have revolutionized commerce in many ways, and efficient delivery of goods can reduce GHG emissions. Local vendors and larger businesses can bring goods and services to neighborhoods further reducing VMT. However, this must be balanced with the need to support stable, prosperous communities that improve our quality of life and maintain vibrant downtowns with plentiful work opportunities. A similar consideration is the proliferation of ride hailing services, which provide residents with convenient transportation in lieu of owning a car. Incorporating these services in an efficient and emissions-reducing manner to maintain quality of life and good wages can benefit the environment as well as the public. Benefits from these strategies could be investigated in future iterations of this report.

## **Emissions Reduction Pathway 5:** Support regional and national efforts to reduce greenhouse gas emissions of light-duty fossil-fuel powered new vehicles

It is expected that fossil-powered vehicles will continue to be sold in significant quantities over the next several years. Therefore, it is prudent to pursue technology improvements in existing internal combustion engine vehicles that reduce GHG emissions. Continued improvements in the GHG emissions standards for light-duty motor vehicles can further reduce emissions from new fossil fueled vehicles. Based on the USEPA 2012 Regulatory Impact Analysis (2012 RIA) for model years 2017-2025 a GHG reduction of 13 MMT $CO_2e$ by 2050 can be anticipated (Figure 1.13) (USEPA, 2012). The 2019 EMP and the emissions analysis below incorporate these standards. However, these standards were rolled back through the adoption of the Safer Affordable Fuel-Efficient Vehicles (SAFE) rule (Federal Register, 2019; Federal Register, 2020). More recently, California announced an agreement with six auto manufacturers whereby each manufacturer agreed to meet national fleet-wide year-over-year efficiency improvements that surpass the rolled-back federal standards. The automakers have also made various commitments to promote electric vehicles sales within the Clean Air Act section 177 states (CARB, 2019a; CARB, 2019b).

***Figure 1.13. Transportation Sector Emissions under USEPA 2012 RIA.***

*This Figure considers the estimated benefits of light-duty GHG emissions standards based on the USEPA's 2012 RIA, apportioned to New Jersey. It does not consider other reduction strategies. This illustrates how early emission reductions can be achieved, complementing other strategies that take longer to fully implement such as electric vehicle adoption. In addition to reduced tailpipe emissions, USEPA's projections also accounted for emissions reductions from petroleum refineries and increased emissions from electricity generation for a small number of electric vehicles.*

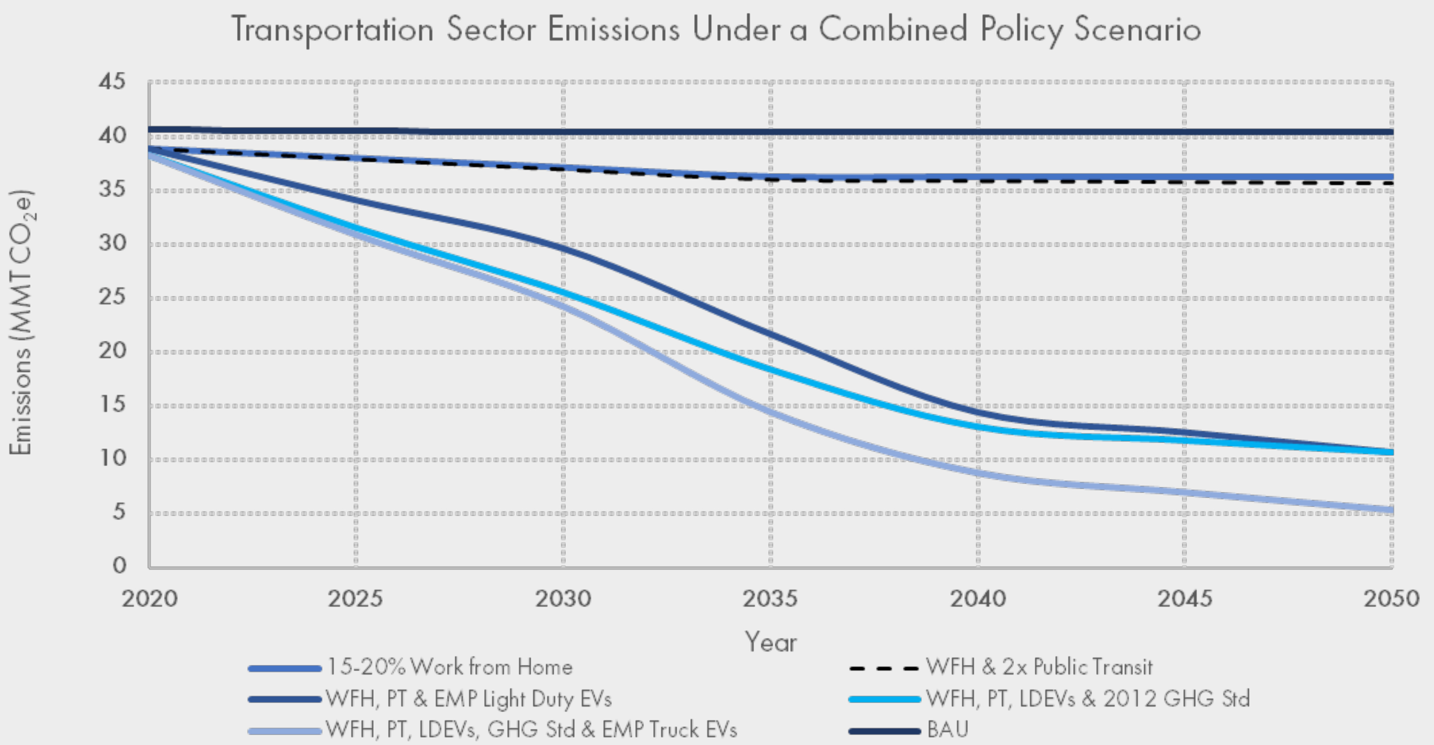



## **Combined Pathway Analysis:** The benefits of applying multiple strategies for early emissions reductions

Building on the 2019 EMP projections of vehicle electrification, this analysis evaluates additional pathway combinations. The various pathways described above are not independent. For example, introducing a program that substantially reduces overall demand for transportation will displace potential benefits from programs that lower emissions on a per-mile basis. It is therefore necessary to consider demand-reduction strategies such as work-from-home and public transit ridership increases first. After addressing these reductions in demand, the rate of light-duty electric vehicle adoption further displaces fossil fuel vehicles. Tighter GHG emission standards can then reduce emissions from the remaining fossil-powered fleet. Finally, electrification of medium- and heavy-duty vehicles can eliminate still more emissions.

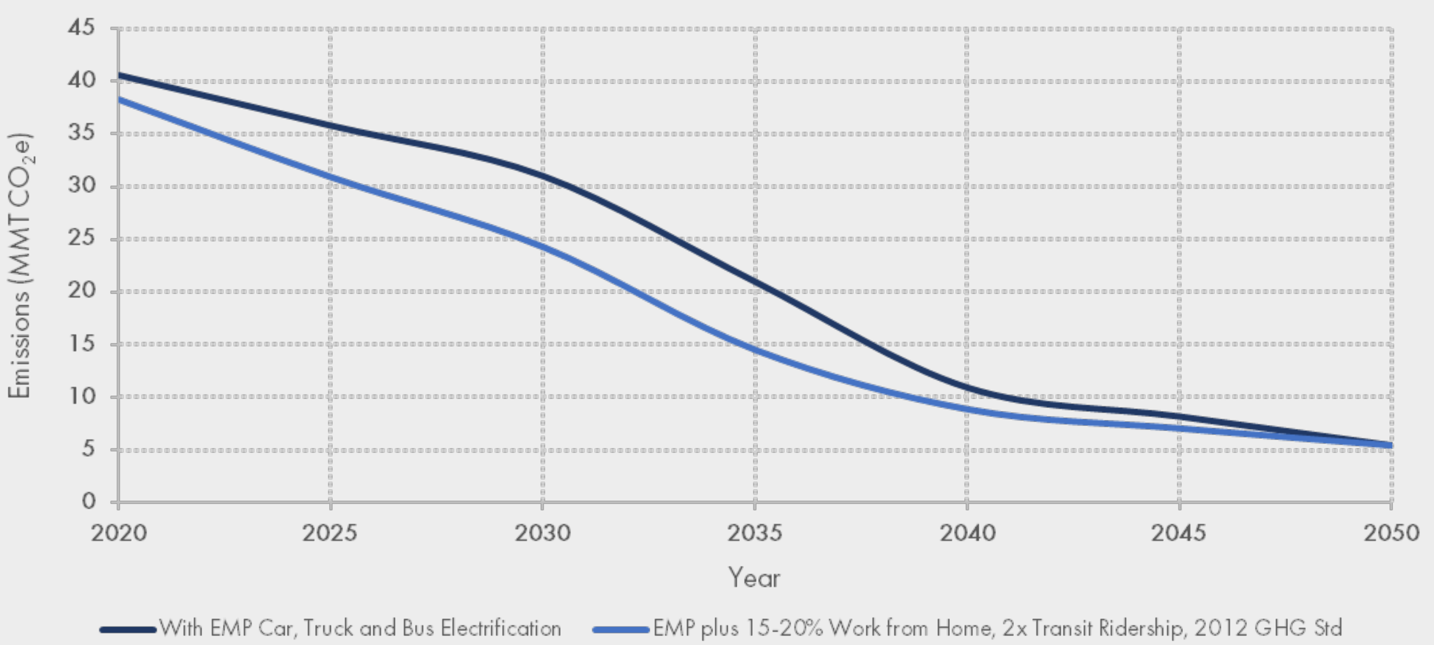
As an example, a combination of policies based on the above pathways can illustrate the potential benefits. Assuming adoption of work-from-home policies resulting in 15% of the working public to remain at home now, with the rate rising to 30% in 2035 (Pathway 4A), is projected to result in an immediate 6% decrease in VMT for light-duty vehicles and a 16% decrease by 2035. Taken alone, this would reduce transportation sector emissions to 36.3 MMT $CO_2e$ in 2035 (Figure 1.14). Doubling bus and rail ridership by 2050 (Pathway 3) would reduce VMT by a further 2.7% reducing 2050 emissions to 35.6 MMT $CO_2e$. Next, adopting light-duty electric vehicles consistent with the 2019 EMP would further reduce 2050 emissions to 10.6 MMT $CO_2e$. Applying the Obama era GHG emission standards evaluated in the 2012 RIA to the DEP modeled electrification rate called for in the 2019 EMP would realize emissions reductions sooner. Finally, replacing medium- and heavy-duty trucks with their decarbonized counterparts as per the 2019 EMP results in 2050 emissions of 5.4 MMT $CO_2e$.

*Figure 1.14. Transportation Sector Emissions Under a Combined Policy Scenario.*
*The emissions reductions strategies of the 2019 EMP can be combined with additional measures to achieve even greater reductions.*




Coupling programs that reduce overall demand for transportation with electrification efforts, as illustrated in this example, provides an additional net savings of 115 MMT $CO_2e$ over the 30-year period, compared to the implementation of the 2019 EMP vehicle electrification alone (Figure 1.15).[10] Implementing transportation measures now results in immediate emissions reductions while allowing time for technologies to develop and costs to decrease.

*Figure 1.15. Transportation Sector Emissions Under 2019 EMP Alone and With Additional Measures.*
*Combining strategies brings earlier reductions in emissions, and thereby lowers cumulative emissions. Under the combined scenario shown here, cumulative emissions through 2050 were 115 MMT $CO_2e$ lower than projected for the 2019 EMP measures alone.*




[10] Lowers cumulative emissions over the 30-year period from 673 MMT $CO_2e$ in the 2019 EMP-only case to 477 MMT $CO_2e$ for the policy combination case.

# 2050 RECOMMENDATIONS

Accomplishing transportation electrification at the scale envisioned in the 2019 EMP and in this report will require aggressive electric vehicle adoption rates. The recently signed EV Law (P.L.2019, c.362) calls for significant electrification, with average electric vehicle adoption rates of greater than 60,000 vehicles through 2025. However, the projections of electric vehicle growth in the 2019 EMP require a more than doubling of that number through the same time period. New Jersey should aggressively pursue the EV Law goal of registering 330,000 light duty electric vehicles by the end of 2025. These efforts can be bolstered with additional early emissions savings provided by incentivizing increased ridership on public transit and implementation of work-from-home policies, while the electric vehicle market matures and expands vehicle offerings. In just two years (by 2022), automakers are scheduled to offer 100 electric vehicle models in varying price points, styles and capabilities to meet consumer demands (Automotive News, 2018).

For widespread adoption of electric vehicles to occur, consumers and fleet operators need a robust network of charging stations, including both regular home and workplace systems (Hardman, S. & et al., 2018) and high-power chargers along travel corridors to enable long distance driving (Nicholas, 2018). New Jersey's EV Law sets initial state goals for the development of plug-in electric vehicle charging infrastructure. By 2025, at least 400 direct current fast chargers (DCFC), and 1,000 level two chargers shall be available for public use. Additionally, 15% of all multi-family residential properties and 20% of franchised overnight lodging establishments shall be equipped with electric vehicle charging stations. These initiatives along with public utility and private investment in electric vehicle charging infrastructure will enhance charger availability and consumer confidence. Currently New Jersey ranks 45th in the U.S. (Solomon, 2018) with 1,000 public charging stations at 300 public charging locations (NJDEP, 2020e). New Jersey is on schedule to meet the level two charging goal outlined in the EV Law. Installing DCFC presents greater challenges, based on cost and siting. The DEP is working with the EDA and the BPU to identify funding and other opportunities to help develop these charging locations. To meet the DCFC goals, a combination of strategies is underway or planned, including streamlining the local approval process, prioritizing funding for DCFC, BPU's proposal for a charging ecosystem which outlines the role of utilities, and advancing public-private partnerships.

Furthermore, the state should prioritize the creation of an electric vehicle strategic map that identifies the optimal density of charging stations within New Jersey to eliminate driving-range anxiety, establishing the entire state as "range safe." The strategic map should be the first step in the creation of a long-term infrastructure program dedicated to deploying electric vehicle charging infrastructure throughout New Jersey. The long-term infrastructure program should establish clear targets and timelines for the build out to meet the EV Law and 2019 EMP's goals. The recently issued BPU Electric Vehicle Straw Proposal advances these efforts by promoting appropriate roles for both electric distribution companies and private investors (NJBPU, 2020).

Especially during the early years of electric vehicle adoption, use of electric vehicles by state, county and local governments can raise public awareness and contribute to the sustained demand that drives economies of scale. Fleet vehicles (both public and private) often realize high mileage rates and operational costs, making electrification particularly attractive in reducing emissions and maintenance costs. Further, an early expansion in the number of light-duty electric vehicles operated by local and county governments can contribute to the EV Law target of 330,000 registrations by 2025. DEP should undertake a concerted effort to provide tools to local government that will enable them to understand the benefits of electrification and the financial and educational resources available to them. This should be done in collaboration with existing organizations such as Sustainable Jersey, the New Jersey League of Municipalities and the Metropolitan Planning Organizations who can leverage their expertise to increase penetration of electric vehicles in local government fleets.

To date, emphasis has been placed on purchasing heavy-duty vehicles such as electric transit buses and more recently through the EV Law, on electrifying state-owned vehicles. Specifically, the EV Law (P.L. 2019 c.362) established that 25% of state-owned non-emergency light duty vehicles, approximately 1,200, shall be plug-in electric vehicles by the end of 2025, and 100%, approximately 4,500, by the end of 2035. The statute also requires adoption of electric buses by NJ TRANSIT, reaching 100% of new bus purchases by 2032. The state should enact complementary legislation and provide dedicated funding through RGGI and Clean Energy Program funding to support the electrification of county and local government's vehicle fleets. Additionally, the Department of Treasury should continue taking steps to implement the state fleet mandates. Initial actions include developing a state fleet transition plan and a contract to install electric vehicle charging stations at all state facilities.

New Jersey should also enhance its consumer awareness campaign by conducting Ride and Drive test drive events statewide, funding the regional consumer awareness campaign "*Drive Change. Drive Electric.*" and the PlugStar auto dealer training and certification program and expanding its event, web and social media strategy.

Meeting the targets outlined in the EV Law will help to create momentum in New Jersey's electric vehicle market. However, it is vital that the state closely track its progress towards its electric vehicle goals. Currently, the EV Law requires the DEP to submit a progress report every five years (starting in 2020), outlining the state of the plug-in electric vehicle market and achievement of goals. Recognizing the importance of decarbonizing transportation, the DEP should evaluate increasing the frequency of reporting. To align with 80x50 goals, the report should also evaluate GHG reductions achieved by current policies. The transition to a cleaner transportation sector will require adaptive management and continual monitoring of the climate, air quality and other benefits associated with various incentive programs and policy design.

Norway can serve as a strong case study for complementary incentive programs. They are currently leading the world in electric vehicle usage, having implemented electric vehicle incentives starting in the late 1990's (Henley, 2020). Using Norway as an example, New Jersey should explore other incentive structures to galvanize electric vehicle adoption, including: exempting electric vehicles from paying road tolls, allowing free parking, providing company car tax reductions, giving access to high occupancy vehicle lanes, and offering compensation for scrapping fossil vehicles when converting to zero-emission vehicles.

Decarbonizing medium- and heavy-duty vehicles will provide a greater challenge. Currently, zero-emission technologies are at earlier stages of development, with vehicle classes at different levels of technological maturity. New Jersey should monitor research and technology development, and where possible enable promising demonstration projects and invest in nascent technologies to foster the zero-emission vehicle market. In July 2020 New Jersey signed onto a Memorandum of Understanding with 14 other states and the District of Columbia to advance and accelerate the market for medium- and heavy-duty vehicles with the goal of ensuring 100% of all new medium- and heavy-vehicles sales be zero emissions by 2050, with an interim goal of 30% by 2030. Electrification of buses and trucks will deliver widespread health benefits to marginalized communities. To advance this transition New Jersey is participating in the development of an action plan that identifies barriers and solutions to support widespread decarbonization of medium- and heavy-duty vehicles. The state should also consider regulatory pathways to send a signal to the market that ensures reductions. For example, California is pursuing regulations that would require manufacturers to produce electric medium- and heavy-duty vehicles, and fleets to increasingly turn over to electric. These efforts will help to accelerate the transition away from fossil fuels and could be part of a larger collaborative effort with NESCAUM.

During the early years of building the market for electric vehicle adoption in New Jersey, the state should rely on meeting emission goals through VMT reduction strategies. Policymakers should focus on increasing public ridership of transit through the expansion of transportation options in heavily trafficked corridors of the state. Better coordination of transportation planning and land use, through transit-oriented development and complete streets[11] would also serve to reduce VMT. This, combined with expanding participation in work-from-home and flexible work hour programs, would help reduce the number of single passenger vehicle trips. The state should consider developing incentive mechanisms for companies that adopt robust work-from-home policies.

Finally, in the short-term, reducing emissions from fossil-powered vehicles will remain a priority so long as these vehicles remain on the market. Support for strong GHG emission standards is therefore one of the principal means to achieve near-term gains.

[11] A transportation policy and design approach which requires streets to be planned and operated to enable safe access for all users, including pedestrians, bicyclists, motorists and transit riders of all ages and abilities.

*Table 1.6. Recommendations for Electrification of Light-Duty Vehicles.*

| Actions | Entity | Timeframe[12] | References |
|---|---|---|---|
| Develop a program to facilitate a complete transition away from gasoline-powered vehicles, until all light-duty vehicles and light-duty trucks are electric by 2035. | DEP, BPU, EDA | Near-term | 2019 EMP Goal 1.1.1, State Zero Emission Vehicle Program Memorandum of Agreement, EV Law |
| Develop an electric vehicle strategic map that identifies the preferred locations of charging stations within New Jersey to eliminate driving-range anxiety and to establish the entire state as "range safe". | DEP | Near-term | 2019 EMP Goal 1.1.2 |
| Assist county and local governments to lead by example by electrifying their vehicle fleets. | DEP, BPU | Near-term | |
| Regularly release a Vehicle Electrification Progress Report. | DEP | Throughout | EV Law |
| Consider alternative mechanisms for increased electric vehicle adoption, such as exempting electric vehicles from paying road tolls, allowing free parking, providing company car tax reductions, giving access to high occupancy vehicle lanes, and offering compensation for scrapping fossil vehicles when converting to zero-emission vehicles. | Legislature, BPU, DEP, DOT, Treasury | Throughout | |
| Implement $30 million incentive program to support purchase of electric vehicles. | BPU | 2020 | 2019 EMP Strategy 1 Goal Summary, p. 88 |
| Apply resources from Volkswagen Settlement fund; NJ Clean Energy Program; utility programs; public-private partnerships, It Pay$ to Plug In program to build charging infrastructure. | DEP, BPU, EDA | Near-term | 2019 EMP Goal 1.1.2 |
| Update building codes to require appropriate electric provisions for electric vehicle readiness in wide range of situations. Streamline local approval process. | DCA, DEP | Near-term | 2019 EMP Goal 1.1.2. See also Goal 4.1.5. |
| Incorporate planning for installation of electric vehicle charging upon renewal of lease and/or facility upgrades at each yard where technically feasible. | NJ TRANSIT | Near-term | 2019 EMP Goal 1.1.2; EMP Strategy 1 Goal Summary, p. 89 |
| Expand state-owned electric vehicle and hybrid fleet, with concomitant expansion of charging infrastructure through the development of a state contract to install electric vehicle chargers at state properties and through the development of a state fleet transition plan. | Treasury, All State Agencies with fleets | Near- and mid- term. Transition plan due by June, 2021. Full transition ten years after charging infrastructure is fully operational. | 2019 EMP Goal 1.1.2; 2019 EMP Strategy 1 Goal Summary, p. 89 |

[12] Near-term: now through 2030. Mid-term: 2030-2040. Long-term: 2040-2050. Throughout: Ongoing now through 2050.

| Actions | Entity | Timeframe[12] | References |
|---|---|---|---|
| Consider expansion of sales tax exemption to new and used plug-in hybrid models commensurate with battery range. | Legislature, Treasury | Near-term | 2019 EMP Goal 1.1.3 |
| Increase consumer and fleet awareness and acceptance of electric vehicles. | DEP | Throughout | 2019 EMP Goal 1.1.4 |

*Table 1.7. Recommendations for Decarbonization of Medium- and Heavy-Duty Vehicles.*

| Actions | Entity | Timeframe | References |
|---|---|---|---|
| Partner with industry to develop incentives to electrify the medium- and heavy-duty vehicle fleet with battery or fuel cell technology, and to support research and development that will enable such electrification. | EDA | Throughout | 2019 EMP Goal 1.1.8 |
| Implement initiatives and identify funding sources to fulfill the multi-state memorandum of understanding which sets targets for zero-emission medium- and heavy-duty truck sales. | DEP, BPU | Near-term | |
| Evaluate potential regulatory pathways including requirements for manufacturers to produce zero emission trucks and for fleets to turnover to zero emission trucks. Consider establishing "zero emission zones" around the port to protect health of citizens in disproportionately impacted areas. | DEP | Near-term | |
| Develop an action plan to identify barriers and propose solutions, including regulatory, to support widespread electrification of medium- and heavy-duty vehicles. | DEP | December 2020 | EV Law |
| Explore creating a truck rebate program to reduce the incremental up-front cost of purchasing zero-emission vehicles. | DEP, EDA, BPU | Near-term | 2019 EMP Goal 1.1.8 |
| Collaborate with NESCAUM to develop multi-state zero-emission medium- and heavy-duty vehicle action plan. | DEP | Spring 2021 | 2019 EMP Strategy 1 Goal Summary, p. 93 |

*Table 1.8. Recommendations for reducing vehicle miles traveled.*

| Actions | Entity | Timeframe | References |
|---|---|---|---|
| Increase public transit capacity in heavily trafficked areas, specifically on the trans-Hudson connection and through implementation of the gateway project.[13] | NJ TRANSIT | Throughout | NJ TRANSIT 2030 Strategic Plan |
| Expand light rail service in new corridors. | NJ TRANSIT | Throughout | NJ TRANSIT 2030 Strategic Plan |

[13] The gateway project will create two new tunnels connecting New Jersey to New York and expand the Port Authority bus terminal.

| | | | |
|---|---|---|---|
| Prioritize complete streets and other bicyclists and pedestrian-friendly improvements. | NJ TRANSIT, DOT | Throughout | NJ TRANSIT 2030 Strategic Plan |
| Better coordination of land-use and transit planning, with a focused on expanding transit villages and transit-oriented development. | NJ TRANSIT, DOT, DEP | Throughout | 2019 EMP Goal 1.2.2<br><br>NJ TRANSIT 2030 Strategic Plan. |
| Develop recommendations to Legislature that support work-from- home initiatives such as tax breaks to companies that support employees working from home at least part of the time. | DEP, DOT | Near-term | |

*Table 1.9. Recommendations for maximizing efficiency of existing fossil fuel vehicles.*

| Actions | Entity | Timeframe | References |
|---|---|---|---|
| Continue to advocate for stricter GHG emission standards for fossil fuel vehicles. | DEP | Throughout | |

Complementary recommendations are specific actions that provide co-benefits, reduce soft costs associated with electrification build out and ensure equity in the electrification transition. They do not necessarily reduce GHG emissions directly.

*Table 1.10. Complementary Recommendations.*

| Complementary Actions | Entity | Timeframe | References |
|---|---|---|---|
| Ensure that all residents benefit from electric modes of transportation by implementing electric ride sharing/hailing, electric transit buses, tiered incentives for low- and moderate-income households, and proportional incentives for used EVs. | BPU, DEP, DOT | Near-term | 2019 EMP Goal 1.1.7 |
| Promote use of LOGOS highway exit signage program to alert public to availability of charging stations. | DOT | Near-term | 2019 EMP Goal 1.1.2; 2019 EMP Strategy 1 Goal Summary, p. 89 |
| Develop public-private partnerships with transportation network companies, investors, other parties to advance charging infrastructure. | EDA | Near-term | 2019 EMP Goal 1.1.2 |
| Establish ownership model for charging infrastructure in context of utility filings. | BPU | End of 2020 | 2019 EMP Goal 1.1.2; 2019 EMP Strategy 1 Goal Summary, p. 89 |
| Support and expand the Complete Streets program. Prioritize multi-modal accommodations (e.g. pedestrians and bicycles) in projects located in low- and moderate-income and environmental justice communities. | DCA, DOT | Near-term | 2019 EMP Goal 1.2.1; 2019 EMP 1.1.7 |

| | | | |
|---|---|---|---|
| Continue and expand programs to electrify diesel-powered transportation and equipment at New Jersey ports and airports. | DEP, NJDOT | Near-term. Incentive funding to be disbursed 2020. PSEG/PANYNJ electrification roadmap proposed for 2020 completion. Cargo handling phase-out program starts 2021. | 2019 EMP Goal 1.3.1 |
| Enact policies to attract private capital into electric vehicle charging; use shareholder support instead of ratepayer funds wherever possible. | BPU, other agencies | Near-term | 2019 EMP Goal 1.1.2 |
| Revise rate structures to accommodate electric vehicle charging, for example by changing demand-charge structures. | BPU | Near-term | 2019 EMP Goal 1.1.2 |
| Enact policies to reduce risk to ratepayers for stranded electric vehicle infrastructure investments due to technology changes and limited use. | BPU, other agencies | Throughout | 2019 EMP Goal 1.1.2 |
| Provide recommendations to the Legislature to create sustainable funding mechanisms to replace fuel tax revenues currently used to maintain transportation infrastructure. | DOT, NJ TRANSIT, State Agencies | Near-term | 2019 EMP Goal 1.2.4 |

## WORKS CITED

APTA. (2019). *Quantifying Greenhouse Gas Emissions from Transit.* Retrieved from https://www.apta.com/wp-content/uploads/Standards_Documents/APTA-SUDS-CC-RP-001-09_Rev-1.pdf

Automotive News. (2018, October 1). *Nearly 100 electrified models slated to arrive through 2022*. Retrieved from Automotive News: https://www.autonews.com/article/20181001/OEM04/181009990/nearly-100-electrified-models-slated-to-arrive-through-2022

CARB. (2019a, July 25). California and major automakers reach groundbreaking framework agreement on clean emission standards. Retrieved from https://ww2.arb.ca.gov/news/california-and-major-automakers-reach-groundbreaking-framework-agreement-clean-emission

CARB. (2019b). Terms for Light-Duty Greenhouse Gas Emissions Standards. Retrieved from https://ww2.arb.ca.gov/sites/default/files/2019-07/Auto%20Terms%20Signed.pdf

Dingel, J. I., & Neiman, B. (2020a, April 16). *How Many Jobs can be Done at Home?* Retrieved from University of Chicago Booth School of Business: https://bfi.uchicago.edu/wp-content/uploads/BFI_White-Paper_Dingel_Neiman_3.2020.pdf

Dingel, J. I., & Neiman, B. (2020b, June 1). *Work at Home Potential by Metropolitan Statistical Area.* Retrieved from GitHub: https://raw.githubusercontent.com/jdingel/DingelNeiman-workathome/master/MSA_measures/output/MSA_workfromhome.csv

Federal Register. (2019). *The Safer Affordable Fuel-Efficient (SAFE) Vehciles Rule, 84 Fed. Reg. 51,310.* Retrieved from https://www.govinfo.gov/content/pkg/FR-2018-08-24/pdf/2018-16820.pdf

Federal Register. (2020). SAFE Rule 85 Fed. Reg. 24,174.

Guyot, K., & Sawhill, I. V. (2020, April 6). *Telecommuting will likely continue long after the pandemic.* Retrieved from Brookings Institution: https://www.brookings.edu/blog/up-front/2020/04/06/telecommuting-will-likely-continue-long-after-the-pandemic/

Hardman, S., & et al. (2018). A review of consumer preferences of and interactions with electric vehicle charging infrastructure. *Transportation Research Part D: Transport and Environment*, 508-523. doi:https://doi.org/10.1016/j.trd.2018.04.002

Henley, J. a. (2020, April 19). Norway and the A-ha moment that made electric cars the answer. Retrieved from https://www.theguardian.com/environment/2020/apr/19/norway-and-the-a-ha-moment-that-made-electric-cars-the-answer

International ZEV Alliance. (2020). *Announcement*. Retrieved from http://www.zevalliance.org/international-zev-alliance-announcement/

NESCAUM. (2018a). *State Zero-Emission Vehicle Programs Memorandum of Understanding.* Retrieved from http://www.nescaum.org/documents/zev-mou-9-governors-signed-20180503.pdf/

NESCAUM. (2018b). *Multi-State ZEV Action Plan 2018-2021.* Retrieved from http://www.nescaum.org/documents/2018-zev-action-plan.pdf/

NESCAUM. (2019). *California and seven states commit to faster transition to zero-emission trucks and buses. Next step is formal agreement.* Retrieved from http://www.nescaum.org/documents/nescaum-press-release_12-12-19.pdf/

Nicholas, M. a. (2018). *Lessons Learned on Early Electric Vehicle Fast-Charging Deployments.* The International Council on Clean Transportation. Retrieved from https://theicct.org/sites/default/files/publications/ZEV_fast_charging_white_paper_final.pdf

NJ TRANSIT. (2020). *Facts at a Glance FY 2019.* Retrieved from https://content.njtransit.com/sites/default/files/2020-04/FactsAtaGlance.pdf

NJBPU. (2020). *New Jersey Electric Vehicles Infrastructure Ecosystem 2020 Straw Proposal.* Retrieved from https://www.nj.gov/bpu/pdf/Final_EV_Straw_Proposal_5.18.20.pdf

NJDEP. (2008). *New Jersey Greenhouse Gas Inventory and Reference Case Projections 1990-2020.* Retrieved from https://www.nj.gov/dep/climatechange/data.html

NJDEP. (2009). *New Jersey Statewide Greenhouse Gas Emissions Inventory Update: 2005, 2006, 2007.* Retrieved from https://www.nj.gov/dep/climatechange/data.html

NJDEP. (2019). *2018 Statewide Greenhouse Gas Emissions Inventory.* Retrieved from https://www.nj.gov/dep/aqes/docs/nj-ghg-inventory-report-2018.pdf

NJDEP. (2020a). *New Jersey Partnership to Plug-In.* Retrieved from https://www.drivegreen.nj.gov/dg-partnership-to-plugin.html

NJDEP. (2020b). *It Pay$ to Plug In.* Retrieved from https://www.drivegreen.nj.gov/plugin.html

NJDEP. (2020c). *New Jersey to invest nearly $45 million in electrification of transportation sector; focus on air quality improvements in environmental justice communities.* Retrieved from https://www.nj.gov/dep/newsrel/2020/20_0018.htm

NJDEP. (2020d, August 3). Bureau of Air Monitoring, The Impact of the "Stay at Home" Directive on Air Quality in New Jersey Presentation. Retrieved from: https://www.nj.gov/dep/cleanair/cac-past-meet-agenda-minutes.html.

NJDEP. (2020e, January 28). *Drive Green*. Retrieved from https://www.drivegreen.nj.gov/dg-charging.html

NJDOT. (2019). *Transit Village Initiative*. Retrieved from https://www.state.nj.us/transportation/community/village/

P.L. 2005 c.219. (2005). *Diesel Retrofit Law.* Retrieved from https://www.nj.gov/dep/stopthesoot/docs/Diesel%20retrofit%20law%20for%20website%20with%202006%20amendments.pdf

P.L. 2019 c.362. (2020). *An Act Concerning the Use of Plug-In Vehicles.* Retrieved from State of New Jersey: https://www.njleg.state.nj.us/2018/Bills/PL19/362_.HTM

P.L. 94-163. (1975). *Energy Policy and Conservation Act.* Retrieved from https://www.govtrack.us/congress/bills/94/s622/text

Solomon, M. (2018). *Moving to Zero Emissions in the Northeast.* Retrieved from https://www.state.nj.us/dep/cleanair/PPP/2018/Moving%20to%20Zero%20Emissions%20in%20the%20Northeast.pdf

US Bureau of Labor Statistics. (2019, September 24). *Table 1, Workers who could work at home, did work at home, and were paid to work at home.* Retrieved from Job flexibilities and work schedules - 2017-2018 Data from the American Time Use Survey, : https://www.bls.gov/news.release/flex2.t01.htm

US Bureau of Labor Statistics. (2020). *Economy at a Glance: New Jersey.* Retrieved from https://www.bls.gov/eag/eag.nj.htm

US Census Bureau. (2018). *New Jersey Profile, from 2018 American Community Survey 1-year estimates.* Retrieved from https://data.census.gov/cedsci/profile?q=New%20Jersey&g=0400000US34&tid=ACSDP1Y2018.DP05

USEPA. (2012). *Regulatory Impact Analysis: Final Rulemaking for 2017-2025 Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards (EPA-420-R-12-016).* Washington, D.C.: USEPA.

USEPA. (2014). *Motor Vehicle Emissions Simulator (MOVES).* Retrieved from https://www.epa.gov/moves

CHAPTER 2

# RESIDENTIAL AND COMMERCIAL

## RESIDENTIAL AND COMMERCIAL SECTOR SNAPSHOT

### 2018 EMISSIONS DATA

- The residential sector emitted **15.2 MMT $CO_2$e** and the commercial sector emitted **9.4 MMT $CO_2$e** in 2018.

### EMISSIONS ACTIVITIES

- New Jersey's residential and commercial sector emissions are associated with space and water heating, cooking and onsite power generation.

### CLIMATE POLLUTANTS OF CONCERN

- Carbon Dioxide ($CO_2$)

### EMISSION REDUCTION PATHWAYS

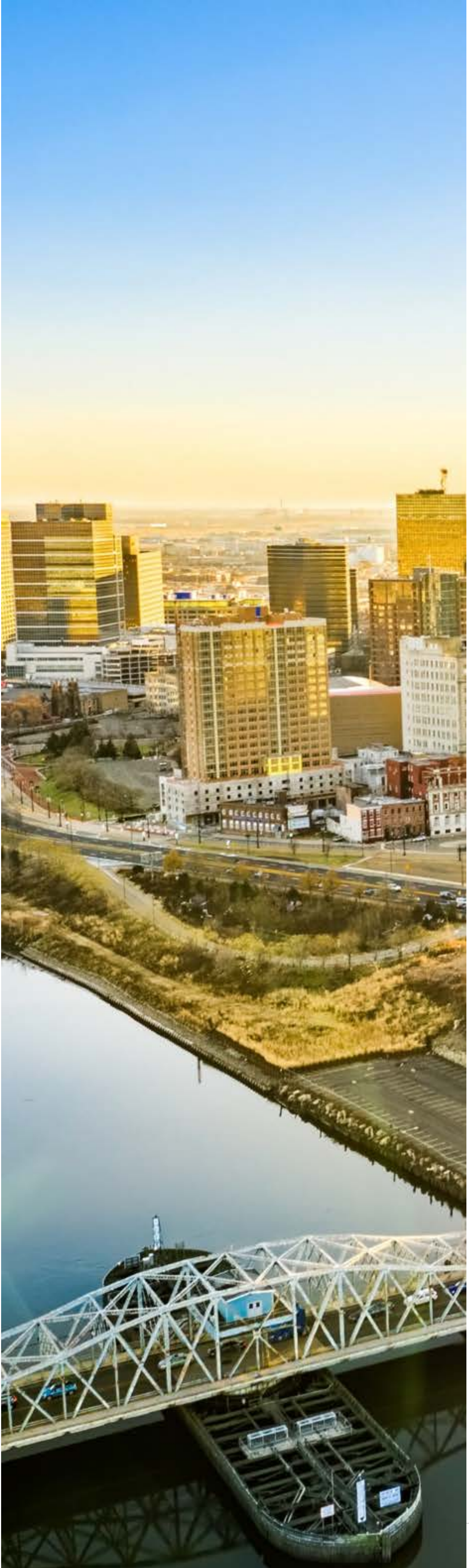
1. Electrify space and water heating
2. Maximize energy efficiency in existing buildings

### RECOMMENDATIONS

1. Develop a Buildings Electrification Roadmap, which provides strategies and concrete timelines for achieving widespread electrification.
2. Prioritize near-term conversion of buildings relying on propane and heating oil, starting no later than 2021.
3. In coordination with the New Jersey Department of Community Affairs (DCA), consider legislation governing all new construction and upgrades to facilitate the transition to a decarbonized building.
4. Mandate energy audits in State buildings and encourage/incentivize energy audits in county and municipal buildings.
5. Adopt new construction net zero carbon goals for commercial and residential buildings.

### AGENCY STAKEHOLDERS

- New Jersey Board of Public Utilities
- New Jersey Department of Community Affairs
- New Jersey Economic Development Authority
- New Jersey Department of Environmental Protection
- New Jersey Department of Treasury



## OVERVIEW

The residential sector consists of private households, multi-family and apartment buildings, while the commercial sector includes retail space, hospitals, senior care facilities, schools, local, state and federal government buildings, religious buildings, universities, and sewage treatment facilities (USEIA, 2020). Combined these sectors are the 2nd largest emitter of greenhouse gases (GHG) in New Jersey.

GHGs are emitted by both sectors through "direct" emissions that are produced onsite at the facilities and via "indirect" emissions that occur offsite but are associated with the building sector's use of electricity. This chapter narrows its focus to direct emissions, which come from the onsite consumption of fossil fuels (e.g., natural gas or fuel oil) for space and water heating, clothes drying and cooking needs; management of waste and wastewater, and leaks from refrigerants in homes and businesses (USEPA, 2019). Indirect emissions[1] are associated with grid-supplied power consumed for lighting, refrigeration, air conditioning, heating, and other devices and are accounted for under the Electric Generation Chapter. Halogenated gas emissions related to consumer products such as refrigerants for air conditioning and other appliances are captured under the Short-Lived Climate Pollutant Chapter and non-energy emissions from waste and wastewater treatment are captured in the Waste and Agriculture Chapter.

To achieve New Jersey's 80x50 goal the building sector will need to phase out reliance on fossil fuels and aggressively pursue electrification of heating, cooling and appliances. According to the 2019 Energy Master Plan (2019 EMP), by 2050 at least 90% of the residential and commercial sectors must be electrified to meet the state's clean energy and climate goals (NJBPU, 2019a). This is a significant undertaking, as New Jersey has over 3.6 million housing units (United States Census Bureau, 2019b) that constitute more than 8.6 billion square feet of built area and over 597,000 commercial properties with a total building area of 338.5 million square feet (Reonomy, 2020). The average building area is 2,986 square feet which is almost three times the national average. Additionally, New Jersey's building inventory median age is 61 years, compared to the United State median of 50 years. To achieve the 80x50 GHG reduction target, the state should prioritize the creation of a building electrification roadmap paired with incentives that initially target buildings currently relying on propane and heating oil for space and water heating and inefficient electric resistance baseboard heating. Additionally, the state should mandate that all new construction is net zero carbon no later than 2025 in order to alleviate dependence on fossil fuels for building heating and cooling and to avoid the cost of stranded assets.

[1] Indirect emissions are produced by burning fossil fuel to make electricity, which is then used in residential and commercial activities such as lighting and running appliances (USEPA, 2019).

## WHERE WE STAND

In 2018, the State's residential and commercial sectors collectively emitted an estimated 24.6 MMT $CO_2e$ contributing to New Jersey's net GHG emissions of 97.0 MMT $CO_2e$ (NJDEP, 2019). Natural gas used to heat space and water is responsible for 85% of the 24.6 MMT $CO_2e$ from these sectors; fuel oil and propane use make up the balance (3.7 MMT $CO_2e$).

New Jersey currently estimates emissions from both sectors using fuel consumption data from the United States Energy Information Administration's State Energy Data System (SEDS). New Jersey also collects information on large commercial emitters (e.g., university campuses, hospitals) through the Department of Environmental Protection (DEP) Emission Statement Program, [2] which gathers information on permitted entities to help inform the state's GHG inventory and determine emission reduction strategies.

### *Residential Buildings*

New Jersey's GHG emissions from the residential sector have varied to some degree over time, with a general upward trend. Between 2006 and 2018, the sector experienced a net increase of 1.5 MMT $CO_2e$ (Table 2.1). This increase is attributed to the expansion of housing and its associated natural gas consumption. New Jersey added about 140,000 housing units between 2006-2018 (United States Census Bureau, 2010; United States Census Bureau, 2019a) and on average, over 12,000 new natural gas service lines every year since 2004 (see natural gas transmission and distribution subsection of the Short-Lived Climate Pollutants Chapter). New Jersey's emissions growth in these sectors has been held to the 1.5 MMT $CO_2e$ due to aggressive energy efficiency and clean energy programs sponsored by New Jersey Board of Public Utilities (BPU), New Jersey Economic Development Authority (EDA) and the New Jersey Department of Community Affairs (DCA). BPU's Clean Energy Program, comprised of gas and electric energy efficiency and renewable energy efficiency programs, reduced New Jersey's GHG emissions by about 363,000 metric tons $CO_2e$ in fiscal year 2018 alone (NJBPU, 2018).

***In 2018, the Residential sector was estimated to release 15.2 million metric tons of $CO_2e$. This represents 15.6% of New Jersey's total net emissions.***

*Table 2.1. Annual Residential Sector Greenhouse Gas Emissions 2006 – 2018 (MMT $CO_2e$).*

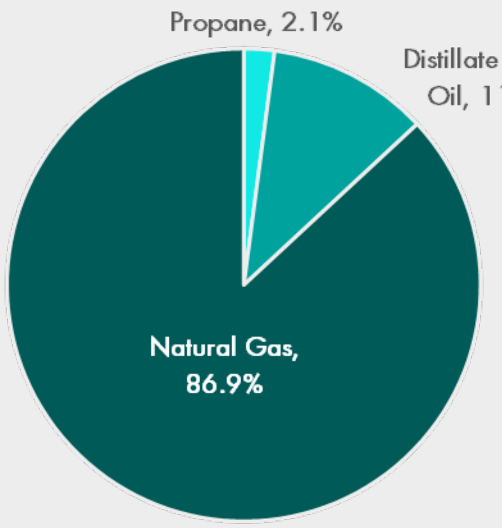
| 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13.7 | 15.6 | 14.9 | 15.2 | 14.2 | 13.6 | 12.1 | 14.7 | 16.1 | 15.5 | 14.6 | 14.5 | 15.2 |

In 2018, direct emissions from the residential sector were primarily attributed to natural gas use (NJDEP, 2019) (Figure 2.1).

[2] Emissions Statement Program is a reporting system that requires all facilities, including commercial buildings, that emit above a certain threshold of emissions, in $CO_2$ or methane, to report actual emissions to DEP under this program.

***Figure 2.1. Residential Emission Sources by Percentage of Total 15.2 MMT $CO_2e$ in 2018.***
*Natural gas was responsible for the greatest proportion of direct emissions from the residential sector, at nearly 87%. Fuel oil contributed an additional 11%, and propane just over 2%.*

*Source: USEIA*



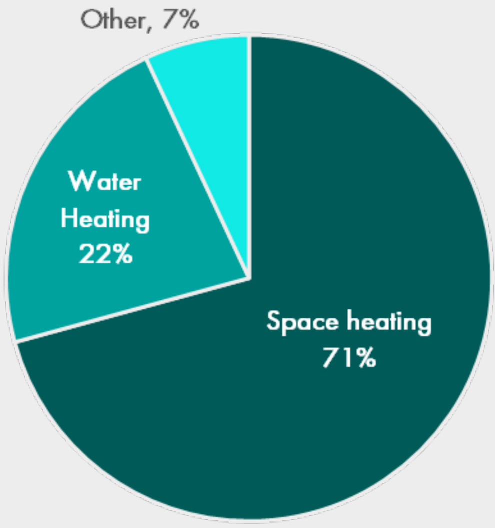




***Figure 2.2: Natural Gas End Uses in Residential Buildings in Mid-Atlantic Region in 2015.***
*Combined, space and water heating accounted for 93% of residential emissions and represented the greatest opportunities for emissions reductions from this sector.*

*Source: EIA RECS 2009 Survey (USEIA, 2015) Note: 'Other' category includes appliances such as clothes driers and generators*

A recent EIA survey (USEIA, 2015) of the mid-atlantic region's residential sector (New York, New Jersey and Pennsylvania) estimated natural gas end-uses to be largely space heating and water heating (Figure 2.2). According to most recent Residential Energy Consumption Survey, New Jersey households, on a per-household basis, are the highest consumers of natural gas used in residential heating in the country (in Btu per year), (USEIA, 2015). Three out of four New Jersey homes use natural gas as their primary home heating fuel (USEIA, 2019). The prevalence of natural gas use is linked to the fact that five major interstate gas pipelines crisscross the state and to New Jersey's proximity to Pennsylvania, a well-known source of natural gas.

### *Commercial Buildings*

GHG emissions from the commercial sector have varied over the past twelve years; however, most recently emissions trended down from a high of 12.3 MMT $CO_2e$ in 2014 to 9.4 MMT $CO_2e$ in 2018 (Table 2.2). Much of this downward trend is attributed to the BPU's Clean Energy Program. In its most recent fiscal year 2019 data, the Clean Energy Program noted emission savings from the commercial and industrial sector of 113,000 metric tons. (NJBPU, 2019b).

***In 2018, the Commercial sector was estimated to release 9.4 million metric tons of $CO_2e$. This represents 9.7% of New Jersey's total net emissions.***

*Table 2.2. Annual Commercial Sector Greenhouse Gas Emissions 2006 – 2018 (MMT $CO_2e$).*

| 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9.2 | 10.6 | 10.2 | 10.8 | 10.6 | 11.3 | 10.1 | 10.6 | 12.3 | 10.8 | 10.9 | 9.0 | 9.4 |

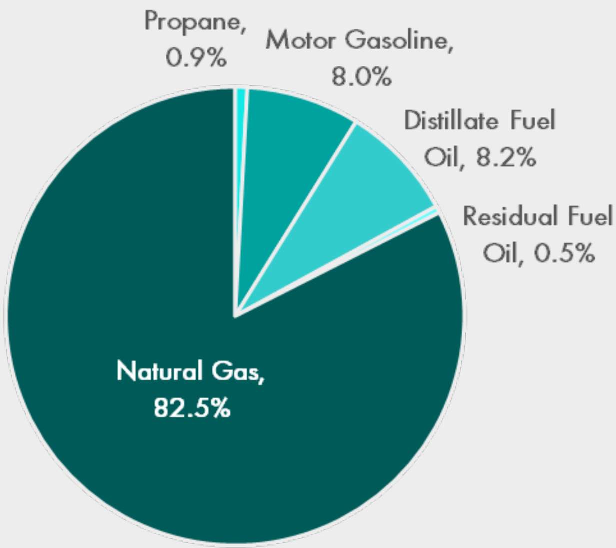
In 2018, direct emissions from the commercial sector were primarily attributed to natural gas, distillate fuel oil, and motor gasoline (NJDEP, 2019) (Figure 2.3).

Common equipment that consumes energy within this sector includes space heating, water heating, cooking, non-road equipment and generators to support the activities of the commercial establishments. Based on the DEP Emissions Statements, the commercial building categories that are significant emitters include colleges, universities, and professional schools; general medical and surgical hospitals; national security (military establishments); sewage treatment facilities; and warehousing/storage facilities.

***Figure 2.3. Commercial Emission Sources by Percentage of Total 9.4 MMT $CO_2e$ in 2018.***

*Natural gas is the largest source of commercial sector emissions at nearly 83%. Commercial emissions also include those from gasoline and diesel-powered equipment such as generators.*

*Source: USEIA*



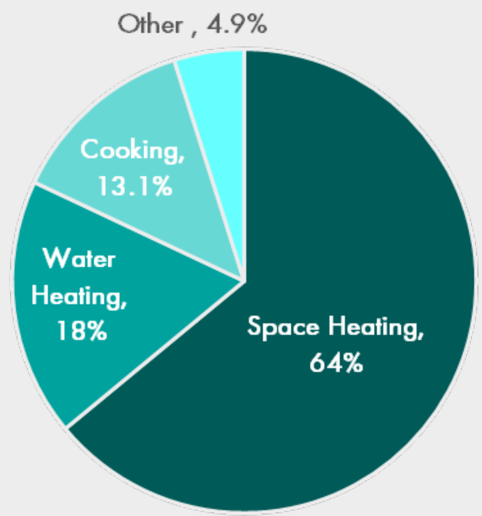




***Figure 2.4: Natural Gas End Uses in Commercial Buildings in the Mid-Atlantic Region in 2012.***

*As with the residential sector, space and water heating make up the largest emissions activities in the commercial sector and offer the greatest opportunities for emissions reductions.*

*Source: (USEIA, 2016)*

## Existing Emissions Reduction Policies

State agencies work in tandem to implement policies that reduce emissions in residential and commercial buildings throughout New Jersey. The BPU reduces emissions in the building sector through the New Jersey Clean Energy Program (NJCEP) and anticipates even greater energy savings in future years due to the recently adopted energy efficiency resource standard established by the 2018 Clean Energy Act and adopted by the BPU in 2020. The DEP regulates air emission sources such as generators, boilers, and process equipment at commercial facilities to ensure compliance with emission standards and to minimize their environmental impact. The DCA oversees building codes aimed at reducing energy demand and improving energy efficiency in new and existing construction.

### *Clean Energy Act*

The Clean Energy Act (CEA) (P.L. 2018, c.17) established new clean energy and energy efficiency programs and significantly increased New Jersey's renewable portfolio standards (RPS) requirement. The CEA requires utilities to implement energy efficiency measures to reduce natural gas consumption by at least 0.75% per year and electricity consumption by at least 2% per year until 2030. The BPU set the goal at 1.10% for natural gas reductions and 2.15% for electricity reductions based on achievable potential found in the 2019 Market Potential Study. It also calls for increases in renewable energy such as solar and wind from 21% in 2020 to 50% by 2030, and for adoption of peak demand reduction programs. The reduction of natural gas consumption resulting from increased on-site renewables and reduced peak demand will limit building sector emissions.

### *New Jersey Clean Energy Program*

The NJCEP is administered by the BPU. Currently, the NJCEP offers a suite of programs such as COOLAdvantage and WARMAdvantage[3] for natural-gas fueled residential buildings and SmartStart Buildings for commercial properties, that include rebates for energy efficient heating and cooling equipment including heat pumps and water heaters (NJBPU, 2020a). When the BPU has U.S. Department of Energy funding available, these programs are also available to oil and propane customers. The program issues rebates for energy efficient appliances, lighting, home heating and cooling equipment and office equipment. In-store incentives on energy efficient products are also provided through retailers across New Jersey. The Pay for Performance and Large Energy Users programs help existing and new construction for the large commercial and industrial sector with overall energy use and efficiency improvements. The NJCEP also supports the statewide growth of commercial and industrial combined heat and power and fuel cell (CHP-FC) technologies to enhance energy efficiency through on-site power generation and productive use of waste heat. The Direct Install Program is aimed at providing services to small businesses. Also offered by NJCEP are the Home Performance with ENERGY STAR program that provides low cost energy audits for New Jersey residents, and the Comfort Partners Program offering free energy savings and energy education programs to low-income customers. For local and state government, the NJCEP offers the Local Government Energy Audit and the Energy Savings Improvement Program. The Weatherization Assistance Program provides similar services for the elderly, physically disabled, and low-income persons through the DCA using federal support.

The BPU has established a new framework for utilities to reach the CEA-mandated electric and gas goals in June 2020, to be implemented beginning June 2021. Many of the existing state-administered programs will be consolidated into core program offerings through the state's utilities.

### *Building Codes*

The DCA oversees the building and energy codes for the state. New Jersey's Uniform Construction Code (UCC) is updated approximately every three years, adopting the most current International Building Codes in effect at that time. The most recent updates included 2018 International Building and Energy Conservation Codes. The International Energy Conservation Code (IECC) regulates minimum energy conservation requirements for new buildings and addresses energy uses in both residential and commercial construction, including heating, ventilation, lighting, water heating and power usage for appliances. The IECC also has provisions to encourage installation of onsite renewable energy systems by preparing new commercial and residential buildings for future installation of solar PV or solar thermal systems.

### *'Lead by Example' programs*

BPU's 'Lead by Example' initiative funds, up to a cap, a Local Government Energy Audit (LGEA) program that assists local government agencies, state colleges and universities, select non-profit agencies, and others to examine and identify how they can reduce their energy use (NJBPU, 2020b). Additionally, state agencies promote energy efficiency by working with the Division of Property Management and Construction to develop energy savings plans and P.L 2007, c. 269 requires all new state construction over 15,000 square feet to meet LEED silver level or above.

[3] Rebates and promotions can be found at the following New Jersey's Clean Energy Program webpage https://njcleanenergy.com/main/rebates-and-promotions/rebates-and-promotions

## Business-As-Usual (BAU) Projections

If New Jersey stays on a Business-as-Usual path, emissions from the residential sector are projected to only decrease from 15.2 MMT $CO_2e$ in 2018 to 14.0 MMT $CO_2e$ (Figure 2.5) and emissions from the commercial sector are projected to only decrease from 9.4 MMT $CO_2e$ in 2018 to 8.6 MMT $CO_2e$ (Figure 2.6) by 2030 and remain flat until 2050. Both Business-as-Usual projections assume only fulfillment of the CEA energy efficiency mandate of a 0.75% annual reduction of natural gas use until 2030.

***Figure 2.5. New Jersey Residential Sector Emissions 2018-2050 Business-As-Usual Projection (MMT $CO_2e$).***
*Existing energy efficiency policies are projected to result in modest reductions in emissions from the residential sector through 2030.*

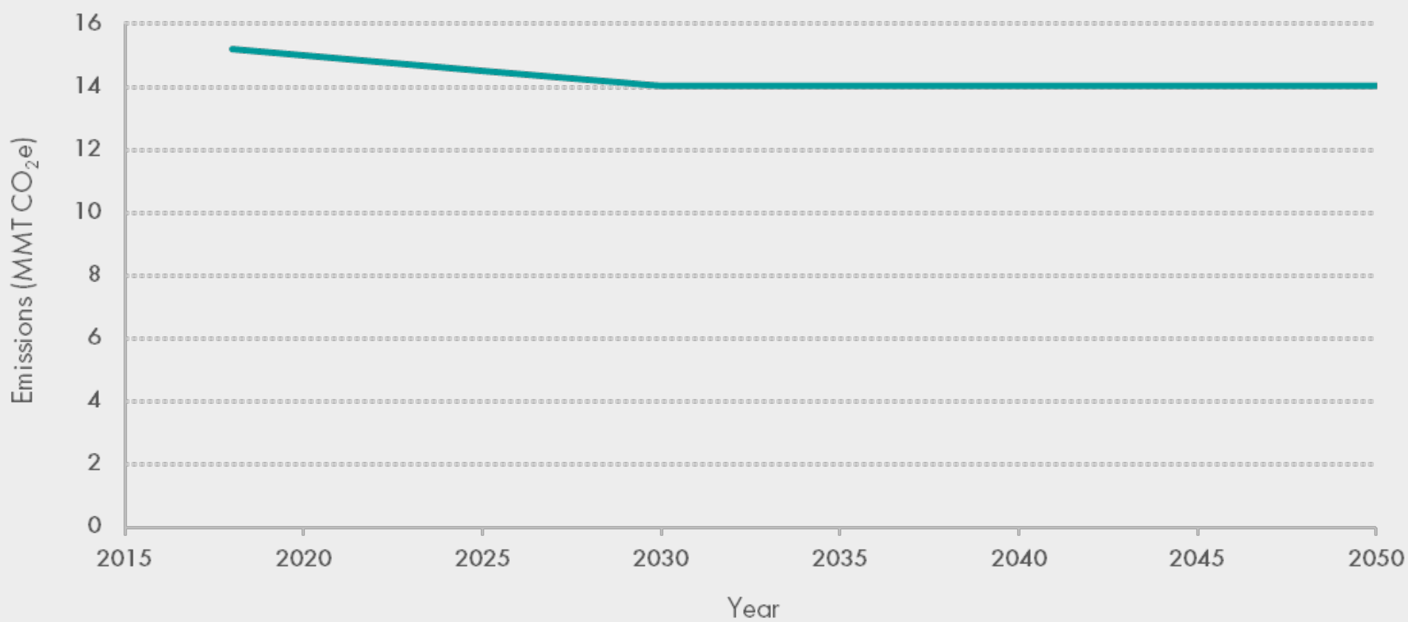
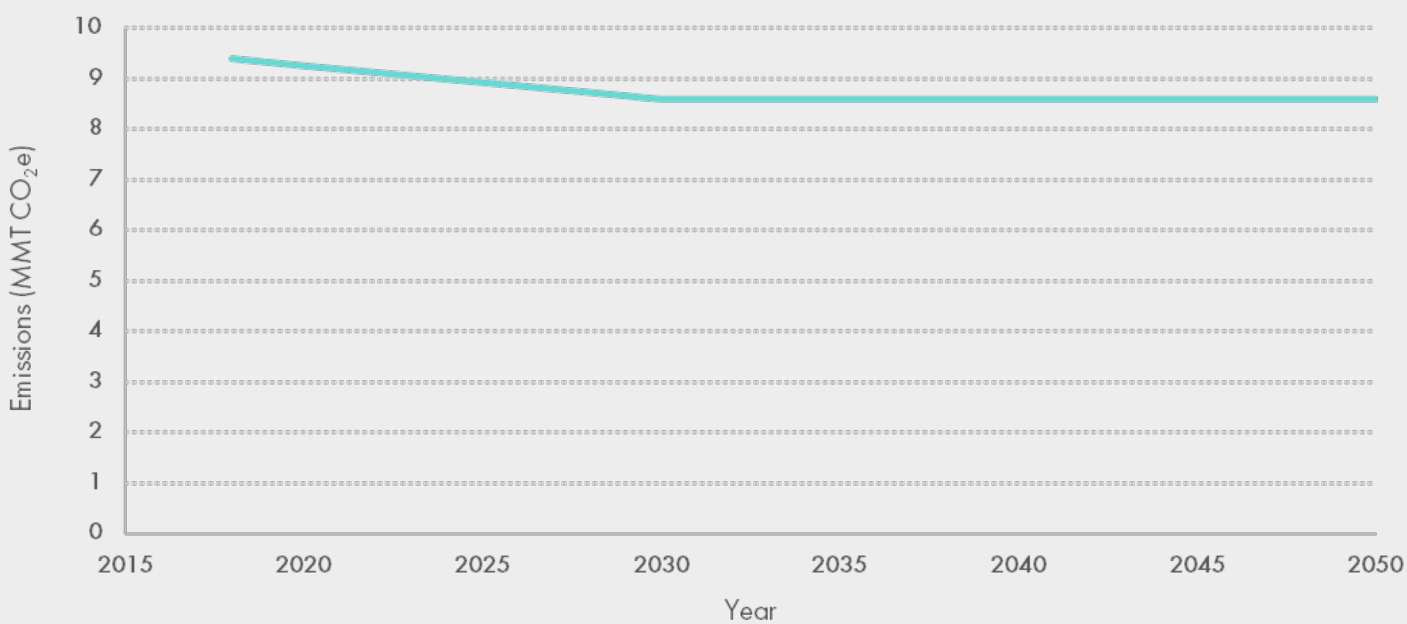



***Figure 2.6. New Jersey Commercial Sector Emissions 2018-2050 Business-As-Usual Projection (MMT $CO_2e$).***
*Commercial sector emissions, like their residential counterparts, are only projected to undergo small reductions through 2030 under current policies.*



## THE PATH FORWARD

As illustrated in the 2019 EMP modeling, the residential and commercial sectors must transition to electric sources of heating, hot water and cooking with 90% conversion completed by 2050 to meet the state's 80% emissions reduction goal at least cost. The 2019 EMP's preferred least cost scenario relies on achieving GHG reductions in the building sectors by converting to electric energy sources such as air-source heat pumps to heat space and water, and electric clothes dryers. With much of New Jersey already developed, the modeling assumes that the majority of fossil fueled equipment is replaced gradually and at the point of failure (i.e., a stock rollover model) by 2050 with significant numbers of replacement beginning in 2030, after several years of demonstration projects illustrating the technologies' effectiveness.

As the commercial and residential sectors transition from relying on fossil fuels to electrification to provide heat and hot water, demand for electricity will increase. The 2019 EMP modeling results showed that New Jersey's electric demand would more than double by 2050 from 75,000,000 MWh (Megawatt hours) to 168,000,000 MWh annually due to electrification of the transportation and building sectors; of this increased electric demand, 38,600,00 MWh is attributed to residential electricity demand and 66,800,000 MWh is attributed to commercial electricity demand. In order to meet the 80x50 emissions mandate, it is critical that the transition away from reliance on natural gas, propane and oil for building electricity and heating needs is accompanied by complementary efforts that decarbonize the electric generating sector. These decarbonization pathways are discussed in the Electric Generation Chapter.

Two pathways have been identified as key to achieving the emissions reductions envisioned in the 2019 EMP;

- Pathway 1, Electrify Space and Water Heating and other appliances, evaluates emissions impacts associated with electrification; and
- Pathway 2, Maximize Energy Efficiency, examines improving the energy efficiency of existing buildings and ensuring new construction is built to the highest efficiency standards.

Collectively, Pathway 1 and 2 will potentially eliminate about 21.9 MMT $CO_2e$ from the building sector by 2050 (Figure 2.7 and 2.8). This estimate of GHG reductions is based on inhouse projections developed by DEP, which take into account the CEA's mandated energy efficiency goals and 2019 EMP recommended electrification of space and water heating.

### EMISSIONS ACTIVITES

- Space Heating
- Water Heating
- Cooking
- Clothes Drying
- Running Generations

### EMISSIONS REDUCTION PATHWAYS

1. Electrify space and water heating
2. Maximize energy efficiency

*Figure 2.7. Estimated emissions due to electrification and natural gas energy efficiency in the Residential Sector (MMT $CO_2e$).*
*Substantial reductions in emissions will be achieved through adoption of electric-powered alternatives. The greatest reductions are associated with electrifying natural gas systems.*

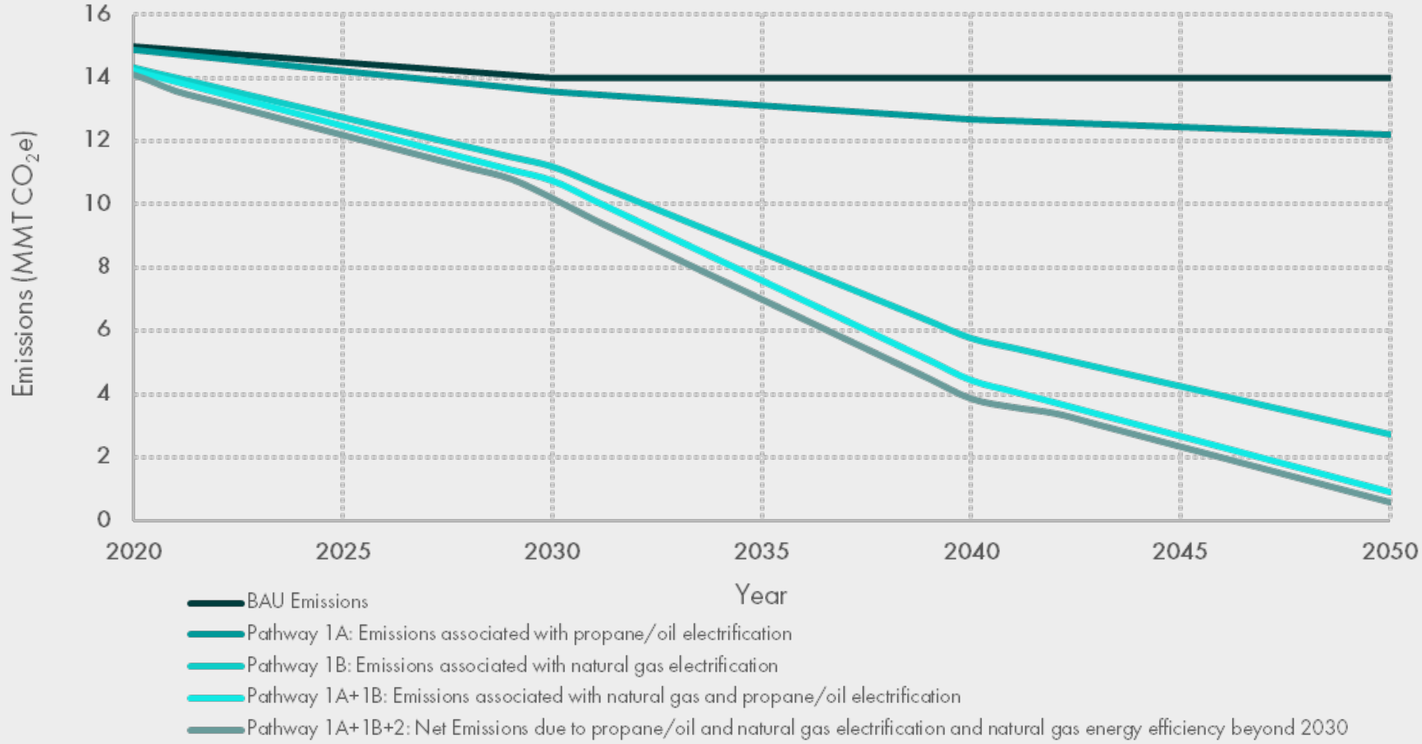
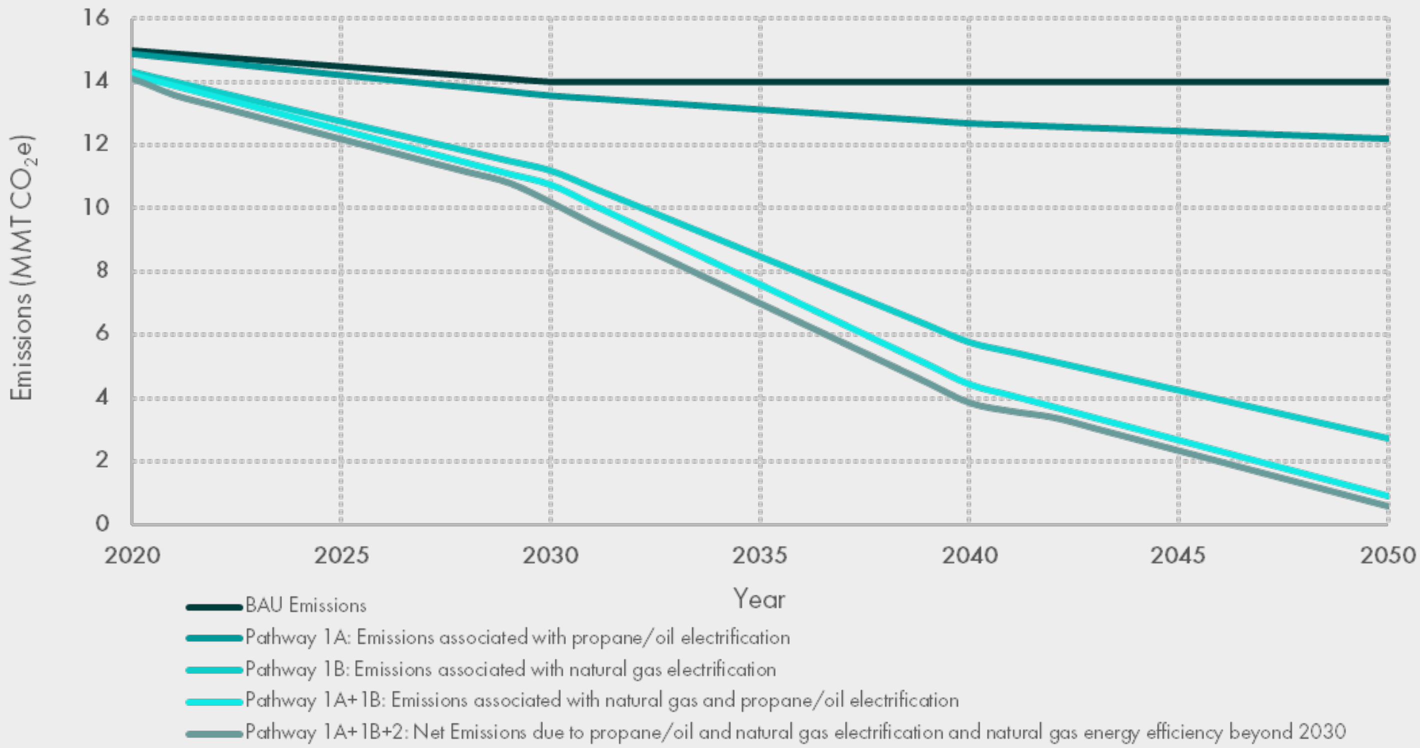



*Figure 2.8. Estimated emissions due to electrification and natural gas energy efficiency in the Commercial Sector (MMT $CO_2e$).*
*As with the residential sector, emissions reductions in the commercial sector will benefit from adoption of electric-powered alternatives.*

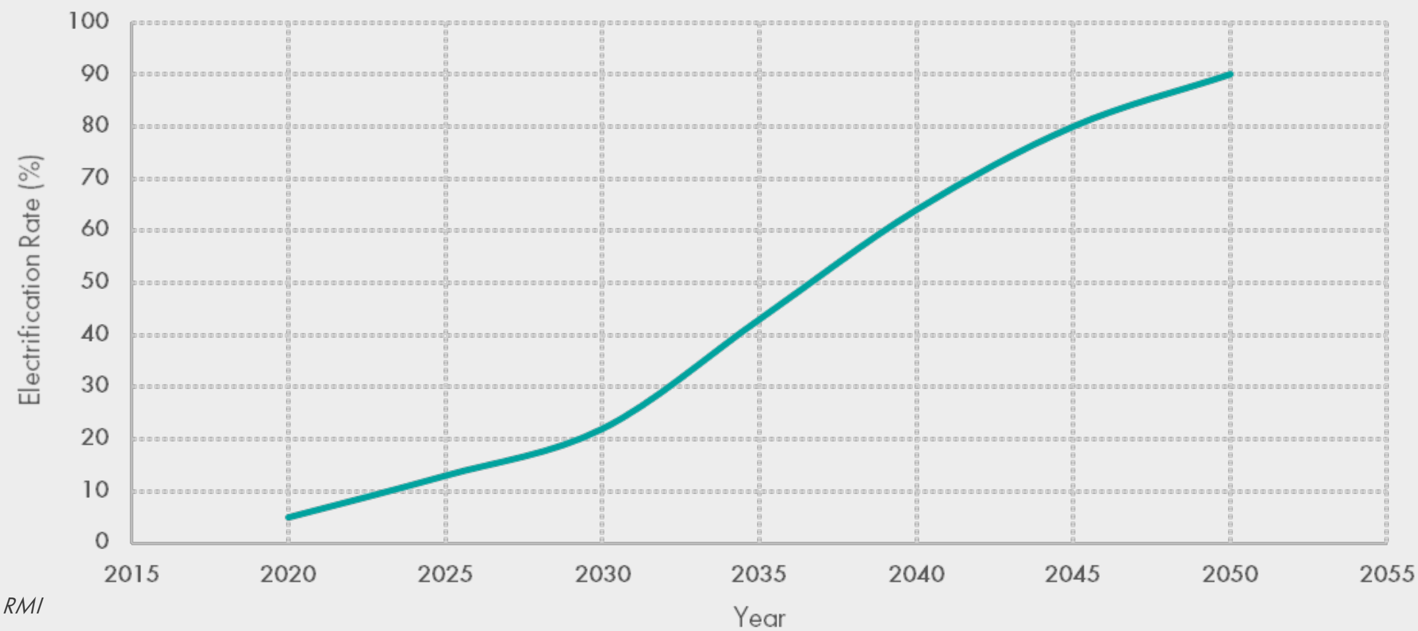


## **Emissions Reduction Pathway 1:** Electrify space heating and water heating

Pathway 1 quantifies the emission benefits of electrification of space and water heating and other appliances. The 2019 EMP relies on significant electrification of existing residential and commercial buildings to eliminate on-site fossil fuel combustion. Its least cost scenario assumes 90% of residential and commercial buildings are electric by 2050. The adoption of electric heat pumps as prescribed by the 2019 EMP modeling uses an electrification curve that starts at a lower rate of ~5% in 2020 and increases until a maximum rate of ~90% in 2050 in both sectors (Figure 2.9).

***Figure 2.9: Average Electrification Rate in Residential and Commercial Buildings.***

*By 2050, the installed base of electric high-efficiency alternatives for space heating and hot water will reach approximately 90% under the least cost scenario of the 2019 EMP. Since these types of equipment have long service lives, sales of new heating and hot water units must shift rapidly to the new technologies, reaching approximately 75% of total sales by 2030.*




*Source: RMI*

DEP evaluated emission reductions from fuel oil and propane electrification (labeled Pathway 1A in Figures 2.7 and 2.8) and emission reductions associated with natural gas electrification (labeled Pathway 1B in Figures 2.7 and 2.8). Pathway 1A is anticipated to reduce emissions in the residential sector by 1.8 MMT $CO_2e$ and in the commercial sector by 0.6 MMT $CO_2e$ by 2050. Pathway 1B brings larger reductions, with an anticipated decrease of 11.3 MMT $CO_2e$ in the residential sector and 5.7 MMT $CO_2e$ in the commercial sector by 2050.

Immediate opportunity for electrification exists in areas without natural gas distribution and areas with significant numbers of legacy fuel oil and propane heating systems. Oil and propane are carbon intensive fuels, hence prioritizing the transition away from these fuels will result in significant early reductions in residential and commercial building emissions. Additionally, efficiently produced heat from air source heat pumps is less expensive than propane and heating oil. The American Council for an Energy Efficient Economy (ACEEE) found that paybacks to replace oil or propane furnaces with air source heat pumps are in the two-year timeframe, and replacement of oil and propane boilers with ductless air source heat pumps had a six to nine year payback period (Nadel, 2018). These heat pumps can also provide efficient space cooling which avoids purchasing separate air conditioners and furnaces, and results in additional energy and cost savings.

In 2018, the largest percentage of homes using fuel oil for heating were located in Morris, Sussex, Essex, Warren and Hunterdon counties (Figure 2.10) (United States Census Bureau, 2018). Similarly, the greatest percentage of homes using propane were located in Sussex, Warren, Hunterdon, Burlington, Atlantic and Cape May counties (Figure 2.11). The northwest parts of the state and rural southern areas do not have access to natural gas infrastructure making them obvious earlier adopters for electrification. Moreover, Newark and Jersey City have some of the highest number of homes using fuel oil and propane. Focusing initial conversions to this segment of the building sector could also provide local air quality co-benefits, through the reduction of particulate matter, exposure to which is linked to asthma, obesity, developmental delays, and other health problems.

***Figure 2.10. Fuel oil heating equipment by total and percentage in the Residential Sector.***

*The largest percentage of homes using fuel oil for heating were located in Morris, Sussex, Essex, Warren and Hunterdon counties, however Jersey City and Newark also have a large number of homes with these systems.*

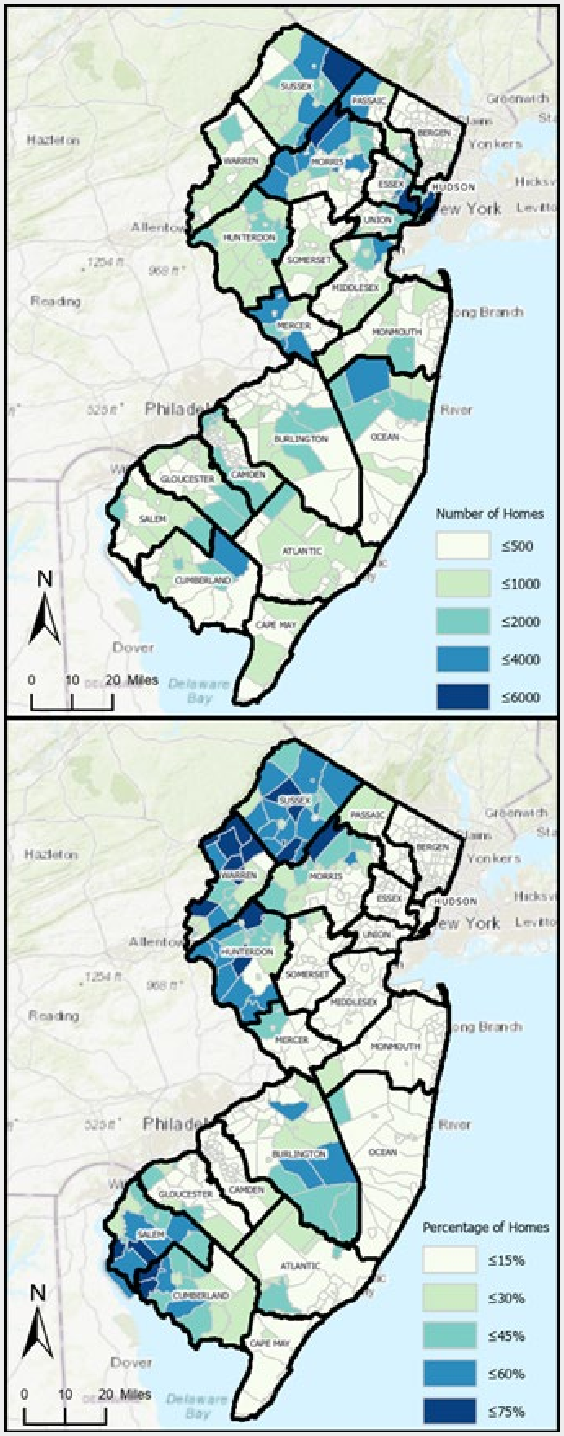
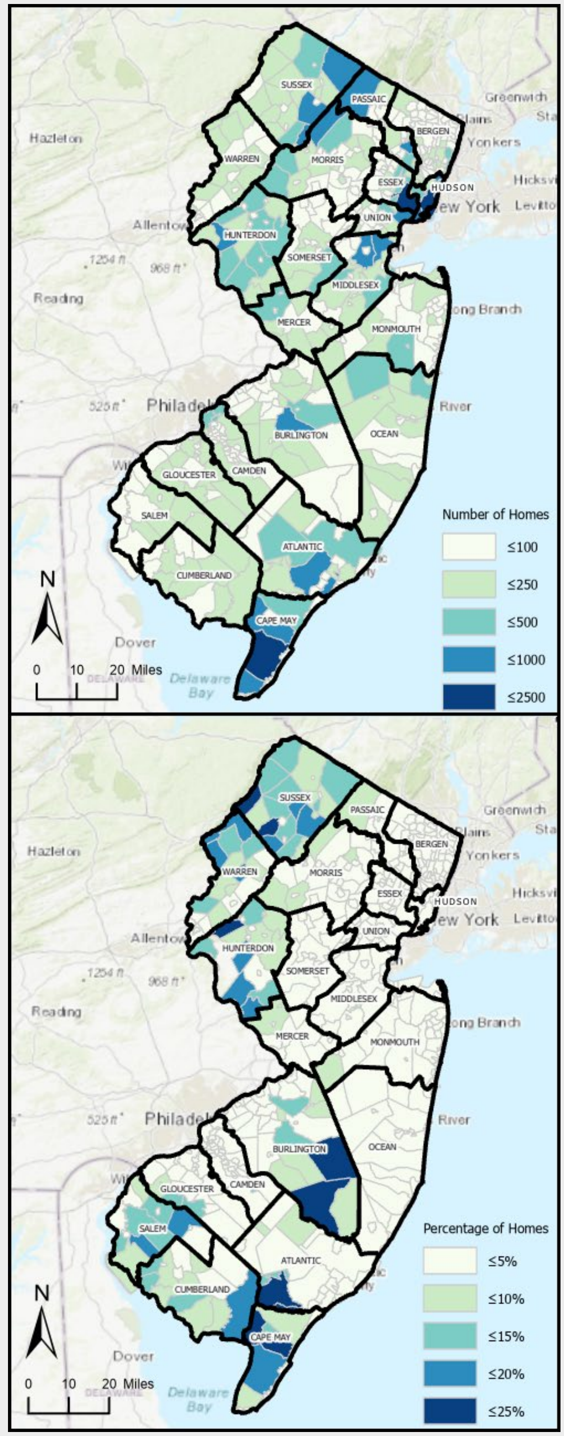



***Figure 2.11. Propane heating equipment by total and percentage in the Residential Sector.***

*The greatest percentage of homes using propane were located in Sussex, Warren, Hunterdon, Burlington, Atlantic and Cape May counties.*



Tackling natural gas use in the building sector will be a more complex and impactful process than addressing propane and fuel oil. Seventy-five percent of New Jersey residences are heated with natural gas, representing the bulk of the emissions in this sector. These buildings coupled with commercial properties will need to begin conversion to electricity by 2030 to achieve the 80x50 goal. The 2019 EMP notes in Strategy #4 that state-of-the-art air and ground-source heat pumps are approximately twice as efficient as electric baseboard resistive heating and have similar or lower operational costs than natural gas furnaces. Incentivizing the replacement of existing oil, propane and natural gas with modern heat pumps is a cost-effective strategy in decarbonizing existing buildings. Although not accounted for here, resistive heating systems are also a candidate for replacement.

## **Emissions Reduction Pathway 2:** Maximize energy efficiency

Energy efficiency improvements are firmly established as among the most cost effective strategies available for reducing fossil fuel consumption and resulting GHG emissions (Molina & Kiker, 2019; Optimal Energy, 2019). A reduction in natural gas use will result in direct emissions reductions from the commercial and residential sector while a reduction in grid-supplied electricity consumption will result in indirect emissions reductions that will be realized in the electric generating sector.

With respect to the residential and commercial sectors, the 2019 EMP least cost scenario assumes that energy efficiency improvements occur at the same time that electric technologies are adopted. It is useful to look at the relative contributions of each effort to understand their roles. Because emissions reductions for the electricity sector are discussed in a separate chapter of this report, the discussion here is focused on emissions from natural gas. It is also important to note that the 2019 EMP assumes a "just-in-time" coordination of effort between expansion of renewable electric capacity and the shift of services from fossil fuels to the electric grid so that emissions are not simply shifted but instead are eliminated entirely.

The energy efficiency pathway projection assumes reduced fuel demand due to electrification in a particular year and further reductions in natural gas consumption at the rate of 0.75% each year due to energy efficiency measures until 2050. Pathways 1A, 1B and Pathway 2 can reduce emissions by 89% for the residential and commercial sectors combined, with residential emissions reduced 14.6 MMT $CO_2$e and commercial emissions reduced 7.3MMT $CO_2$e in 2050 (Figure 2.7 and 2.8).

In order to achieve the energy efficiency benefits described in Pathway 2 within the building sector, New Jersey will need to utilize a variety of tools and techniques, including energy audits, retrofits and improved building codes.

### *Conducting Energy Audits*

The first step towards achieving emissions reductions from the building sector is through the deployment of energy audits. Energy audits provide building owners with an understanding of current energy use and the associated carbon footprint. A comprehensive energy audit will identify energy conservation measures, energy efficiency practices and on-site generation options. Building owners will need to implement suggested improvements to achieve emissions reductions. Once the identified measures are implemented emissions reductions can be measured and verified.

The 2019 EMP calls for energy audits at all existing state buildings (Goal 3.3.5). Additionally, as of September 2020, 688 unique local government entities (i.e. municipalities, school districts, colleges, municipal utility authorities, etc.) have conducted energy audits by participating in BPU's Local Government Energy Audit (LGEA) program.

### *Benchmarking*

Benchmarking is another important step toward reducing energy consumption and is an effective means to inform and motivate building owners to undertake energy efficiency improvements. Building energy benchmarking uses data to measure how efficiently a building performs over time and enables comparison between similar buildings. As an indicator of energy performance, benchmarking can drive up demand for energy efficiency. Buildings labeled more efficient can command higher rents, have lower vacancy rates, and result in higher property values. The CEA required energy benchmarking in commercial properties of 25,000+ sq.ft. or greater; implementing this law will help further energy efficiency improvements.

### *Retrofitting Existing Buildings*

Modifying the heating and cooling systems of buildings when they are being renovated or retrofitted can provide increased energy efficiency and thermal comfort, while creating safer and healthier living or workspaces. The 2019 EMP's Goal 3.3.3 notes that "retrofitting existing buildings and upgrading equipment has the potential to save 4,247,130 MWh of electricity in the residential sector and 10,172,845 MWh in the commercial and industrial sector." Collectively this is about 2% of annual average savings compared to the state's 2017 electricity consumption. In terms of emissions, this would result in a reduction of 2.6 MMT $CO_2e$ across the residential, commercial, and industrial sectors. Residential retrofits and commercial and industrial upgrades combined can generate savings of 0.7% annually compared to the state's natural gas consumption. Retrofits have the potential of generating energy savings to satisfy the energy efficiency resource standard requirements of the 2018 CEA.

### *Strengthening Building and Energy Codes*

In addition to improving energy efficiency in existing buildings, it will be necessary to consider building codes or above-code alternatives that require and or incentivize efficient building energy use, efficiency grading and increased appliance standards in new construction, as well as the use of onsite renewable energy sources. As reported in the 2019 EMP's Goal 3.3, a 2016 United States Department of Energy (DOE) study found that New Jersey could achieve 26.0 MMT of avoided $CO_2$ emissions and cost savings of $5 billion dollars through continued adoption of updated building codes between 2019 and 2040.

Strategies outlined in the pathways for electrification and energy efficiency can be more easily implemented by adopting them into stricter building codes for new construction. Adoption of new technologies and innovations in buildings can be made easier through inclusion in new construction building or appliance codes.

California has set ambitious state goals for the development of zero net energy buildings.[4] California's requirements include by 2020, all new residential construction will be zero net energy, by 2025 all new major renovations of state buildings will be zero net energy, by 2030 all new commercial construction will zero net energy and 50% of commercial buildings will be retrofit zero net energy. New Jersey can look to these initiatives to inform its efforts and potentially adopt new construction net zero carbon goals.

## 2050 RECOMMENDATIONS

Achieving the 80x50 goal will be a multi-decade process of eliminating fossil fuel use in the building sector through large-scale electrification, while simultaneously ensuring that electricity is produced by clean energy sources. Advancing building electrification, at the scale envisioned in the 2019 EMP and in this report, requires the development of a building electrification roadmap. The roadmap is a crucial first step in facilitating a managed transition to fossil fuel-free buildings. It should establish an equitable and just approach to electrification and detail strategies and concrete timelines for achieving widespread electrification.

The state should also begin paving the way to electrification by tackling low hanging fruit. Electrification of standalone propane, oil heating and inefficient electric resistance baseboard heating can be implemented easily for systems at or near end-of-life. Existing incentives for replacing propane and oil heaters with electric heat pumps for space and water heating need to be strengthened while incentives for efficient fossil fuel appliances are eliminated. Furthermore, State buildings offer an opportunity to demonstrate the viability of technology and identify barriers to electrification. As outlined in the 2019 EMP, state buildings should, under the leadership of the Department of Treasury (Treasury), conduct both in-house and contracted American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) Level 3 energy audits prior to starting retrofits and upgrades. The audits will provide a baseline for a reduction target that will incentivize more efficient use of energy in these buildings. Where the state's resources fall short, Treasury should contract with private entities to complete these audits within 2 years. The audits will facilitate implementation of energy efficiency

---

[4] A zero net energy building is defined as "an energy-efficient building where, on a source energy basis, the actual annual consumed energy is less than or equal to the on-site renewable generated energy" (CPUC, 2020).

as well as renewable energy projects that will lead to clean jobs and cost savings and contribute to building a green economy in the state.

Ultimately the best opportunity to electrify is when a building is being built. Pursuit of updated building and energy codes can improve thermal efficiency and facilitate adoption of electric heat pumps and appliances in new residential and commercial buildings which will avoid locking in investments in natural gas heating systems. Currently the Uniform Construction Code (UCC) Act (N.J.S.A. 52:27D-119 et.seq) requires the State to adopt the most current national model codes. These codes will likely not be as rigorous as those needed to achieve the level of electrification and energy efficiency necessary to meet the 80x50 goal. Enabling legislation should be considered to ensure that New Jersey can adopt more stringent standards.

Any delay in the building electrification transition will lead to stranded assets, higher costs and limited flexibility to further reduce emissions. This is because the infrastructure necessary to support consumption of fossil fuels in buildings, including consumer items such as boilers and appliances, as well as the underlying utility infrastructure, has decades of anticipated lifespan. Further, because the building sector's GHG emissions are so significant, efforts to restrict building electrification will increase pressure in other sectors of New Jersey's economy to reduce emissions in ways that are less feasible or more expensive. The 2019 EMP suggests that it would be most cost-effective to begin new construction of all-electric buildings by 2025 and transition existing building stock during natural stock rollover beginning by 2030. Pursing consumer product rules that require the phase out of fossil fuel heating and other building appliances can assist in this transition.

*Table 2.3. Recommendations for Building Electrification.*

| Actions | Entity | Timeframe[5] | References |
|---|---|---|---|
| Consider enabling legislation to ensure DCA can adopt more stringent building and energy codes. | Legislature | Near-term | EMP Goal 4.1.4 |
| Develop a roadmap to a fully electrify the building sector. | BPU, DCA and DEP | Near-term | 2019 EMP Goal 4.2.2 |
| Create an interagency task force to lead the building sector transition. | BPU, DCA and DEP | Near-term | 2019 EMP Goal 4.2.2 |
| Adopt new construction net zero carbon goals for commercial and residential buildings. | Legislature, BPU, DCA and DEP | Near-term | |
| Evaluate adopting consumers product rules requiring sales of heating and other equipment to be all electric by a specific date. | Legislature, DCA | Near-term | 2019 EMP Goal 3.3.7 |
| Evaluate under the NJPACT rule development, limiting the carbon intensity of allowable fuels, ramping up stringency over time, with an initial focus on banning high-carbon fuels (heavy oils). | DEP | Near-term | NJPACT |
| Strengthen incentives for replacing propane and oil heaters with electric heat pumps for space and water heating and eliminate programs that incentivize fossil fuel replacements. | BPU | Throughout | 2019 EMP Goal 4.2.1 |

[5] Near-term: now through 2030. Mid-term: 2030-2040. Long-term: 2040-2050. Throughout: Ongoing now through 2050.

| | | | |
|---|---|---|---|
| Develop incentives for residential properties replacing older or end-of-life natural gas boilers with electric heat pumps. | BPU | Throughout | 2019 EMP Goal 4.2.1 |
| Regulate facility-wide fleets of boilers at commercial properties to achieve greater emissions reductions and expand electrification. | DEP | Near-term | NJPACT |
| Update building codes for greater electrification to support net zero carbon new construction. | DCA | Near-term – by 2025 | EMP Goal 4.1.4 |
| Require utilities to achieve a certain percentage of energy efficiency savings from the electric sector annually. | BPU | Throughout | EMP Goal 3.1.1 |
| Develop incentives for replacing gas appliances with electric stoves, clothes dryers. | BPU | Throughout | NJCEP Appliance Rebates |
| Implement early electrification pilot projects. | BPU | Near-term with rigorous adoption by late 2020's. | EMP Goal 4.1.2 |

*Table 2.4. Recommendations for Energy Efficiency.*

| Actions | Entity | Timeframe | References |
|---|---|---|---|
| Implement CEA required energy benchmarking in Commercial Properties of 25,000+ sq.ft. or greater. Implement annual EE improvements of 2.15% for electric utilities and 1.10% for gas utilities. | BPU | Near-term | EMP Goal 3.3.2 |
| Mandate energy audits in State buildings. | BPU, Treasury | Near-term | EMP Goal 3.3.5 |
| Require all publicly funded construction to meet lowest technically feasible emissions working towards net zero. | BPU | Throughout | EMP Goal 3.3.4 |
| Incentivize solar thermal water heating in residential buildings. | BPU, DCA | Throughout | EMP Goal 2.3.4 |

*Table 2.5. Complementary Recommendations.*

| Actions | Entity | Timeframe | References |
|---|---|---|---|
| Develop incentive programs to subsidize the cost of replacing fossil equipment (lawn and garden equipment, gas powered pumps and generators) with electric. | BPU, DEP | Near-term | 2019 EMP 4.2.1 |

## WORKS CITED

Molina, M., & Kiker, P. (2019). *The Greatest Energy Story You Haven't Heard: How Investing in Energy Efficieincy changed the US Power Sector and Gave Us a Tool to Tackle Climate Change.* Retrieved March 4, 2020, from American Council for an Energy Efficient Economy: https://www.aceee.org/research-report/u1604

Nadel, S. (2018). *Energy Savings, Consumer Economics, and Greenhouse Gas Emissions reductions from Replacing Oil and Propane Furnaces, Boilers, and Water Heaters with Air-Source Heat Pumps.* American Council for an Energy-Efficienct Economy. Retrieved from https://www.aceee.org/research-report/a1803

NJBPU. (2018). *New Jersey's Clean Energy Program Report: 4QFY18 Final Report.* Retrieved from https://www.njcleanenergy.com/files/file/FINAL%20REPORT%20-%204QFY19(1).pdf

NJBPU. (2019a). *2019 New Jersey Energy Master Plan, Pathway to 2050.* Trenton, NJ: State of NJ.

NJBPU. (2019b). *New Jersey's Clean Energy Program Report: 4QFY19 Final Report.* Retrieved from https://www.njcleanenergy.com/files/file/FINAL%20REPORT%20-%204QFY19(1).pdf

NJBPU. (2020). *New Jersey's Clean Energy Program*. Retrieved from New Jersey Board of Public Utilities: https://njcleanenergy.com/

NJDEP. (2019). *2018 Statewide Greenhouse Gas Emissions Inventory.* Retrieved from https://www.nj.gov/dep/aqes/pdf/GHG%20Inventory%20Update%20Report%202018_Final.pdf

Optimal Energy. (2019). *Energy Efficieincy Potential in New Jersey.* Retrieved from New Jersey Board of Public Utilities: https://s3.amazonaws.com/CandI/NJ+EE+Potential+Report+-+FINAL+with+App+A-H+-+5.24.19.pdf

P.L. 2018, c.17. (n.d.). *Clean Energy Act.* Retrieved from https://www.njleg.state.nj.us/2018/Bills/PL18/17_.PDF

Reonomy. (2020). Retrieved from https://www.reonomy.com/properties/commercial-real-estate/us/new-jersey/1

United States Census Bureau. (2010). *Housing Units Intercensal Datasets: 2000-2010.* Retrieved from https://www.census.gov/data/datasets/time-series/demo/popest/intercensal-2000-2010-housing-units.html

United States Census Bureau. (2018). *American Community Survey- Selected Housing Characterstics.* Retrieved from www.census.gov/programs-surveys/acs

United States Census Bureau. (2019a). *National, State, and County Housing Unit Totals: 2010-2019.* Retrieved from www.census.gov/data/datasets/time-series/demo/popest/2010s-total-housing-units.html

United States Census Bureau. (2019b). *Quick Facts New Jersey*. Retrieved from https://www.census.gov/quickfacts/NJ

USEIA. (2015). *2009 Residential Energy Consumption Survey.* Retrieved from www.eia.gov/consumption/residential/data/20092015/

USEIA. (2016). *Commercial Buildings Energy Consumptions Survey (CBECS)*. Retrieved from https://www.eia.gov/consumption/commercial/reports.php

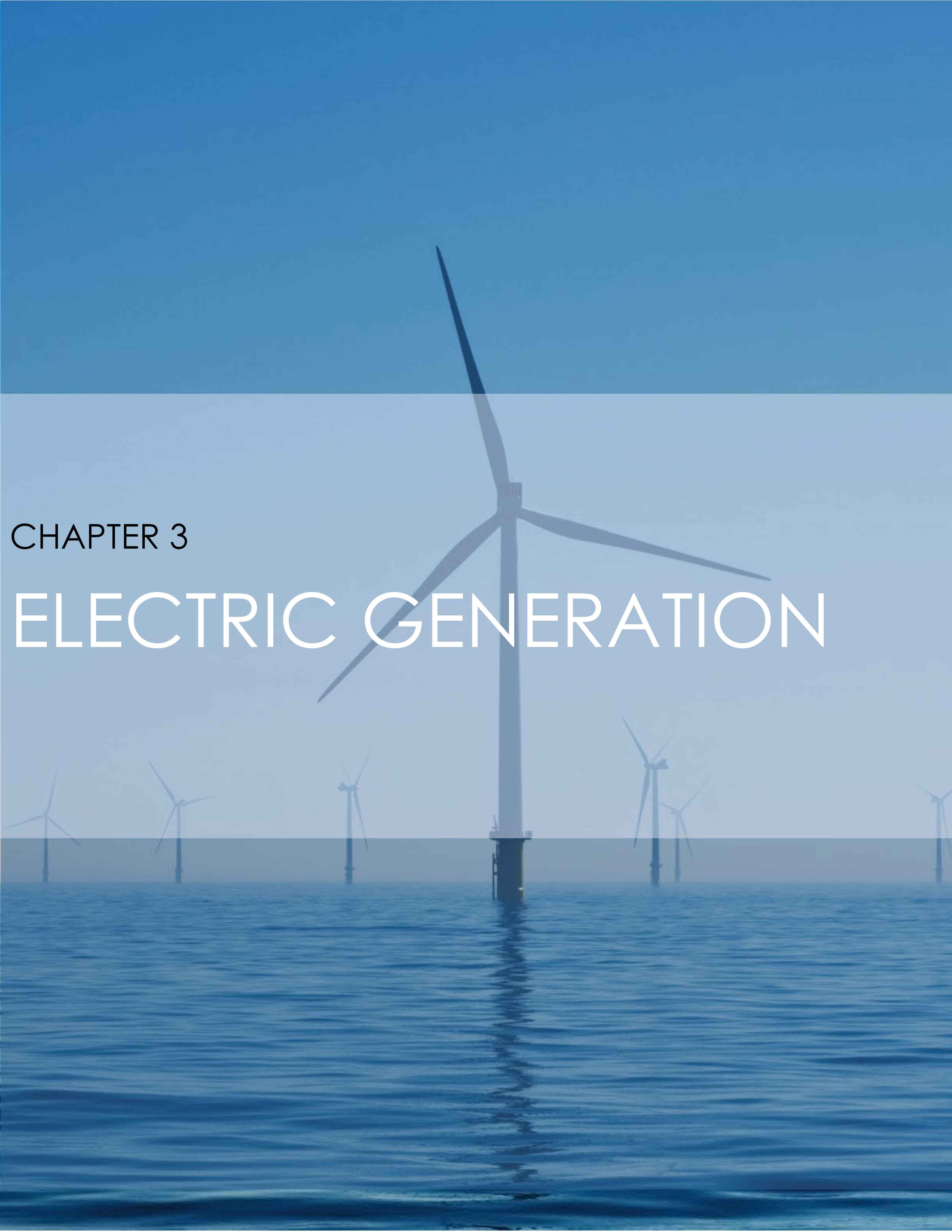
USEIA. (2019). *New Jersey Profile Analysis.* Retrieved from https://www.eia.gov/state/analysis.php?sid=NJ#87

USEIA. (2020). *Glossary*. Retrieved from https://www.eia.gov/tools/glossary/

USEPA. (2019, September 13). *Sources of Greenhouse Gas Emissions - Commercial and Residential Sector Emissions*. Retrieved from https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions

CHAPTER 3

# ELECTRIC GENERATION



# ELECTRIC GENERATION SECTOR SNAPSHOT

## 2018 EMISSION DATA

- The electric generation sector emitted **18.1 MMT $CO_2$e** in 2018.

## EMISSIONS ACTIVITIES

- Electric generation emissions are caused by natural gas fired electric generation, coal fired combined, heat and power, waste refuse fueled electric generation and, liquid petroleum and butane fueled electric generation.

## GHGs OF CONCERN

- Carbon Dioxide ($CO_2$)

## EMISSION REDUCTION PATHWAYS

1. Reduce demand through energy efficiency
2. Transition from fossil fuel electric generation to renewable energy
3. Procure out of state renewable energy

## RECOMMENDATIONS

1. Pursue the rapid development of renewable electric generation.
2. Implement regulatory limitations on $CO_2$ emissions.
3. Limit reliance upon and development of new fossil fuel powered electricity generating units and transition existing natural gas infrastructure for deployment of alternative low-carbon or carbon neutral fuels.
4. Adapt the electricity grid to accommodate distributed energy resources such as solar PV and battery storage, and to support the increasing demand from energy sectors undergoing electrification.
5. Carefully manage loads and improve efficiency to reduce demand and optimize energy use.
6. Retain existing carbon-free resources, including the State's three nuclear power plants.

## AGENCY STAKEHOLDERS

- New Jersey Board of Public Utilities
- New Jersey Department of Community Affairs
- New Jersey Economic Development Authority
- New Jersey Department of Environmental Protection
- New Jersey Division of Rate Counsel

## OVERVIEW

As the prime candidate for replacing other modes of energy, electric power is at the center of both domestic and international efforts to control greenhouse gas (GHG) emissions. Current New Jersey planning anticipates a progressive shift of energy demand away from fossil fuels and toward electricity, with adoption of electric vehicles for transportation, heat pumps for space and water heating, and implementation of other rapidly evolving technologies including battery storage and fuel cells to satisfy diverse applications. The 2019 New Jersey Energy Master Plan (2019 EMP) (NJBPU, 2019a) outlines how these strategies will be applied in the state. Renewable energy systems now offer proven alternatives that are cost-competitive, and in many cases substantially superior, to their fossil fuel counterparts.

New Jersey's in-state electric generation sector is comprised of 34 fossil-fueled facilities totaling approximately 12.5 GW capacity, three nuclear plants totaling 3.4 GW capacity, and a growing number of renewable resources having approximately 3.3 GW total capacity and rising. Overall, by 2018 the state's grid-supplied generating capacity exceeded 17 GW (USEIA, 2019a), with additional energy supply coming from distributed resources (behind the meter). Additionally, New Jersey relies on electricity imports from out-of-state, which typically have a higher emissions profile than electric generators located within New Jersey. It is important to note that this chapter does not include behind-the-meter power generation connected directly to an industrial, commercial or institutional operation; the emissions that result from such dedicated power generators are associated with the specific sector that the unit serves.

New Jersey utilities are among the founding members of PJM Interconnection, L.L.C. (PJM), the Regional Transmission Organization (RTO) that operates the wholesale power markets and controls the transmission of electricity across much of thirteen states and the District of Columbia. Electricity flows across the PJM grid, and between New Jersey and New York (which is managed by a separate independent system operator that performs the functions of an RTO). At any given moment, New Jersey may be a net exporter or net importer of electricity across these transmission systems. Regardless of where the electricity is delivered, the emissions from all electric generating units located in New Jersey are accounted for in the state's GHG inventory.

## WHERE WE STAND

In 2018, emissions in the electric generation sector accounted for 18.1 MMT $CO_2e$ of the total net 97.0 MMT $CO_2e$ emitted in the state.[1] Estimates of GHG emissions from New Jersey's fossil-powered electric generating stations are based on emission statements submitted to the New Jersey Department of Environmental Protection (DEP) by individual facilities. Emissions from resource recovery facilities that burn municipal solid waste for electric generation are based on data from the United State Environmental Protection Agency GHG Reporting Program (USEPA, 2018). Net annual imports of electricity from outside the state, when they occur, are calculated as the difference between in-state generation and in-state electricity sales, pursuant to the requirements of the Global Warming Response Act (GWRA) (P.L. 2007 c.112; P.L. 2018 c.197). A system-wide emissions factor based on the entirety of generation in the PJM Interconnection is used to estimate emissions from these imports. Overall, the emissions reported here are the total of these three sources (fossil, waste and imports).

**In 2018, Electric Generation was estimated to release 18.1 million metric tons of $CO_2e$. This represents 19% of New Jersey's net emissions.**

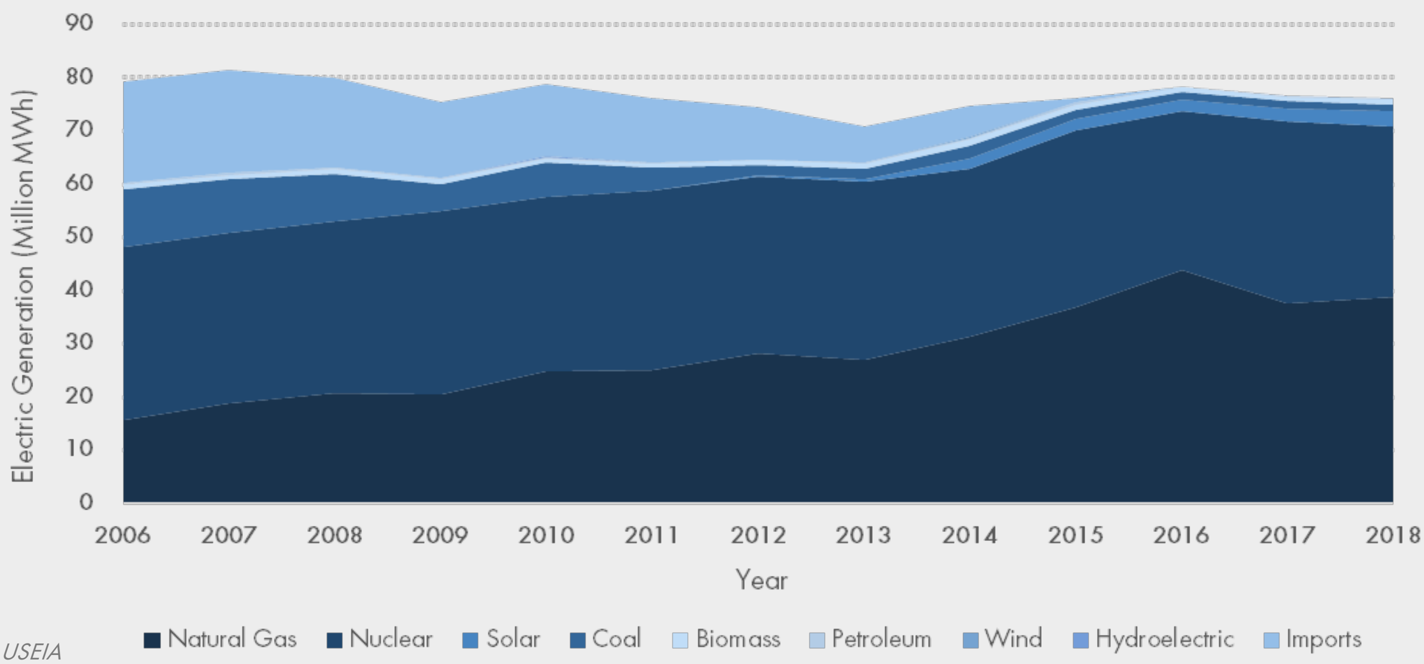
Historically, New Jersey's electric sector emissions decreased from 31.0 MMT $CO_2e$ in 2006 to 18.1 MMT $CO_2e$ in 2018 (Table 3.1) (NJDEP, 2019). This is largely due to the introduction of inexpensive natural gas from the Marcellus Shale formation that accelerated beginning in 2008. Low-cost natural gas and high-efficiency combined cycle generating units have displaced and nearly eliminated older coal-fired stations in the state (Figure 3.1) (USEIA, 2019b). In addition to cost advantages, the new natural gas units emit less than half the $CO_2$ per MWh of coal plants. Overlapping with this transition, New Jersey has also experienced a steady increase in renewable energy to the point where the state is now a national leader in solar photovoltaic (PV) capacity. As of early 2020, total solar PV capacity in the state was more than 3.3 GW, generated by over 120,000 installations (NJBPU, 2020a). According to the Solar Energy Industries Association (SEIA, 2020), New Jersey is ranked seventh in the United States for total installed solar PV capacity. New Jersey is also ranked first in the United States in total installed solar PV capacity per square mile (NJDEP, 2017; and DEP/BPU 2020 internal data)

*Table 3.1 Annual Electric Sector Greenhouse Gas Emissions 2006-2018 (MMT $CO_2e$).*

| 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 31.0 | 35.6 | 29.9 | 23.5 | 26.1 | 23.2 | 20.9 | 19.7 | 21.7 | 17.7 | 21.4 | 18.0 | 18.1 |

[1] 105.1 MMT $CO_2e$ gross emissions, minus 8.1 MMT carbon sequestration by natural resources. Electric generation was 17.1% of gross emissions and 19% of net emissions.

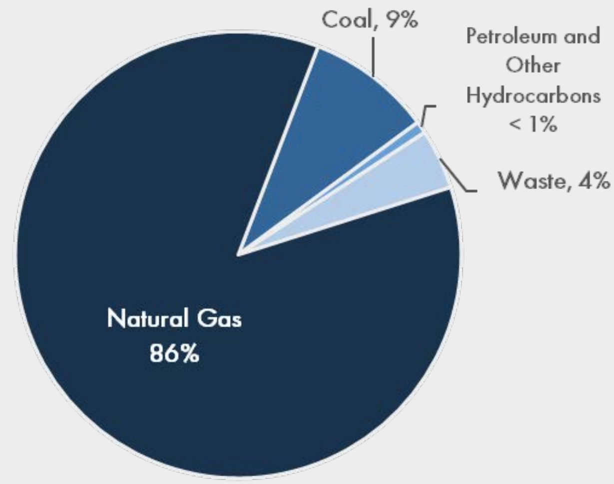
***Figure 3.1. New Jersey's electric generation by fuel type (including imports), 2006 – 2018.***
*As coal-fired generation and imports have decreased, natural gas and renewables have taken their place.*[2]




*Source: USEIA*

Emissions within the electric generation sector are primarily due to the combustion of natural gas, and to a lesser extent coal, waste materials (including waste-to-energy and biomass), and other fuels including liquid petroleum and butane (USEIA, 2019c). In 2018, natural gas combustion accounted for 86% of the emissions from the sector (15.7 MMT CO2e), with coal (1.6 MMT CO2e), waste (0.7 MMT CO2e) and petroleum and other fuels (less than 0.2 MMT CO2e) representing the remainder (Figure 3.2) (USEIA, 2019d; NJDEP, 2019)

***Figure 3.2. 2018 Emissions from In-State Electric Generation (18.1 MMT $CO_2e$) by Percentage.***
*Combustion of natural gas represents the greatest source of emissions, with smaller contributions from coal and other fuels.*




*Source: USEIA*

## Existing Emissions Reduction Policies

New Jersey has long recognized the importance of achieving GHG emissions reductions in the electric generating sector. Building on the foundation of the Global Warming Response Act (GWRA) (P.L. 2007 c.112; P.L. 2018 c.197), the Clean Energy Act (CEA) (P.L. 2018, c.17) strengthens the goals of New Jersey's renewable energy portfolio standard; increases offshore wind procurement goals; establishes provisions for electric storage; mandates an energy efficiency resource standard; and calls for improved implementation of the state's solar renewable energy standard. With specific reference to climate change, the CEA calls for 35% of the state's electric power to be matched to renewable credits originated from renewable sources by 2025 and 50% by 2030.

[2] Imports in the graphic are represented as the difference between New Jersey retail sales (MWh) and in-state generation (MWh).

### *Offshore Wind*

The Offshore Wind Economic Development Act (OWEDA) (P.L. 2010 c.57) establishes the Offshore Wind Energy Certificate (OREC) program and supports development of up to 1,100 MW of generation. However, Governor Murphy's Executive Order 8 (EO-8, 2018) increased that generation goal to 3,500 MW from offshore wind by the year 2030, and his Executive Order 92 (EO-92, 2019) increased the overall goal again to 7,500 MW by 2035.

In pursuit of these objectives, on June 21, 2019, BPU completed its solicitation for the first 1,100 MW installation, a project with the potential to power nearly 500,000 homes as early as 2024, by awarding the project to the Danish developer Ørsted. BPU has also created a framework for future solicitations and adopted OREC Funding Mechanism Rules (NJBPU, 2019b).

### *Regional Greenhouse Gas Initiative*

New Jersey was a founding member of the Regional Greenhouse Gas Initiative (RGGI), authorized pursuant to the Global Warming Solutions Fund Act (P.L. 2007 c.340). After a period of absence, the state adopted regulations to again become a RGGI participating state effective January 1, 2020, pursuant to Governor Murphy's Executive Order 7 (EO-7, 2018). Subsequent legislation (P.L. 2019 c.328) assured New Jersey's full participation in RGGI in the years ahead.

The RGGI cap-and-trade system works by reducing permissible emissions across the RGGI region by approximately 3% annually through application of a regional cap, with allocation of emissions assigned by auction sale of $CO_2$ allowances. Auction proceeds then provide funding to further programs aimed at reducing climate emissions, enhancing natural carbon removal processes and providing bill assistance to rate payers.

RGGI allowances are fully fungible across the region, so emitting facilities in one state can produce more emissions than that state is allocated provided emissions in other states decrease rapidly enough to keep the region below the cap. Over time the entire region's emissions decrease as the regional allowance is reduced. RGGI cap limits therefore provide a backstop to assure continued reductions while at the same time maintaining flexibility through the multi-state trading process.

The goals of the above initiatives and underpinning legislation are summarized in Table 3.2.

*Table 3.2. New Jersey Energy Policy Related to the Electric Sector.*

| Goal | Date | Reference |
|---|---|---|
| **Offshore Wind** | | |
| 3,500 MW (Revised by EO 92, below) | 2030 | Murphy Executive Order 8 |
| 7,500 MW | 2035 | Murphy Executive Order 92 |
| **Electric Power Storage** | | |
| 600 MW | 2021 | Clean Energy Act |
| 2,000 MW | 2030 | Clean Energy Act |
| **Renewable Portfolio Standard** | | |
| 21% Class I | 2020 | Clean Energy Act |
| 35% Class I | 2025 | Clean Energy Act |
| 50% Class I | 2030 | Clean Energy Act |
| 2.5% from Class II, effective on passage of Clean Energy Act. | 2018 | Clean Energy Act |
| **Solar Renewable Energy Mandates** | | |
| Minimum fractions of power sales to be supplied by solar renewables in the Solar Renewable Energy Certificate (SREC) program, reaching 5.1% by 2020 and then scaling back annually until reaching 1.1% in 2033. The BPU is developing a successor to the SREC program. | 2020-2033 | Clean Energy Act |

| Goal | Date | Reference |
|---|---|---|
| **Community Solar Program** | | |
| Legislated goal of at least 50 MW added per year following three-year pilot program.<br><br>BPU rule and 2019 EMP anticipate minimum 75 MW/year during 3-year pilot program and 150 MW/year thereafter. | Ongoing | Clean Energy Act<br>51 NJR 232 |
| **Energy Efficiency Mandates** | | |
| At least 2.15% annual reduction in electricity usage, adjusted for expanded use of electric vehicles, distributed energy resources, etc., within five years of implementation of a utility's electric energy efficiency program. | Ongoing | Clean Energy Act; BPU Order |
| **Regional Greenhouse Gas Initiative (RGGI)** | | |
| Participation in RGGI cap-and-trade program to achieve approximately 3% annual reductions in $CO_2$ emissions from electric generation sector. Goals periodically updated by participating states. | Beginning 2020 | Global Warming Solutions Fund Act; Murphy Executive Order 7; An Act Concerning the Reduction of Greenhouse Gas Emissions (P.L. 2019 c.328) |

## ASSESSMENT STRATEGY

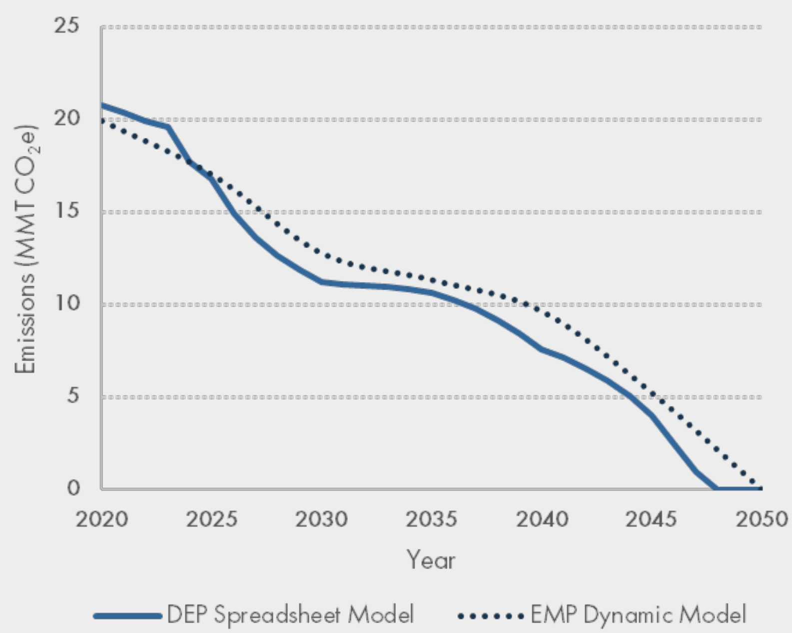
To assist in evaluating policy alternatives presented in this Chapter, the modeling results underlying the 2019 EMP were broken into components based on load and supply characteristics and then applied to a simplified spreadsheet model to examine behavior. Using this approach, assumed loading profiles could be adjusted for factors such as increased electric vehicle use or improved energy efficiency, and supply profiles could be varied to include differing amounts and types of renewable energy. Capacity factors for wind and solar were carried over from the 2019 EMP modeling, as were assumptions regarding in-plant loading and energy losses. The state's renewable portfolio standards (RPS) were not considered since the RPS applies to retail sales and is not tied directly to actual renewable MWh delivered to New Jersey or emissions reductions inside the state.

The DEP's spreadsheet model takes bulk load as an input and adjusts for energy efficiency improvements. Zero-carbon energy supply is found by adding solar, wind, and renewable biofuels, as well as retaining nuclear power based on the 2019 EMP modeling assumptions. The remaining power is then assumed to be supplied either by renewable energy imported from out-of-state or by fossil energy. Fossil-fuel emissions are found by using an emissions factor based on recent fuel consumption and electricity output from New Jersey natural-gas fired plants (USEIA, 2019c; USEIA, 2019e). Emissions estimates are based on assumed model parameters in order to maintain consistency with 2019 EMP modeling, and therefore differ slightly from official inventory measures.

While this approach allows for rapid assessment of alternatives, it in no way replaces the complex dynamic modeling used to prepare the 2019 EMP. In terms of accuracy, when the spreadsheet model was used to evaluate the same scenario conditions as the least cost pathway of the 2019 EMP, emissions estimates tracked closely with the modeling but in later years were typically between 1 and 2 MMT $CO_2e$ lower than the 2019 EMP results (Figure 3.3). This difference likely arose from the fact that the 2019 EMP model tracks vast numbers of individual devices such as vehicles, appliances and generators, each with its own set of properties. The spreadsheet model on the other hand only tracks large aggregates and applies simplified conditions. However, the results from the simplified spreadsheet model gives insight into the effects a potential policy will have, and therefore informs future use of advanced modeling to target the most promising alternatives.

## Reference Cases

*Figure 3.3. Comparison of estimated electric-sector emissions using DEP spreadsheet model and 2019 EMP dynamic model for the least cost scenario.* *Output from the two models track closely together.*




Four reference cases were evaluated using the spreadsheet model to determine the impact of current trends and existing policies. The cases progress from a "business-as-usual" case where current trends are allowed to play out with little disturbance; to scenarios modeled on current policies; and finally, a scenario where grid load increases as projected in the 2019 EMP least cost scenario but without adequate expansion of renewable resources. Each case highlights specific consequences that must be considered when shaping future policies. It should be noted that the reference cases presented here are different from those in the 2019 EMP.

### *Reference Case A: Business-as-Usual*

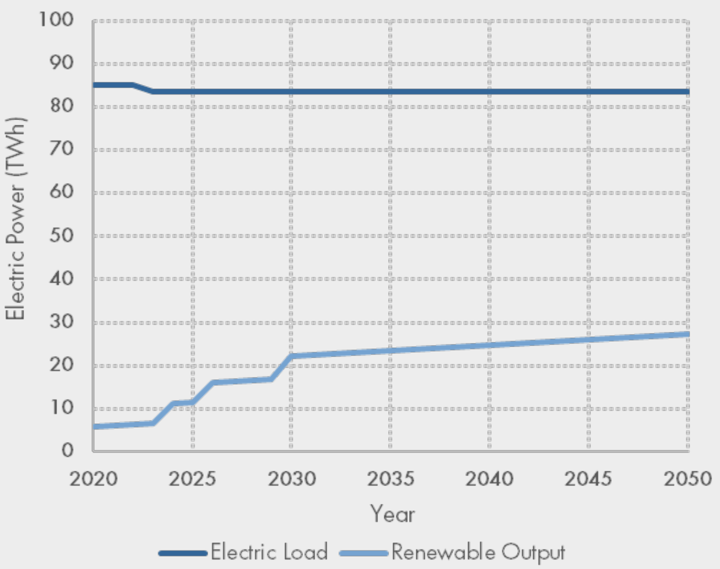
As a starting point, Reference Case A considers a situation where electric demand remains constant at its 2020 level (as identified in the 2019 EMP modeling). Demand is then increased to account for sales of electric vehicles, which are assumed to occur at a constant rate through 2050 of 8,000 new vehicles per year. For this analysis, the electric vehicles are assumed to be extended range Nissan Leaf e+ models, a midrange product with respect to power consumption at 274 Wh/mile (EV Vehicle Database, 2020) and to remain under New Jersey registration for 11 years based on recent history.[3] Annual energy efficiency improvements of 2%, based on the average demand of the past three years as specified in the CEA, are subtracted from load from 2023 through 2030, at which point the efficiency gains are held constant. Solar PV capacity is assumed to be added at the recently observed rate of 152 MW/year, and offshore wind increases to 3,500 MW by 2030 but then grows no further. 2019 EMP modeling assumed nuclear output of 28.4 TWh/year is held constant through 2050.

In this scenario, the electric load remains nearly constant, decreasing by small amounts through 2030 due to efficiency improvements, and increasing slightly after 2031 due to EVs (Figure 3.4). Renewable output increases through 2030 as solar and offshore wind are added, and then slowly rises thereafter due to additional solar (Figure 3.4). Most importantly, electric sector emissions drop from a starting level of 20.6 MMT $CO_2e$ (based on the 2019 EMP's parameters) to 13.3 MMT $CO_2e$ in 2030, followed by a more gradual decrease to 11.3 MMT $CO_2e$ in 2050 (Figure 3.5).

After reviewing this scenario, the conclusion is that even if electric loads remain essentially constant, the locked-in amounts of offshore wind and the recent rates of solar PV expansion are insufficient to reduce emissions to levels consistent with the GWRA 80x50 target.

[3] Vehicles removed from NJ registration are not necessarily scrapped and may be resold elsewhere. The 2019 EMP assumed a 15-year usable life for vehicles.

***Figure 3.4. Electric load under Reference Case A (Business-as-Usual).***
*Load is nearly constant, reflecting only CEA energy efficiency reductions and the addition of 8,000 EVs per year. Offshore wind increases to 3,500 MW in 2030, and then remains steady. Solar PV increases at the current rate of 152 MW/year through 2050.*



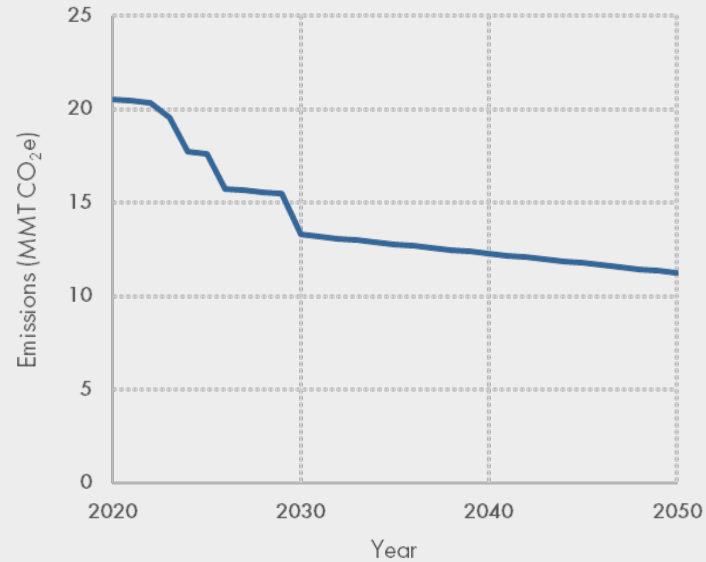
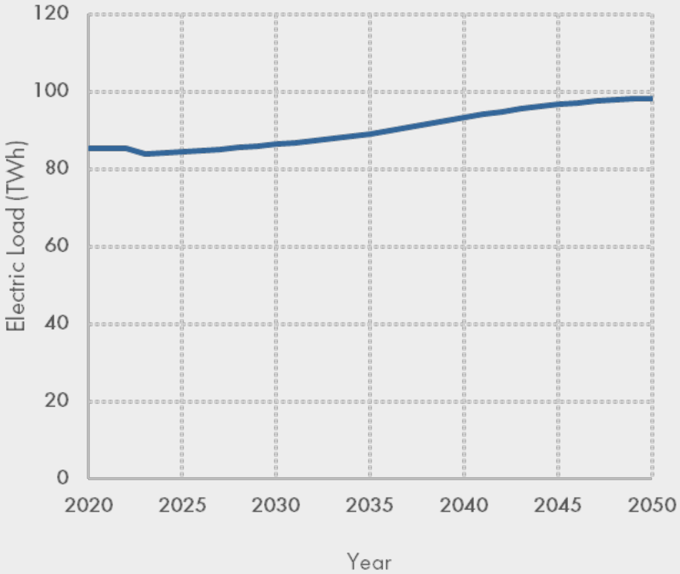




***Figure 3.5. Electric sector emissions under Reference Case A.***
*Emissions are reduced significantly in the early years due to the expansion of offshore wind, followed in later years by slower reductions as solar PV is added at a rate of 152 MW/year.*

## *Reference Case B: Electric Vehicle Adoption in accordance with the EV Law*

This case is identical to the business-as-usual Reference Case A, except that electric vehicles are adopted in accordance with the goals of the EV Law. As above, a Nissan Leaf e+ is used as a model vehicle, and registration numbers climb to over 5 million units by 2050 as described in the Transportation Chapter. Under these conditions, the load increases from 85.2 TWh in 2020 to 98.2 TWh in 2050 after efficiency reductions (Figure 3.6). With the buildout of offshore wind, electric sector emissions decline to a low of 14.4 MMT $CO_2e$ in 2030, but then rebound in later years to 17.1 MMT $CO_2e$ as demand outpaces the gradual expansion of solar capacity (Figure 3.7). The renewable energy output under this scenario is the same as in Reference Case A above (Figure 3.4). The implication of this scenario, which will be seen again in later scenarios, is that increased load must be matched by increased renewable output to avoid emissions increases. In fact, this evaluation likely underestimates the emissions consequences of allowing load to increase without balanced renewable growth because newly added loads are generally served by the marginal electric generating facilities, typically among the greatest emitters and the most expensive to operate. However, because electric vehicles are substantially more efficient than their fossil-powered counterparts, overall emissions reductions, including those in the transportation sector, are still realized.

***Figure 3.6. Electric load under Reference Case B (EV Law).***
*Loads increase gradually through 2050 due to the steady addition of electric vehicles.*



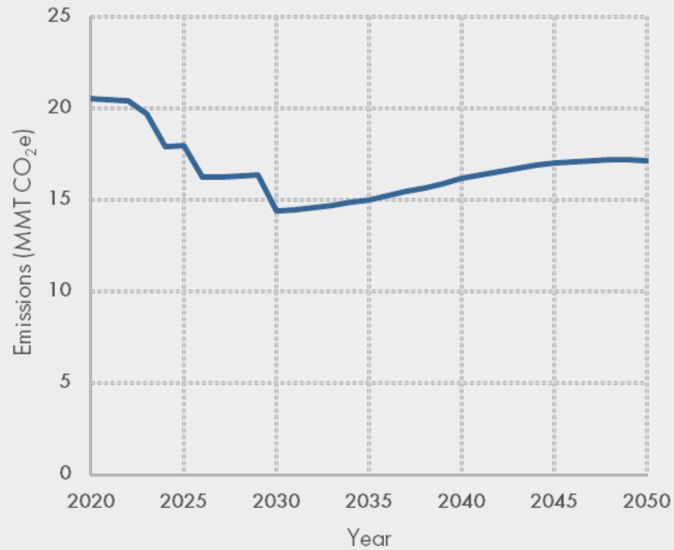
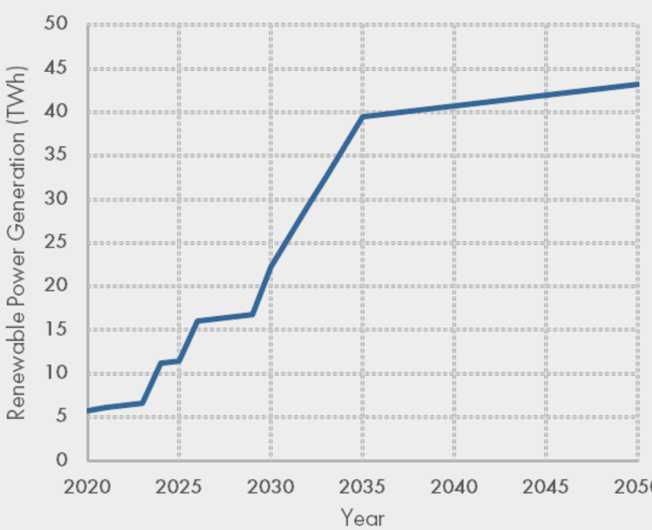




***Figure 3.7. Electric sector emissions under Reference Case B (EV Law).***
*Initial emissions are reduced through increased renewables, however, post 2030 emissions increase due to the growing number of electric vehicles that rely on fossil electric generation to meet the demand.*

## *Reference Case C: Current Legislation and Executive Orders*

As seen in Reference Cases A and B, adding renewables to match increased electric load is essential to minimize the dispatch of fossil resources. Even adding modest amounts of additional renewable capacity can have lasting emissions benefits, especially if placed on the grid early in the transition process. In the next scenario, the impact of an additional 4,000 MW of offshore wind by 2035 in accordance with Governor Murphy's Executive Order 92 is considered (Figure 3.8). Except for increasing offshore wind capacity to 7,500 MW in 2035, this scenario is the same as Reference Case B. With the added offshore wind, renewable capacity is sufficient to balance the rebound observed in Reference Case B (compare Figures 3.9 and 3.7), with 2050 electric sector emissions reduced to 10.7 MMT $CO_2e$ from the previous 17.1 MMT $CO_2e$.

***Figure 3.8. Renewable Energy Output under Reference Case C (7,500 MW Offshore Wind).***
*A greater commitment to offshore wind significantly increases clean energy output through 2035 while solar provides limited clean energy growth in later years.*



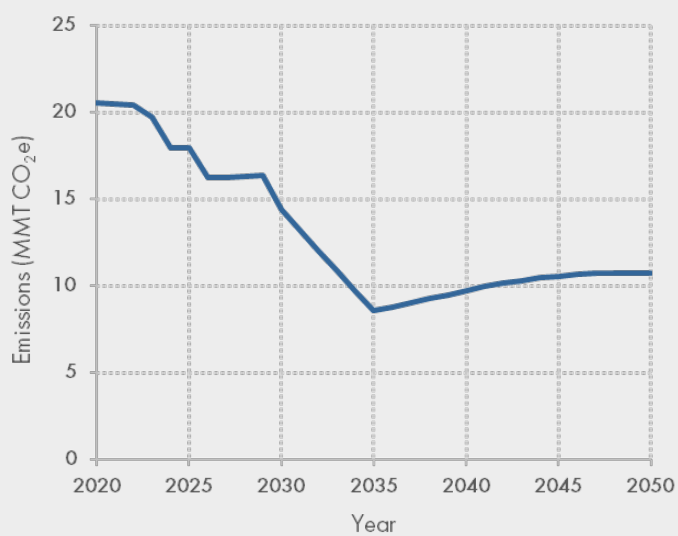



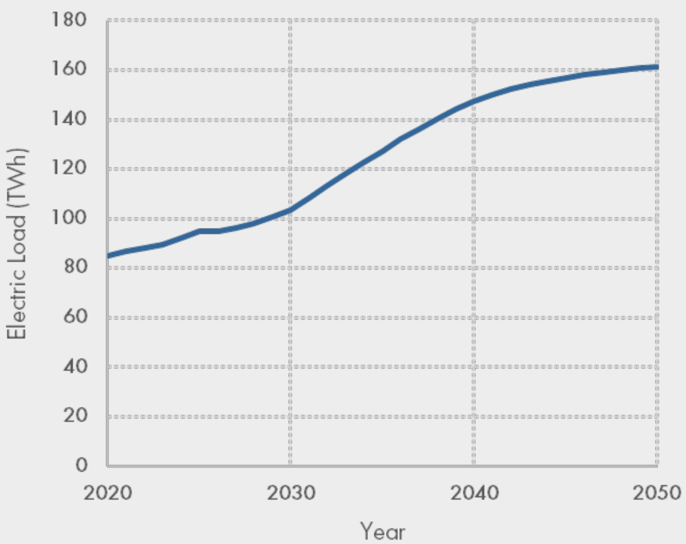

***Figure 3.9. Electric sector emissions under Reference Case C (7,500 MW Offshore Wind).***
*Through 2035, emissions decrease as renewables expansion keeps pace with increasing electric demand under the EV Law. After 2035, emissions increase as new demand outpaces renewable energy expansion.*

### *Reference Case D: Anticipated Load from the Energy Master Plan Least Cost Scenario*

As noted in Reference Case B, increased load from electric vehicle adoption as specified in the EV Law without a comparable increase in renewable energy sources led to sustained electric-sector GHG emissions. Reference Case D shows an even more dramatic increase in electric-sector GHG emissions with the additional load from electrification across the statewide economy as depicted in the 2019 EMP least cost scenario. This results in a doubling of electrical demand over the next thirty years (Figure 3.10). At first, emissions under this scenario are held in check as 7,500 MW of offshore wind are added through 2035, but thereafter emissions rise dramatically. By 2050, emissions reach 36.2 MMT $CO_2e$, nearly twice the rate in 2020 (Figure 3.11). From this, it is clear that if increased loads from electrification are not preceded by a comparable expansion of renewable resources, substantial increases in electric sector emissions will occur.

***Figure 3.10. Electric load under Reference Case D (2019 EMP Least Cost Scenario Electric Load).***

*The least cost scenario of the 2019 EMP anticipates a near doubling of demand for electricity as vehicles, homes and businesses are electrified. The growth in demand accelerates substantially after 2030 as the initiatives take root, but levels off after 2045.*



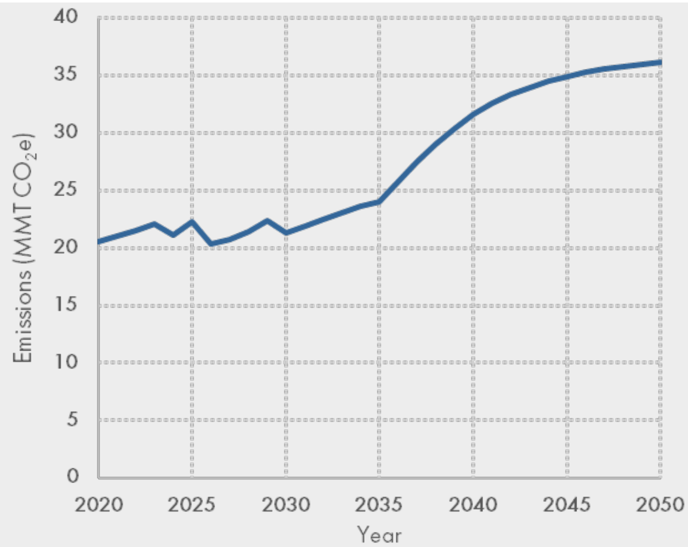




***Figure 3.11. Electric sector emissions under Reference Case D (2019 EMP Least Cost Scenario Electric Load).***

*Without substantial additions of renewable capacity beyond what current policy anticipates, the widescale adoption of electrified alternatives such as EVs and heat pumps will result in heavy reliance on fossil fuel electric generation. Despite emissions reductions in other sectors, failing to meet the 80x50 goal.*

## THE PATH FORWARD

The true challenge for the electric sector is not to simply reduce GHG emissions, but to build a vast replacement infrastructure capable of transmitting and storing new and increasing amounts of renewable energy. This new system must also be able to handle expanding capacity to meet the rising demand of electricity to power transportation, space heating, and other applications where fossil fuels are currently used. In effect, the clean energy transition will require complementary initiatives that adapt existing resources to accommodate the unique characteristics of solar and wind power to deliver what is now provided by a substantially different technology. These efforts must also be implemented in tandem with major investments in energy efficiency, as discussed in the Residential, Commercial, and Industrial chapters elsewhere in this report.

The 2019 EMP lays out a timeline and establishes infrastructure milestones that form the blueprint for achieving this transformation. It also identifies the individual strategies and steps necessary to deliver the new energy infrastructure in accordance with the 2019 EMP's least cost scenario.

Overall, the 2019 EMP envisions four broad initiatives:

1. Increase the amount of renewable resources. (2019 EMP Goals 2.1, 2.2, and 2.3)
2. Adapt the grid to accommodate distributed renewable energy and the increasing demand from energy sectors undergoing electrification. (2019 EMP Goals 5.1, 5.2, and 5.3). Also, adapt the natural gas distribution network for phase-out of fossil fuels and the transition to renewable biogas. (2019 EMP Goal 5.4)
3. Carefully manage loads and improve efficiency to reduce demand and optimize energy use. (2019 EMP Strategies 3 - 6)
4. Retain existing carbon-free energy resources, including the state's three nuclear power plants. (2019 EMP Goal 2.1)

The overall lesson learned from the reference cases above is that the energy transition cannot be a collection of piecemeal strategies cobbled together ad hoc. Instead, the effort must be approached as a single effort coordinated across multiple sectors of the economy. New Jersey needs to enable, or incentivize, renewable energy at sufficient scale to account for new load growth to avoid counterproductive outcomes as seen in Reference Cases B and D above.

In alignment with the 2019 EMP, three broad pathways have been identified to achieve emission reductions.

### EMISSION ACTIVITES

- Natural Gas
- Coal
- Petroleum
- Other fuel

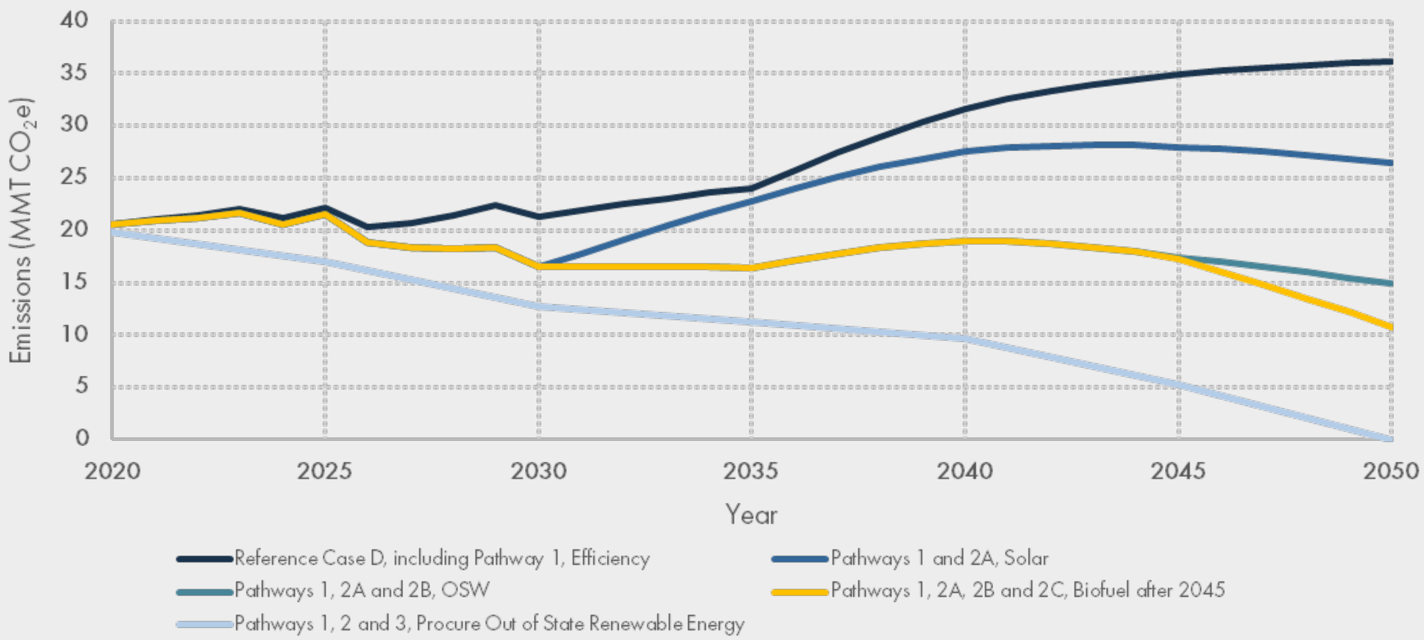
### EMISSIONS REDUCTION PATHWAYS

1. Reduce energy demand
2. Transition in-state fossil fuel electric generation to renewable energy
3. Procure out-of-state renewable energy

- Pathway 1, Reduce energy demand, evaluates the role of demand-based initiatives such as energy efficiency;
- Pathway 2, Transition in-state fossil fuel electric generation to renewable energy, considers the role of individual types of energy resources; and
- Pathway 3, Procure out-of-state renewable energy, evaluates the gap between demand and generation, illustrating the potential need for procuring carbon-free energy from out-of-state as well as from in-state resources.

Collectively, Pathways 1, 2 and 3 could eliminate all GHG emissions from the electric generation sector by 2050 (Figure 3.12). These pathways are based on the 2019 EMP's least cost scenario, adapted to account for New Jersey's more aggressive goals for offshore wind capacity and energy efficiency.

***Figure 3.12. Estimated emissions due to renewable energy and energy efficiency in the Electric Generation Sector (MMT $CO_2e$).***
*Addition of solar PV, offshore wind, and biofuel-powered combustion offset emissions growth as electrification proceeds. Out-of-state renewables or additional in-state resources close the gap and bring emissions to zero by 2050.*




## **Emissions Reduction Pathway 1:** Reduce energy demand

Reducing the need for electricity lessens the amount of new generation capacity required to meet the state's 80x50 goal. Some strategies for demand reduction, such as improved insulation and weatherproofing of homes, are familiar and provide well-documented benefits. Other approaches, such as public support for work-from-home programs, are new and will require social acceptance. A number of these strategies are discussed in other chapters of this report; the assessment presented in this section provides insight into the GHG emissions impacts from implementing these policies.

Specifically, Pathway 1 quantifies the benefits of reductions in electricity demand associated with the CEA electric efficiency requirements; under this mandate, retail electricity sales must decrease by 2% annually.[4] There are sunset provisions included in the CEA that call for terminating the efficiency program when few cost-effective projects remain to be completed. As a result, it is unlikely that this provision will remain active through 2050.

Projections for total electricity demand in the 2019 EMP least cost scenario already incorporate the CEA-mandated reductions, and the spreadsheet model therefore provides a way to break out the benefits of the CEA mandate. To do this, the spreadsheet model's output based on the 2019 EMP scenario was compared to the output using a 2% higher

[4] Reductions are based on the average of retail sales during the preceding three years, and added loads from certain new sources may be exempt from consideration. The NJBPU board recently approved energy efficiency programs that exceed the legislative mandate of 2%, now requiring electric distribution companies (EDCs) to achieve 2.15% annual reductions in electricity demand (NJBPU, 2020b).

load (calculated using the three-year average of retail sales, as per the CEA). The avoided electricity demand ranged from 1.7 to 3.2 TWh annually through 2050 (Figure 3.13) and avoided emissions ranged from 0.7 to 1.3 MMT $CO_2e$ annually (Figure 3.14). However, as noted above, sunset provisions in the CEA, based on the availability of cost-effective opportunities, may end these efficiency programs before 2050. The very low emissions expected during the final years of the transition also limit the theoretical reductions possible at that time.

***Figure 3.13. Annual Electricity Saved due to Energy Efficiency Improvements under Pathway 1.***

*As the energy transition advances, the number of cost-effective opportunities will decrease. Real-life benefits are therefore expected to be lower than shown. Sunset provisions based on the number of cost-effective opportunities may terminate the program before 2050.*

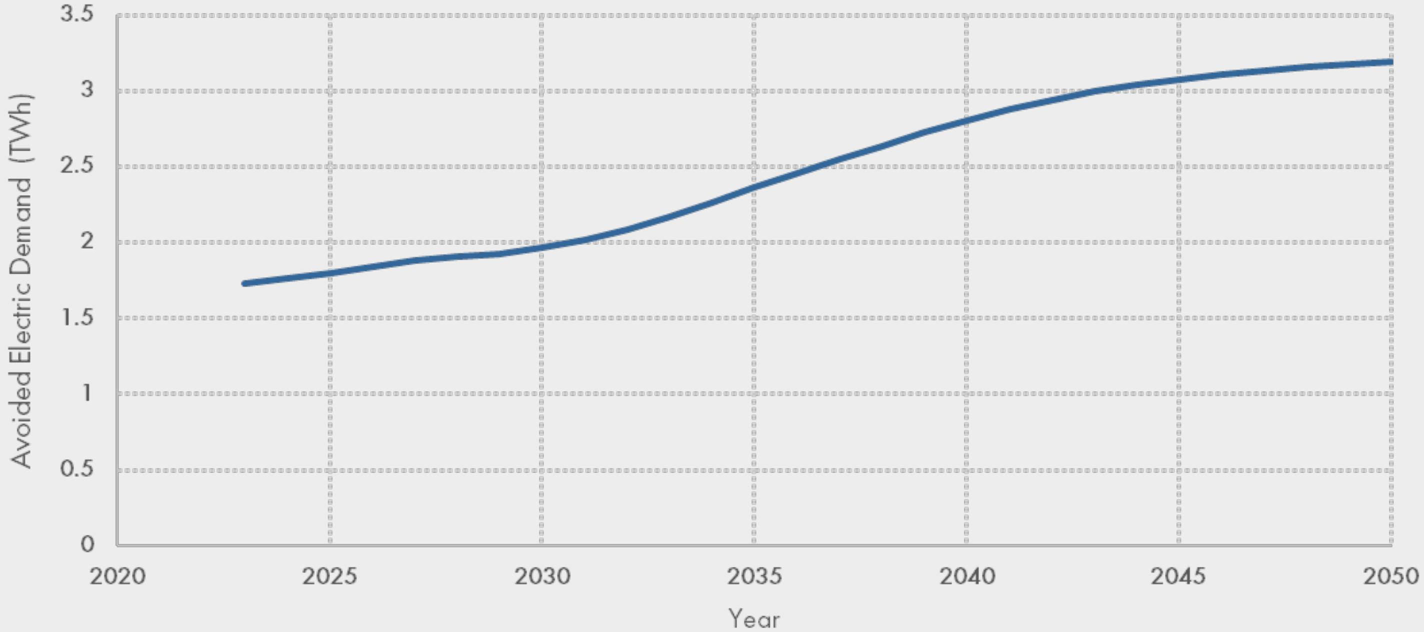
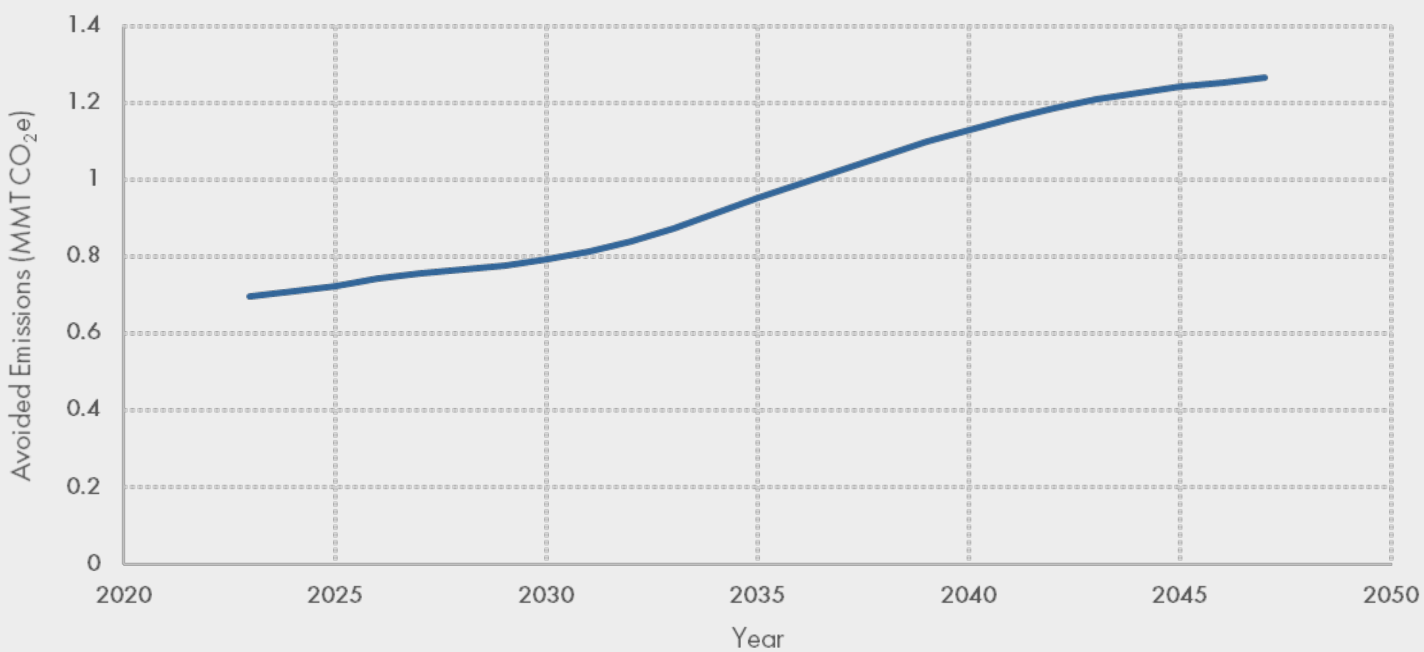



***Figure 3.14. Avoided Emissions due to Energy Efficiency Improvements under Pathway 1.***

*Reductions range from 0.7 to 1.3 MMT $CO_2e$ annually, subject to the availability of cost-effective projects.*



## **Emissions Reduction Pathway 2:** Transition from fossil fuel electric generation to renewable energy

The modeling used as the basis for the 2019 EMP's least cost scenario projected that demand for electricity will more than double to approximately 165 TWh in 2050 (Figure 3.15). As fossil gas is progressively retired and existing nuclear is retained, the entirety of the remaining electricity demand is satisfied by renewable power. In-state generation includes a dispatchable fleet ("firm capacity") that shifts over time from natural gas to alternatives such as renewable biogas and hydrogen (Figure 3.15). The 2019 EMP further assumes a strong and enduring growth in solar PV capacity (Figure 3.16; Table 3.3); substantial reliance on land-based wind generation elsewhere in the PJM region (Figure 3.15; Table 3.4); and a steady rise in offshore wind generation (Figure 3.16; Table 3.4). Emissions continuously drop throughout this period as successive waves of technological change come into effect (Figure 3.12). However, the least cost pathway cannot foresee future developments and therefore cannot be viewed as establishing rigid tests of success or failure. Instead, it establishes timelines and targets that mark progress toward achieving the state's goals.

***Figure 3.15. Electricity Generation, Least Cost Scenario (2019 EMP Figure 8).***
*Fossil gas generation is displaced over time by expanded renewables.*

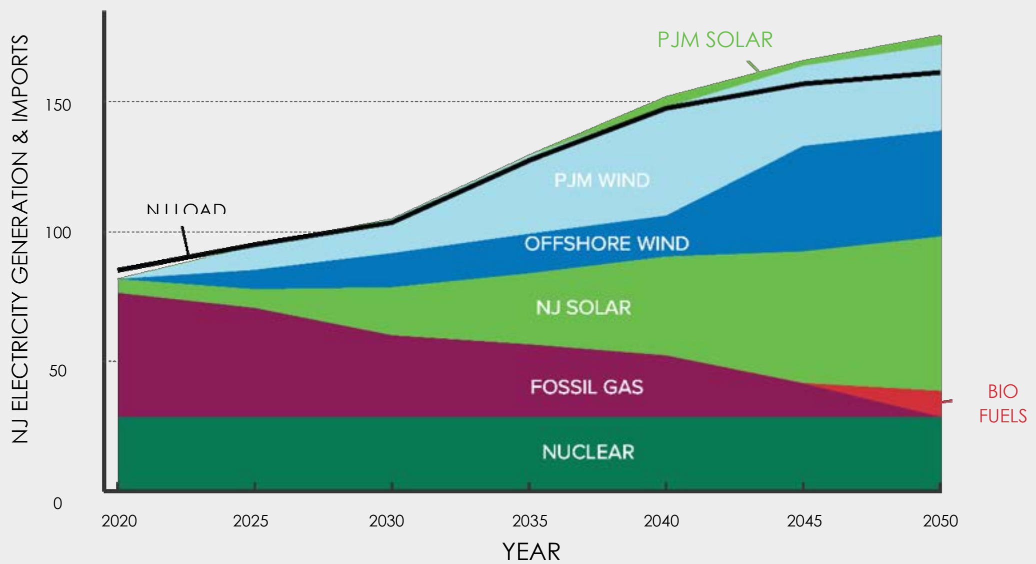



***Figure 3.16. In-State Electricity Capacity, Least Cost Scenario (2019 EMP Figure 12).***
*As solar and wind capacities expand, firm, dispatchable capacity is available to fill gaps in supply when needed. However, this dispatchable capacity is only used infrequently in later years due to effective storage and load management, and transitions to biogas after 2045.*

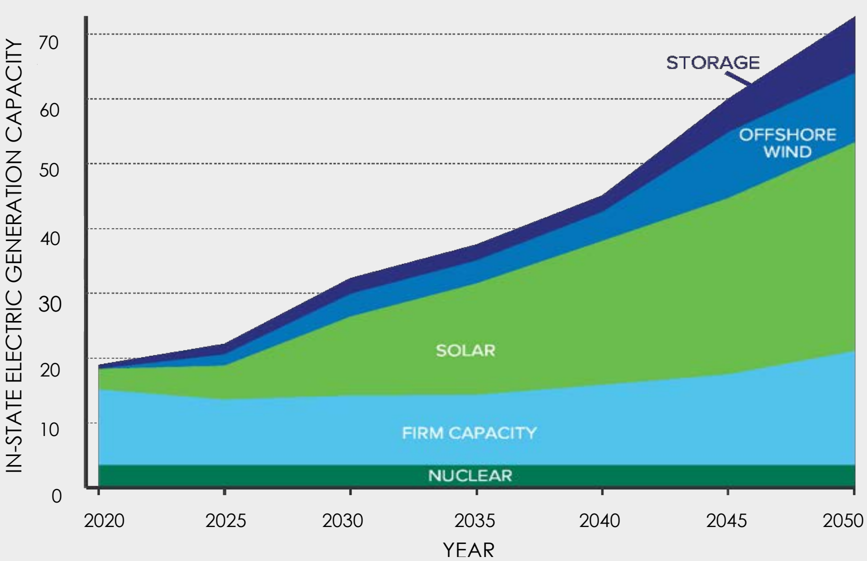


*Table 3.3. In-State Installed Capacity Goals by Year (GW).*[5]

| Resource Type | 2020 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| NJ Solar | 3.5 | 5.2 | 12.2 | 17.2 | 22.2 | 27.2 | 32.2 |
| Offshore Wind | 0 | 1.1 | 3.5 | 7.5 | 8.8 | 10.1 | 10.7 |
| Nuclear | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 |
| Fossil Gas | 11.7 | 10.1 | 10.7 | 10.8 | 12.4 | 13.7 | 0 |
| Biogas, Biofuels and Hydrogen | 0 | 0 | 0 | 0 | 0 | 0.3 | 17.6 |
| Storage | 0.6 | 1.6 | 2.5 | 2.5 | 2.5 | 5.2 | 8.7 |
| Other[6] | 0.97 | 0.25 | 0.26 | 0.22 | 0.19 | 0.16 | 0.15 |
| | | | | | | | |
| **Total** | **20.3** | **21.8** | **32.7** | **41.7** | **49.6** | **60.2** | **72.9** |

*Table 3.4. Annual Generation Goals by Year (TWh).*[7]

| Resource Type | 2020 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
|---|---|---|---|---|---|---|---|
| NJ Solar | 5.8 | 7.3 | 18.6 | 27.5 | 38.1 | 50.7 | 59.7 |
| Offshore Wind | 0.0 | 4.4 | 14.0 | 29.9 | 35.0 | 40.2 | 42.5 |
| Nuclear | 28.4 | 28.4 | 28.4 | 28.4 | 28.4 | 28.4 | 28.4 |
| PJM Regional Wind and Solar | 0 | 9.1 | 13.2 | 30.2 | 26.4 | 33.3 | 34.9 |
| Biogas, Biofuels and Hydrogen | 0 | 0 | 0 | 0 | 0 | 0.3 | 10.1 |
| Fossil Gas | 48.0 | 42.2 | 31.6 | 28.1 | 23.9 | 13.2 | 0 |
| Fossil Coal | 1.2 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | | | | | |
| **Total** | **83.4** | **91.4** | **105.8** | **144.1** | **151.8** | **166.1** | **175.6** |

To better understand how GHG emissions reductions are achieved under the 2019 EMP's least cost pathway, total emissions were broken down into components based on the objectives of the 2019 EMP and current policies. The DEP then evaluated the impact of solar, wind, and renewable biofuels on in-state power generation.

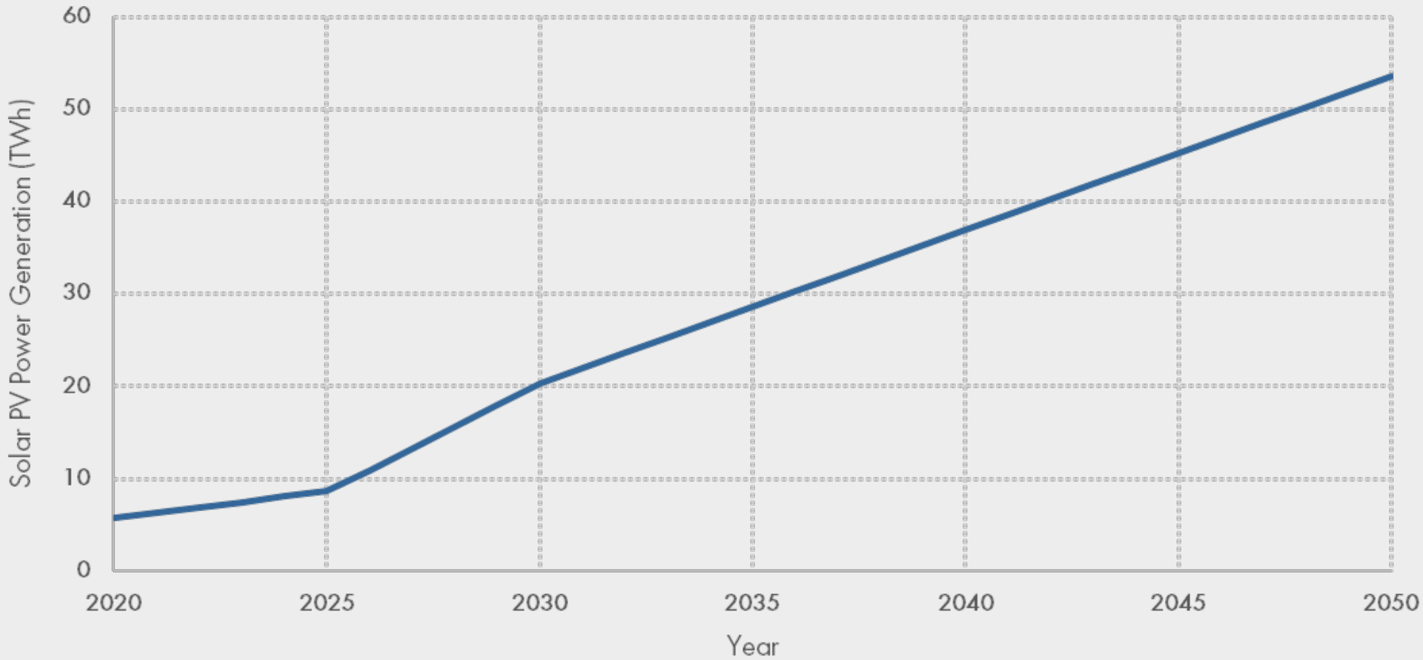
## *Expansion of In-State Solar*

DEP evaluated the emission reductions associated with the expansion of in-state solar envisioned in the 2019 EMP. Pathway 2A increases solar capacity from 3.5 GW in 2020 to 5.2 by 2025, 12.2 GW by 2030, and 32.2 GW in 2050, as per the 2019 EMP's milestones. As shown in Figure 3.17, solar PV power output rises rapidly after 2025, and increases to over 50 TWh by 2050. The installation of solar alone (compared to Reference Case D) lowers emissions by 9.8 MMT $CO_2e$ in 2050 (Figure 3.12).

---

[5] These goals have been adapted here to account for the state's commitment to expanded use of offshore wind by 2035.
[6] Other includes coal, incineration, landfill gas and hydropower.
[7] The additional OSW capacity under EO 92 reduces the need for other resources. In this Table, the amounts of out-of-state renewable energy have been reduced rather than the amounts of fossil because of the uncertainty of out-of-state availability. The total amounts of generated power in this Table remain unchanged from the IEP. Additionally, out-of-state wind and solar are combined into a single category to simplify analysis.

***Figure 3.17. Solar photovoltaic electricity generation under Pathway 2A.***
*From 2025, solar generation expands rapidly, and exceeds 50 TWh by 2050.*




To put these numbers in perspective, a recent BPU solar report (representing installations through May 31, 2020) found that New Jersey has 3.3 GW of installed solar capacity (NJBPU, 2020a), and the rate of solar PV expansion has been about 152 MW of capacity per year. In contrast, averaged over the coming thirty years, solar PV will need to be added at a rate of 1,000 MW annually, or 6.5 times the current level, to meet the objectives of the 2019 EMP (Figure 3.16). To achieve this growth, the state must be prepared to use parking lots, roof tops, and marginal open spaces. To evaluate the abundance of these spatial resources, DEP has quantified the available acreage and potential GW solar capacity for various land types and estimates that 108,656 acres of residential rooftops are available[8] to host an additional 22 GW of solar capacity (NJDEP, 2020). Opportunity also exists for siting solar on commercial and industrial properties, with 128,186 acres available at commercial sites[9] for a potential 26 GW of additional solar capacity and another 29,802 acres available at industrial facilities[10] to host approximately 10 GW of solar capacity (NJDEP, 2020). Furthermore, public property has 49,000 acres available[11] to host 12 GW (NJDEP, 2020). Combined, these total 70 GW, which exceeds the projected need of 32.2 GW. DEP continues to refine its analysis to identify available marginal lands suitable for solar development. Despite the availability of land to accommodate solar PV, siting remains a challenge due to the value of land, the state's population density and the limitations in the existing distribution system.

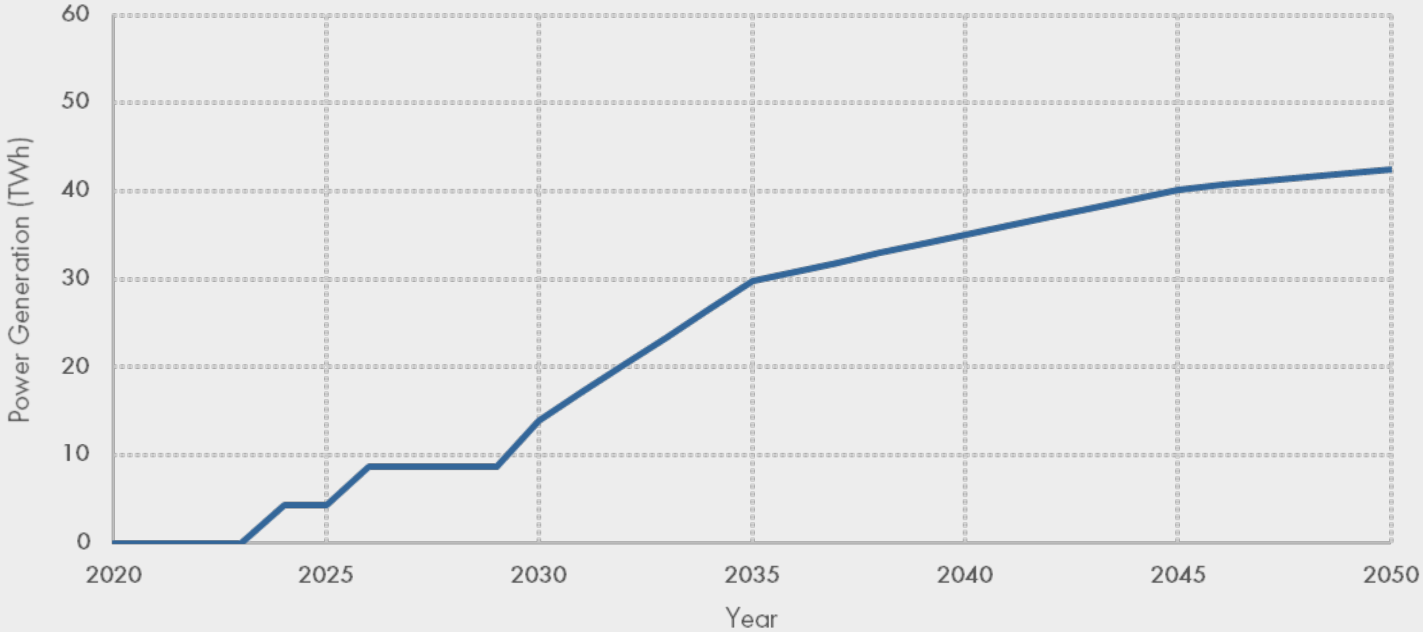
### *Investment in Offshore Wind*

New Jersey has approximately 130 miles of coastline with strong and consistent winds. This renewable resource can be harnessed to generate clean, carbon-free electricity for the grid. Governor Murphy has made strong commitments to offshore wind requiring the state to procure 3,500 MW of offshore wind by 2030 and an additional 4,000 MW of offshore wind by 2035. DEP evaluated the benefits of integrating the additional 4,000 MW capacity of offshore wind by 2035 into the 2019 EMP modeling's least cost scenario. Specifically, Pathway 2B considers the installation of 3.5 GW of offshore wind capacity by 2030, 7.5 GW by 2035, 10.1 GW in 2045, and 10.7 GW by 2050. Power output approaches 30 TWh in 2035, then gradually increases to 42 TWh in 2050 (Figure 3.18). The added renewables in Pathway 2A and 2B combined, lower emissions by 21.3 MMT $CO_2e$ in 2050 compared to Reference Case D (Figure 3.12).

[8] Calculated as building footprint available.
[9] Calculated as rooftops, impervious and non-impervious areas, excluding roadways.
[10] Calculated as rooftops and non-impervious land.
[11] Calculated as building footprint, impervious and non-impervious areas, excluding roadways.

***Figure 3.18. Offshore wind electricity generation under Pathway 2B.***

*New Jersey's commitment to offshore wind has outpaced the assumed rate of growth in the 2019 EMP, providing opportunities for accelerated emissions reductions and economic growth.*



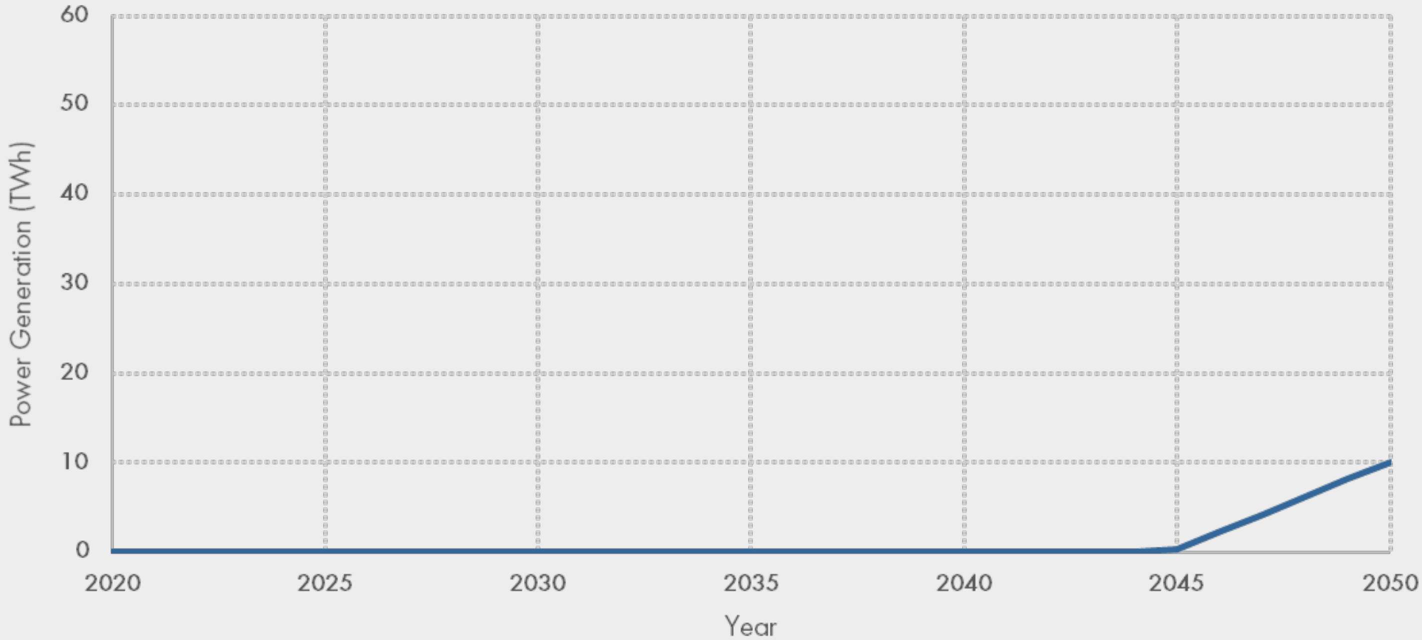

On June 21, 2019, the BPU awarded New Jersey's first offshore wind solicitation for 1,100 MW, the largest single-state procurement of offshore wind electricity generation capacity in the United States at the time (NJBPU, 2019c). To assist with obtaining the offshore wind goals for the state, in February 2020 the Murphy administration announced the offshore wind solicitation schedule, containing five additional solicitations spaced every other year through 2028 (State of New Jersey, Governor's Office, 2020). In July 2020, BPU issued a Draft Guidance Document for New Jersey's second offshore wind solicitation for 1,200 to 2,400 MWs (NJBPU, 2020c).

To date, the Federal Bureau of Ocean Energy Management (BOEM) has executed leases for more than 15 lease areas in the Atlantic Ocean, with roughly four of them located in close proximity to the New Jersey coastline. These executed lease areas, when paired with proposed lease areas, contain enough acreage to meet the state's offshore wind energy goals. Once successfully leased, projects must comply with the BOEM process, which includes thorough site assessment studies as well as detailed plans for construction, operation, and decommissioning.

### *Renewable Biofuels*

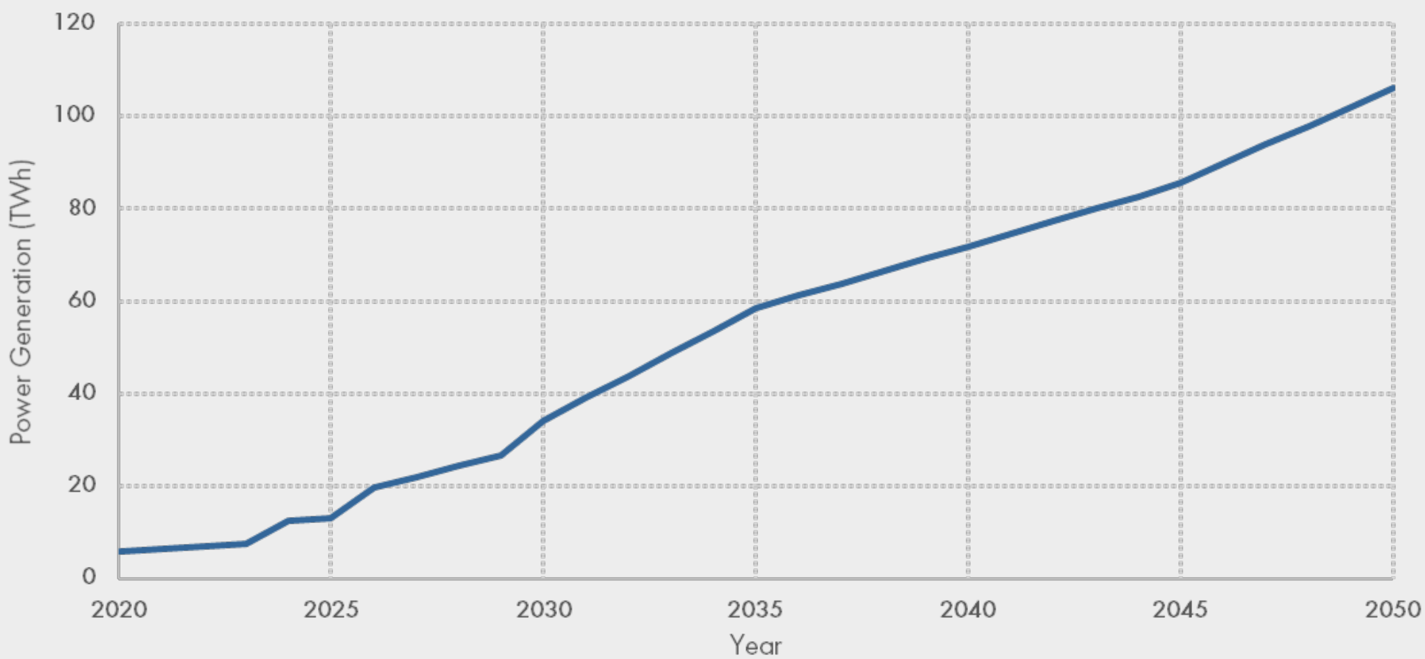
The 2019 EMP's least cost scenario anticipates that existing gas capacity will stay in operation, gradually transitioning from serving as a major supplier of electricity to New Jersey in 2020 to serving as a "backup" resource for renewable energy by 2050. Pathway 2C, evaluates the use of renewable biofuels to decarbonize this remaining portion of New Jersey's electric generation in accordance with the 2019 EMP. Beginning in 2045, in order to meet Governor Murphy's mandated 100% clean energy goal by 2050, renewable biofuels are introduced for dispatchable generation, with output climbing to 10.1 TWh by 2050 (Figure 3.19). Due to their high cost and limited availability, renewable biofuels are used sparingly in the closing years of the transition as the mechanism to decarbonize the few remaining MW of fossil fuel electric generation capacity.

*Figure 3.19. Renewable biofuel electricity generation under Pathway 2C.*
*In order to fully decarbonize electric generation, renewable biofuels have been proposed as a carbon-neutral fuel. However, the 2019 EMP notes that technological advances over the next thirty years may make other alternatives more attractive.*




Taken together, total in-state renewable electric generation rises steadily over time, reaching 106 TWh by 2050 (Figure 3.20). Adding the electricity generated by the state's three nuclear plants (about 28 TWh annually) increases in-state carbon-free generation to 134 TWh in the final year (not shown). The added renewables in the combined 2A, 2B and 2C pathways lower emissions by 25.4 MMT $CO_2e$ in 2050 compared to Reference Case D (Figure 3.12).

*Figure 3.20. In-state renewable electricity generation under Pathways 2A, 2B and 2C.*
*The combined renewable output under the three pathways exceeds 100 TWh by 2050.*

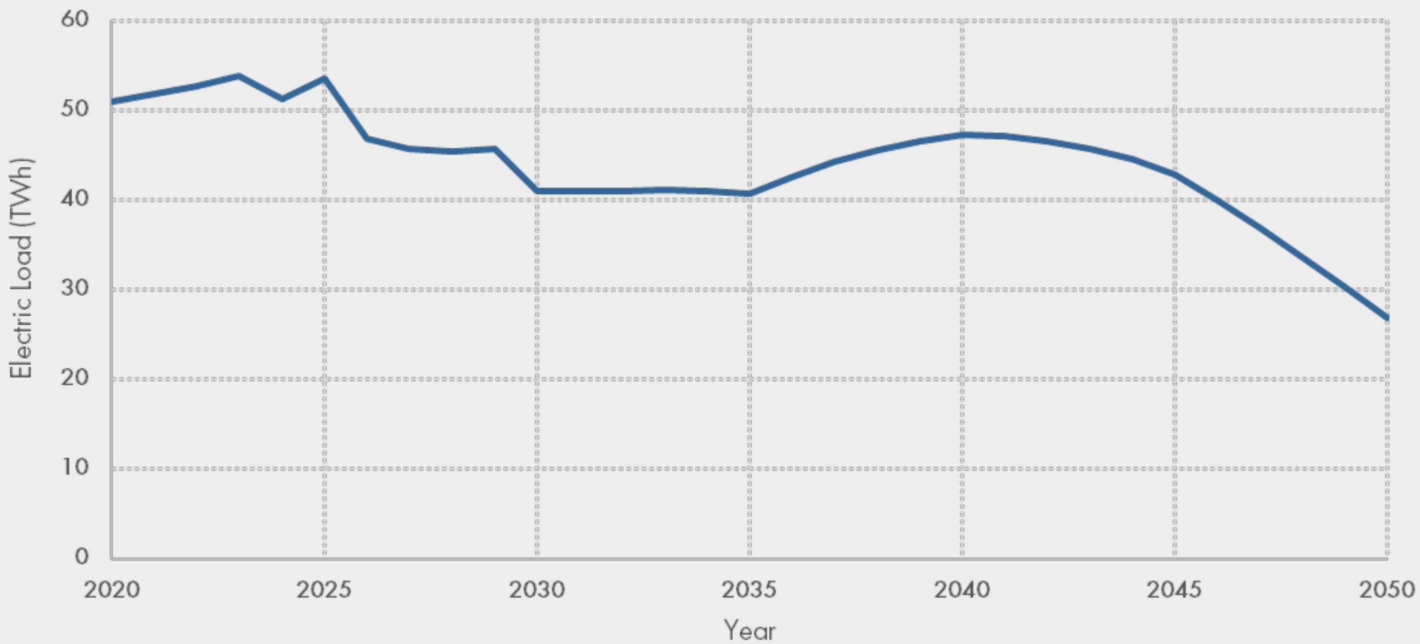


## **Emissions Reduction Pathway 3:** Procure out-of-state renewable energy

DEP's analyses show that even accounting for renewable supplies (Figure 3.20) and available nuclear power, there is still a power supply deficit that must be met either through fossil-powered generation or additional renewable resources (Figure 3.21). This unmet demand remains relatively constant at between 40 and 50 TWh annually through 2045 and then drops to 27 TWh by 2050.

***Figure 3.21. Load not met with in-state zero emitting sources (renewables or nuclear power).***

*The demand not met by in-state clean energy resources must either be satisfied with in-state fossil generation or by resources located outside the state. The 2019 EMP anticipates that all imported energy will come from renewable solar and wind, and that in-state fossil resources will be phased out or converted to renewable biofuels by 2050.*




In the 2019 EMP least cost scenario, this deficit is met at first with fossil generation, but in later years is met with increasing amounts of renewable energy from out-of-state (Figure 3.15). Taking advantage of increasing amounts of out-of-state renewable energy will require doubling transmission capacity from today's 7 GW to 14 GW. This will require significant planning and financial resources.

Applying the emissions reduction pathways described above to Reference Case D, the state's expanded solar and wind commitments eliminate about two thirds of GHG emissions, and renewable biofuels provide further reductions resulting in emissions of 10.8 MMT $CO_2e$ which is short of the goal of carbon-free electric generation (Figure 3.12). The gap between the bottom line in Figure 3.12 (the rate of fossil emissions anticipated in the 2019 EMP) and the yellow line (labeled Pathways 1, 2A, 2B and 2C, Biofuel after 2045, which represents the emissions remaining after application of in-state clean energy) shows the estimated remaining GHG emissions which could be eliminated through out-of-state imports or other measures undertaken by the state (10.8 MMT $CO_2e$) .

## 2050 RECOMMENDATIONS

In order to meet its 80x50 GHG reduction goal, New Jersey must act swiftly to reduce GHG emissions from the electric generation sector. The state will need to rapidly deploy renewable sources of electricity by greatly expanding in-state solar PV and offshore wind production and procuring out-of-state renewable energy. These renewable resources must be available to handle increasing demand from the electrification of the building and transportation sectors. As noted above, if these sectors electrify without adequate renewable resources, substantial increases in electric sector GHG emissions will occur.

Early efforts should focus on creating a dramatically streamlined renewable energy and distributed energy resources (DER) project development process, from the availability of funding mechanisms to expedited permitting and siting of DERs and grid interconnections. The BPU should continue its work towards the timely creation of a successor solar incentive program, development of a mechanism to procure significant grid-supply solar energy, and a permanent community solar program. Enabling legislation may further support the BPU's efforts. These programs will serve as the backbone incentives to further grow the solar capacity in the state. Additionally, New Jersey's distribution grid will need to be upgraded to facilitate the expansion of solar PV. BPU will need to continue its work with utilities to create a strategic plan to evaluate limitations and create policies to accommodate the exponential growth in renewables.

In addition to pursuing the build out of solar PV, the state needs to continue its momentum in pursuit of offshore wind. The BPU has awarded an 1,100 MW solicitation and is offering a second solicitation for up to 2,400 MW, fulfilling the first goal of the CEA. The state must aggressively seek an additional 4,000 MW as committed to in EO-92 and the almost 11,000 MW called for in the 2019 EMP. Additionally, the state must look for cost effective ways to develop the offshore wind transmission system, delivering electricity to onshore customers.

The state should evaluate and implement opportunities for innovative financing models for renewable energy and DER development, such as a Green Bank, C-PACE[12] lending, and on-bill financing. C-PACE legislation would provide an alternative mechanism for financing renewable energy improvements on commercial properties, allowing property owners to finance the up-front cost of DERs on a property and then pay the costs back over time through a voluntary assessment. Additionally, DER compensation should be evaluated in light of all services provided, with multiple potential revenue streams to owners. As an example, battery storage can provide many benefits to the electric grid, including long-term storage, instantaneous response to fluctuations in demand, and reductions in peak loading. When batteries and other distributed energy resources deliver multiple benefits, each represents a potential revenue stream for its owner. It is therefore important that fair compensation be provided, a process called value stacking. Throughout the energy transition process, just and reasonable cost allocations, tariffs, and rate designs must be incorporated to provide ratepayers with the most affordable and reliable service while meeting the state's clean energy goals.

These funding mechanisms need to be complemented with better guidance on siting renewable energy and DERs. Clear guidance and rules need to be immediately developed regarding where renewable energy should and should not be sited. The DEP should work with sister agencies to better define areas that are considered marginalized, and as such, could host renewable energy projects. For example, non-preserved farmland with poor soil conditions could potentially serve as host sites for large-scale solar projects. These decisions must reconcile the goals of open space preservation, the value of land serving as natural carbon sinks and the imperative to quickly build in-state renewable energy. Informed siting is also needed to avoid investments in flood prone areas and locations most vulnerable to the impacts of climate change.

Further location analysis and guidance is needed to lead the interconnection process. DER penetration will fail to reach its maximum potential without upgrades to the distribution systems. A full interconnection study or integrated distribution plan is needed to realize the level of renewable energy and DER adoption envisioned in the 2019 EMP. Developers seeking to vet potential locations for siting DERs would benefit from this detailed guidance. The BPU should also update its policies to require bi-directional grid power flow and modernize its interconnection standards to facilitate the clean energy transition.

Expedited permitting review should also be pursued for large-scale renewables and transmission projects. The New York State legislature recently passed the Accelerated Renewable Energy Growth and Community Benefit Act (Acceleration Act). New Jersey's legislature should consider similar legislation. The Acceleration Act created a new dedicated Office of Renewable Energy Siting, a state-sponsored program to identify, permit and deliver "build-ready" sites for project developers and operators; and an accelerated transmission investment program to identify, target and approve infrastructure upgrades that will facilitate and support the rapid deployment of renewable energy. The NJ PACT regulations offer an opportunity to improve the permitting and review of proposed climate-related infrastructure.

[12] Commercial Property Assessed Clean Energy

Establishing a statutory foundation across the entirety of state government to steer guidance, permitting and regulations toward consideration of climate needs would support the Global Warming Response Act goals.

Beyond dramatically expanding renewable energy and DERs, the state will also need to limit reliance upon and development of new fossil fuel powered electricity generating units. In the long term, the state will need to transition existing natural gas infrastructure for deployment of renewable biogas. New Jersey can make headway on this effort by evaluating opportunities for renewable biomass-to-energy projects. This aligns with the state's ambitious waste reduction recommendations in the Waste Chapter.

Another promising option is the creation of a clean energy market mechanism, such as a clean energy standard, that would reward New Jersey's carbon-free energy resources based on their environmental benefits in a technologically agnostic way. An example of such a market mechanism is provided by the RGGI program, which applies a cap to limit emissions from participating states' electric generating units, and then uses an auction process that creates revenue to support other emission reduction strategies. Planned decreases in the level of the cap allow investors to make informed decisions as they approach development of new power resources. This predictability of a decreasing cap could also be applied by the state to electric distribution companies through an emission portfolio standard. As another example, air regulatory mechanisms could be used to stimulate early investment in renewables based on emissions from fossil resources. One approach would require all new and modified electric generating facilities to meet emission standards or carbon intensity standards ($CO_2$ per MWh), with emissions limits that decrease over time. Facilities could then reduce their net emission rates by building clean energy resources complementary to their existing systems, lowering the overall combined emissions per unit of electricity produced.

Saving energy is the most cost-effective way to reduce demand and emissions. New Jersey needs to build on the successes of past energy efficiency efforts by incorporating innovative strategies that carefully manage loads and improve efficiency. As a first step, BPU has already mandated stricter energy efficiency goals than required by the CEA, setting five-year savings targets of 2.15% for electric distribution companies and 1.10% for gas distribution companies. These more aggressive targets will help propel the state towards meeting the 80x50 goal.

To build on this effort, New Jersey should continually work towards increasing public awareness and access to the Clean Energy Program and its suite of statewide utility-administered programs. Updates to the public interface should implement user-centered design to ensure the website and process is accessible to all customers. The BPU should also create a state-run portal that is comprehensive and inclusive of both state and utility-led programs. Interagency clean energy events should be hosted to demonstrated clean vehicles and energy efficiency technologies.

Further, Time of Use (TOU) rates are likely needed to incentivize customers to reduce energy use during periods of peak energy demand. As New Jersey experiences a rapid growth in electric vehicles, buildings and appliances, policies are needed to manage increasing demand. Currently, electricity rates for residential customers include a small fixed charge and a charge for each kWh of electricity used. These flat rates do not reflect the true cost of electricity production at peak times. The BPU should pilot new rate structures that more precisely price kWhs at what they cost when consumed. This can help customers save money by shifting their use away from high-priced time periods. These rates also reduce utility expenditures by lowering peak demand. Key to navigating this new price structure will be technological upgrades, including smart meters and advanced metering infrastructure (AMI). In February 2020, following the conclusion of a study analyzing the results of AMI adoption in one of the state's public electric utilities, the BPU directed the state's remaining three electric utilities to file plans by August 2020 to implement use of these technologies. These plans have been submitted and are currently under review.

Additional policies crucial to limiting and reducing growth in energy consumption include the adoption of building codes or above-code alternatives that encourage efficiency, building energy use and efficiency labeling, and increased appliance standards. These needs are further discussed in the Residential and Commercial Buildings Chapter of this report. Other strategies that the state could pursue include the development of a Clean Peak Standard designed to set a minimum amount of clean, carbon free generation resources that must be used to meet peak demand, in lieu of traditional fossil fuel peaking plants.

With respect to the federal government's role in the electric sector, the state must vigorously defend its jurisdiction while pressing for united national action. But even in the absence of federal progress, it has been estimated that leadership states, including New Jersey and its partners in the United States Climate Alliance (USCA), working with committed local governments, municipalities and businesses, can fulfill 80% of the nation's Paris Accord goals for 2030 (Hultman, et al., 2019). The legislature should therefore encourage coordinated regional efforts among partner states, local governments, and businesses, and build on the foundation of existing regional initiatives.

*Table 3.5. Recommendations for Expanding In-State Renewable Energy and DERs.*

| Actions | Entity | Timeframe[13] | References |
|---|---|---|---|
| Timely creation of a successor solar incentive program. | BPU | Near-term | |
| Creation of a large-scale grid supply solar incentive program. | Legislature | Near-term | |
| Expand Community Solar Program and transition to permanent program with goal of 150MW/year, and strong low- and moderate-income (LMI) household participation. | BPU | Near-term | |
| Release a full interconnection study or require utilities to develop integrated distribution plans to guide DER siting and assist in opening currently closed circuits. | BPU | Near term, with ongoing review | 2019 EMP Goals 2.1.5; 5.1.1; 5.1.2 |
| Require utilities to enable bi-directional power flow suitable for wide-penetration of DER. | BPU | Near- to mid-term | 2019 EMP Goal 5.1.2. Also see previous entry, "Integrated Distribution Plans" |
| Update interconnection standards to accommodate distribution system flexibility. | BPU | Near- to mid-term | 2019 EMP Goal 5.1.2. Also see previous entry, "Integrated Distribution Plans" |
| Evaluate improvements to compensation for DER in light of multiple services provided, with multiple potential revenue streams to owners ("value stacking"). | BPU, NJ Division of Rate Counsel | Near-term | 2019 EMP Goals 2.1.6; 2.3.6; 5.3.3 |
| Evaluate and implement opportunities for improved financial support of DER development, such as Green Bank, C-PACE lending, and on-bill financing. | BPU, EDA, NJDOBI, DCA, NJHMFA, NJ Redevelopment Authority, NJ Division of Rate Counsel | Near- to mid-term | 2019 EMP Goals 2.1.7 |
| Consider legislation creating a dedicated Office of Renewable Energy Siting, a state-sponsored program to identify, permit and deliver "build-ready" sites for project developers and operators; and an accelerated transmission investment program to identify, target and approve infrastructure upgrades that will facilitate and support the rapid deployment of renewable energy. | Legislature | Near-term | New York State Acceleration Act |

[13] Near-term: now through 2030. Mid-term: 2030-2040. Long-term: 2040-2050. Throughout: Ongoing now through 2050.

| | | | |
|---|---|---|---|
| Establish clear guidance on suitability of locations for DER, preferring marginalized lands and avoiding vulnerable sites. | BPU, DEP, NJDA | Near-term | 2019 EMP Goal 2.1.8 |
| Improve relevant data collection (such as state parcel data classification and BPU incentive tracking) to advance state-level analysis and tool development for renewable energy potential. | BPU, Treasury, DEP | Near-term | |
| Consider legislation requiring solar PV on new construction. | Legislature | Near-term | |
| Continue solicitations for offshore wind to achieve the Governor's goals and EMP projections. | BPU, DEP | Near-term | |
| Evaluate OSW transmission capacity required for full-scale deployment. Implement plans. | BPU | Near- to mid-term | 2019 EMP Goal 2.2.1 |
| Evaluate alternative means to procure clean energy that benefit New Jersey, such as clean energy market. | BPU, DEP | Near-term | 2019 EMP Goal 2.1.1 |
| Evaluate displacement of NJ electric resources with out of state resources due to carbon pricing ("leakage"). If significant, develop rules and/or legislation to mitigate – such as a cross border carbon price adjustment. Re-evaluate with 2019 EMP revision or other significant events. | BPU, DEP | Near- to mid-term | 2019 EMP Goals 2.1.4; 2.1.9 |
| Evaluate transmission system upgrades. | BPU | Throughout | |
| Confer with other states to advocate for any needed changes under PJM and federal domains. | BPU, DEP | Near-term and throughout | 2019 EMP Goal 2.1.4; Strategy 2 Goal Summary, p. 135 |

*Table 3.6. Recommendations for Nuclear Energy and Utilization of Biogas.*

| Actions | Entity | Timeframe | References |
|---|---|---|---|
| Track and evaluate nuclear technologies to determine their feasibility in assisting in the energy transition. | BPU, DEP | Throughout | |
| Evaluate alternatives for "clean firm" dispatchable generation, including biogas-fired turbines, renewably-powered or hydrogen-powered fuel cells and other emerging technologies | BPU, DEP | Research: Near-term and continuing. Implementation will be most important after 2040, but sooner if attractive. | 2019 EMP Goal 2.1.1; 2.3.7. Also see entry below regarding use of source-separated food waste for biogas production. |
| Evaluate opportunities for biomass-to-energy projects, including electricity generation, based on source-separated food waste and anaerobic treatment technologies, as identified in 2019 EMP least cost scenario for 2040 and later implementation. | BPU, DEP, EDA | Research: Near- to mid-term. Implementation: Near- to mid-term if attractive; IEP anticipates biogas turbine applications after 2040. | 2019 EMP Goal 2.3.7. Also see related Goal 2.1.1, |

*Table 3.7. Recommendations for reducing energy demand and managing loads.*

| Actions | Entity | Timeframe | References |
|---|---|---|---|
| Continue implementation of the Clean Energy Act mandate to reduce electric and gas consumption while accounting for fuel switching, electrification and peak reduction goals. Develop guidelines, performance indicators, cost recovery strategies, and aggregate, fuel-neutral energy indicator. Review utility proposals. | BPU | Programs for efficiency commence July 2021. | 2019 EMP Goal 3.1.1; Strategy 3 Goal Summary, p. 155 |
| Increase public awareness of efficiency programs. Make programs accessible. Develop financing mechanisms with specific attention to low- and moderate- income stakeholders. | BPU, DCA, EDA, NJHMFA, NJ Redevelopment Authority | Throughout | 2019 EMP Goals 3.1.2; 3.1.3; 3.1.4; 3.1.5; 3.1.6; |
| Evaluate role of solar in supporting other 2019 EMP goals, e.g. storage capacity expansion. | BPU | Near-term | 2019 EMP Goal 2.3.2 |
| Mandate applicable non-wires solutions for managing load on all state-funded projects, such as demand response, grid controls, and storage, to reduce need for transmission and distribution system upgrades. | State Agencies, Treasury | Initial mandate: Near-term. Implementation: Throughout | 2019 EMP Goal 2.3.5 |
| Develop and implement mechanisms to achieve storage goals and meet existing mandates and projected needs based on least cost pathway, and grid distribution needs. | BPU | Near-term | 2019 EMP Goal 2.3.6; Strategy 2 Goal Summary, p. 134. Also see related Goal 2.1.6, "Value Stacking" above. |
| Evaluate advantages of co-located and paired systems, for example storage plus wind, among others. | BPU | Near-term | 2019 EMP Goal 2.3.6 |
| Evaluate and implement programs to manage and reduce peak demand, and strategies to meet peaks with clean resources. Consider use of Clean Peak Standard requiring clean resources. Work should complement parallel efforts re: AMI and DER value stacking. | BPU | Near- and mid-term | 2019 EMP Goal 3.2.1 |
| Require consideration of Non-Wires Solutions (NWS) as alternatives to infrastructure investments. Support pilot programs for NWS. | BPU | BPU to solicit proposals for pilot programs by mid-2020; Policies and resources for NWS adoption to be completed by December 2021. | 2019 EMP Goal 5.1.4 |
| Implement smart meter and AMI programs to allow ratepayers to benefit. Use data to optimize grid management. | BPU | Near-term | 2019 EMP Goal 5.3.1; Strategy 5 Goal Summary, p. 195 |

## WORKS CITED

EO-7. (2018). *Murphy Executive Order 7, New Jersey to Rejoin the Regional Greenhouse Gas Initiative.* Retrieved from https://nj.gov/infobank/eo/056murphy/pdf/EO-7.pdf

EO-8. (2018). *Murphy Executive Order 8, Promoting Offshore Wind.* Retrieved from State of New Jersey: https://nj.gov/infobank/eo/056murphy/pdf/EO-8.pdf

EO-92. (2019). *Murphy Executive Order 92, Expansion of Offshore Wind Capacity to 7500 MW by 2035.* Retrieved from State of New Jersey Web Site: https://nj.gov/infobank/eo/056murphy/pdf/EO-92.pdf

EV Vehicle Database. (2020, May 11). *Energy Consumption of Full Electric Vehicles.* Retrieved from https://ev-database.org/cheatsheet/energy-consumption-electric-car

Hultman, N., Frisch, C., Clarke, L., Kennedy, K., Bodnar, P., Hansel, P., . . . Goldfield, E. (2019). *Accelerating America's Pledge: Going All-In to Build a Prosperous, Low-Carbon Economy for the United States.* The America's Pledge Initiative on Climate Change; Bloomberg Philanthropies. Retrieved March 2, 2020, from https://www.americaspledgeonclimate.com/accelerating-americas-pledge-2/

NJBPU. (2019a). *2019 New Jersey Energy Master Plan, Pathway to 2050.* Trenton, NJ: State of New Jersey.

NJBPU. (2019b). *New Jersey Celebrates Leadership in Offshore Wind Sector.* Retrieved from New Jersey Board of Public Utilities: https://nj.gov/bpu/newsroom/2019/approved/20190211.html

NJBPU. (2019c, June 21). *New Jersey Board of Public Utilities Awards Historic 1,100 MW Offshore Wind Solicitation to Ørsted's Ocean Wind Project.* Retrieved from https://nj.gov/bpu/newsroom/2019/approved/20190621.html

NJBPU. (2020a). *Solar Activity Reports*. Retrieved from New Jersey's Clean Energy Program: https://njcleanenergy.com/renewable-energy/project-activity-reports/project-activity-reports

NJBPU. (2020b). Retrieved from https://www.nj.gov/bpu/newsroom/2020/approved/20200610.html. Retrieved from https://www.nj.gov/bpu/newsroom/2020/approved/20200610.html

NJBPU. (2020c, July 22). *NJBPU Issues Draft Guidance Document for Second Offshore Wind Solicitation.* Retrieved from https://www.bpu.state.nj.us/bpu/newsroom/2020/approved/20200722.html

NJDEP. (2019). *2018 Statewide Greenhouse Gas Emissions Inventory.* Retrieved from https://www.nj.gov/dep/aqes/docs/nj-ghg-inventory-report-2018.pdf

NJDEP. (2020).Unpublished data from Bureau of Climate Change and Clean Energy.

NJDEP. (Solar Siting Analysis Update). *2017.* Retrieved from https://www.state.nj.us/dep/aqes/SSAFINAL.pdf

P.L. 2007 c.112; P.L. 2018 c.197. (2018). *Global Warming Response Act.* Retrieved from https://lis.njleg.state.nj.us/nxt/gateway.dll?f=templates&fn=default.htm&vid=Publish:10.1048/Enu

P.L. 2007 c.340. (2007). *Global Warming Solutions Fund Act.* Retrieved from https://www.njleg.state.nj.us/2006/Bills/PL07/340_.PDF

P.L. 2010 c.57. (2010). *Offshore Wind Economic Development Act.* Retrieved from https://www.njleg.state.nj.us/2010/Bills/PL10/57_.PDF

P.L. 2018, c.17. (2018). *Clean Energy Act.* Retrieved from https://www.njleg.state.nj.us/2018/Bills/PL18/17_.PDF

P.L. 2019 c.328. (2019). *An Act Concerning Greenhouse Gas Emissions (RGGI), Amending P.L. 2007, c.340.* Retrieved from https://www.njleg.state.nj.us/2018/Bills/PL19/328_.PDF

SEIA. (2020). *Top 10 Solar States.* Retrieved from https://www.seia.org/research-resources/top-10-solar-states-0

State of New Jersey, Governor's Office. (2020, February 28). *Governor Murphy Announces Offshore Wind Solicitation Schedule of 7,500 MW through 2035.* Retrieved from State of New Jersey: https://www.nj.gov/governor/news/news/562020/20200228a.shtml

USEIA. (2019a). *New Jersey Electricity Profile 2018.* Retrieved from US Energy Information Agency: https://www.eia.gov/electricity/state/newjersey/

USEIA. (2019b). *Electricity Data Browser, selected NJ data*. Retrieved from US Energy Information Agency: https://www.eia.gov/electricity/data/browser/#/topic/0?agg=2,0,1&fuel=vtvv&geo=0004&sec=g&linechart=ELEC.GEN.ALL-NJ-99.A&columnchart=ELEC.GEN.ALL-NJ-99.A&map=ELEC.GEN.ALL-NJ-99.A&freq=A&ctype=linechart&ltype=pin&rtype=s&pin=&rse=0&maptype=0

USEIA. (2019c). *State Energy Data System, Data Files, All Consumption Estimates, in BTU.* Retrieved from US Energy Information Agency: https://www.eia.gov/state/seds/sep_use/total/csv/use_all_btu.csv

USEIA. (2019d). *EIA-923, Monthly Generation and Fuel Consumption Time Series File.* Retrieved from US Energy Information Agency: https://www.eia.gov/electricity/data/eia923/

USEIA. (2019e). *Net Generation by State by Type of Producer by Energy Source.* Retrieved from Detailed State Data: https://www.eia.gov/electricity/data/state/annual_generation_state.xls

USEPA. (2018). *Greenhouse Gas Reporting Program (GHGRP).* Retrieved from https://www.epa.gov/ghgreporting

CHAPTER 4

# INDUSTRIAL

# INDUSTRIAL SECTOR SNAPSHOT

## 2018 EMISSIONS DATA

- The industrial sector emitted **7.2 MMT $CO_2$e** in 2018.

## EMISSIONS ACTIVITIES

- New Jersey's industrial sector emissions are associated with onsite energy generation, and process and non-process energy consumption. Non-road equipment used at industrial facilities for construction, operations and maintenance are also included in this sector.

## GHGs OF CONCERN

- Carbon Dioxide ($CO_2$)
- Black Carbon

## EMISSION REDUCTION PATHWAYS

1. Energy Efficient Operations and Investment

## RECOMMENDATIONS

1. Facility-wide energy audits, benchmarking and commitments to energy efficiency upgrades and practices.
2. Investigate opportunities to reduce industrial $CO_2$ emissions through NJPACT regulations.

## AGENCY STAKEHOLDERS

- New Jersey Board of Public Utilities
- New Jersey Department of Environmental Protection
- New Jersey Economic Development Authority

# OVERVIEW

The industrial sector[1] consists of the facilities and equipment used for producing, processing, or assembling goods (USEIA, 2020). In 2018, the largest emitting industries in New Jersey (reporting under the New Jersey Department of Environmental Protection [DEP] emission statement program) were petroleum refineries accounting for more than 56% of emissions in this sector, followed by iron and steel manufacturing, chemical manufacturing, transportation and logistics, glass, paper and food manufacturing.

Greenhouse gases (GHGs) and climate pollutants of concern are emitted by the industrial sector through "direct" or onsite emissions, and via "indirect" emissions from offsite electric generation associated with the facility's electricity consumption. This chapter focuses exclusively on direct emissions. Indirect emissions are captured in other chapters of this report. Specifically, emissions from grid-supplied power consumed in the manufacturing process are accounted for in the electric generation sector; warehousing under the commercial sector; waste processing under the waste sector; and consumer products used for industrial processes under the halogenated gases subsector of the Short-lived Climate Pollutant Chapter. Direct emissions come from the consumption of fossil fuels for process energy, onsite electric generation and onsite non-road equipment, through chemical reactions and from fugitive emissions from industrial processes or equipment (USEPA, 2020). Energy consumption for manufacturing activity is largely used for process heating and cooling, and powering machinery, with a smaller portion used for facility heating, air conditioning, and lighting. Immediate emission reductions can be achieved through implementing energy efficiency measures. Greater reductions will be realized if there is an economy-wide transition away from fossil fuel energy and a subsequent decrease in production at refineries.

[1] An energy-consuming sector that consists of all facilities and equipment used for producing, processing, or assembling goods. The industrial sector encompasses the following types of activity: manufacturing (NAICS codes 31-33); agriculture, forestry,
fishing, and hunting (NAICS code 11); mining, including oil and gas extraction (NAICS code 21); and construction (NAICS code 23).

## WHERE WE STAND

In 2018, the state's industries collectively emitted an estimated 7.2 MMT $CO_2e$ (7%) of New Jersey's net 97 MMT $CO_2e$ GHG emissions (NJDEP, 2019). New Jersey currently accounts for emissions in the industrial sector using fuel consumption data from the United States Energy Information Administration. New Jersey also collects data via emission statements from permitted entities, which is utilized to inform GHG reduction strategies.

GHG emissions from the industrial sector declined from 2006-2015 and leveled off at approximately 7 MMT $CO_2e$ between 2016 and 2018 (Table 4.1). Over the last two decades the state has experienced a shift from heavy industry (like steel manufacturing) to advanced technology industries such as medical equipment manufacturing (NJEDA, 2019). This shift in the type of New Jersey industries, combined with a general decline in New Jersey's industrial sector overall, have contributed to the decrease of emissions. At the same time, energy efficiency improvements have also played a role in the decreasing emissions from the industrial sector. The American Council for an Energy-Efficient Economy (ACEEE) ranking of energy efficiency nationwide indicates New Jersey's efficiency continues to show improvement (ACEEE, 2020).

*Table 4.1. Annual Industrial Sector Greenhouse Gas Emissions 2006 – 2018 (MMT $CO_2e$).*

| 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16.3 | 15.9 | 13.9 | 10.6 | 9.1 | 10.3 | 10.3 | 9.7 | 9.7 | 5.1 | 7.5 | 6.8 | 7.2 |

In 2018, industrial sector emissions were attributed to the use of the following primary fossil fuel types: liquified petroleum gases (such as propane, normal butane, and isobutane) and others (such as ethane, natural gasoline, and refinery olefins) at 44%, natural gas at 32%, distillate fuel oil at 13%, motor gasoline at 6% and biofuels heat and coproducts at 4% (Figure 5.1) (USEIA, 2019).

***In 2018, the Industrial sector emitted an estimated 7.2 million metric tons of $CO_2e$. This represents 7% of New Jersey's net emissions.***

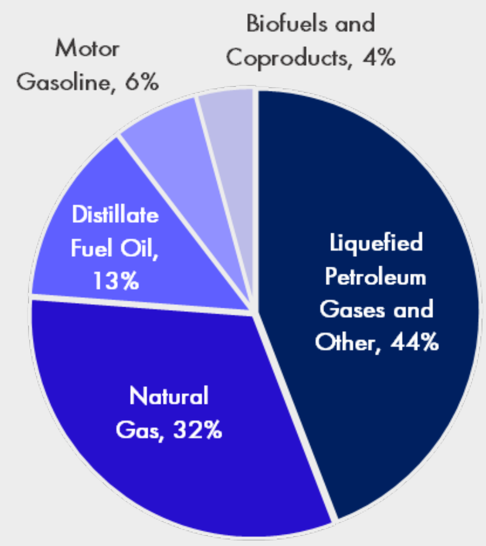
Linden, New Jersey
Source: Google Earth

Generally, emissions are produced onsite at industrial facilities from four main activities:

- **Onsite Energy Generation:** Refers to the generation of heat, steam or electricity within the facility boundaries using fossil fuels or electricity. It covers three categories: (1) conventional boilers that produce steam, (2) combined heat and power/cogeneration to produce steam and electricity and (3) Onsite Electricity Generation, obtained through generators running on fossil fuels or renewable energy sources (USDOE, 2019a). Onsite generation supports process and non-process electrical and thermal load.
- **Process Energy**: Refers to the energy used to convert raw materials into manufactured products. It includes process heating, cooling, refrigeration, machine drive, electrochemical processes, and other process uses (USDOE, 2019a).
- **Non-Process Energy**: Refers to energy used for purposes other than converting raw materials into end products, including; energy used for heating, ventilation and air conditioning (HVAC), facility lighting, onsite transportation, cooking, water heating and other non-process uses (USDOE, 2019b).
- **Non-Road Equipment:** Refers to energy burned in medium- and heavy- duty equipment, including bulldozers, excavators, cranes, and other non-road vehicles moving goods and personnel onsite.

***Figure 4.1. Industrial Emissions Sources by Percentage of Total 7.2 MMT CO2e, 2018, New Jersey.***

*Natural gas, liquified petroleum gases, and distillate fuel oil account for 89% of emissions from the industrial sector.*




*Source: USEIA*

## Existing Emissions Reduction Policies

The DEP regulates air emissions from industrial sources through its broad authority under the New Jersey Air Pollution Control Act (APCA), N.J.S.A. 13:1B-3(e), 13:1D-9, 26:2C-1 et seq. For stationary sources of pollution (i.e., factories, power plants, etc.), the DEP regulates through a permitting process for both existing and new, major and minor facilities to ensure their compliance with applicable air regulatory standards. The air regulatory program has been successful in reducing emissions and improving New Jersey's air quality. These regulation-driven improvements have been accomplished through mandates of the Federal Clean Air Act that require states to achieve attainment with National Ambient Air Quality Standards (NAAQS). DEP has also been a leader in identifying and reducing local health risks from industrial operations as part of the air permit review process (NJDEP, 2020). These efforts have centered around criteria and hazardous air pollutants. However, pollution prevention and efficiency improvements implemented to reduce criteria and hazardous pollutants have also provided GHG reductions.

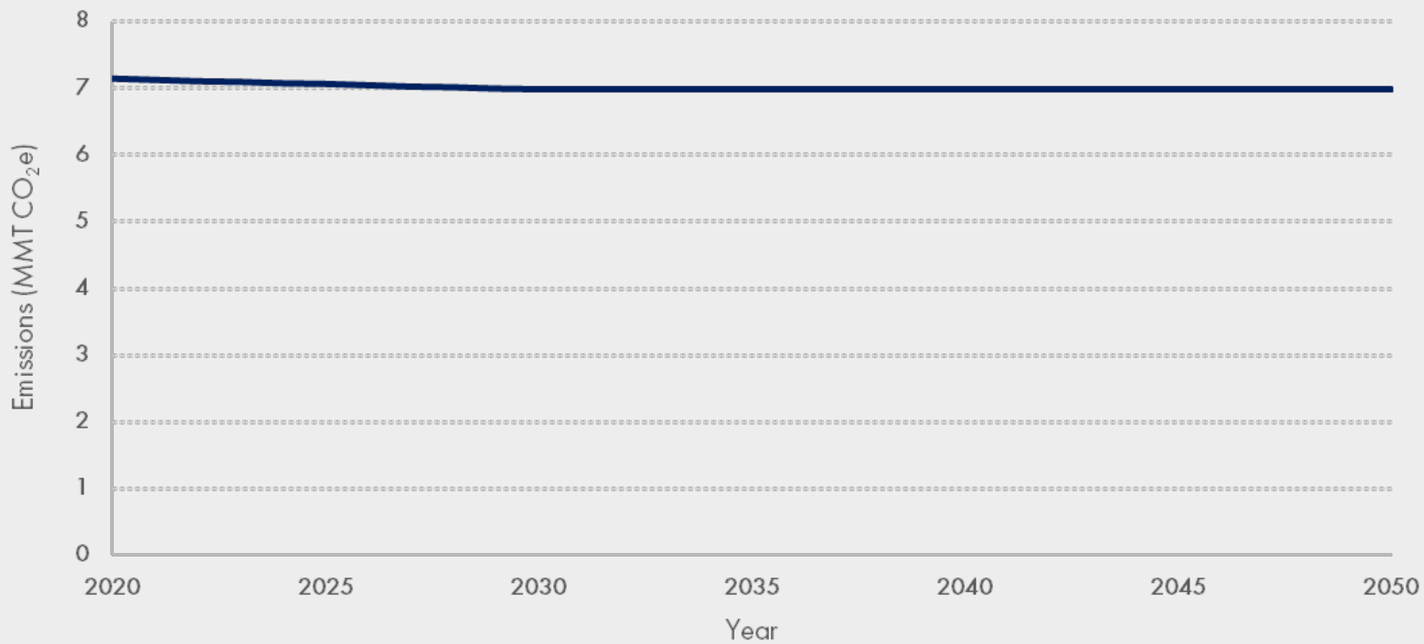
### *BPU Clean Energy Program*

The New Jersey Board of Public Utilities (BPU) commits substantial financial resources to provide incentives that advance both the commercial and industrial sectors' energy efficiency efforts through the New Jersey Clean Energy Program (NJCEP). In fiscal year 2020, $180 million was dedicated to energy efficiency incentives in the commercial and industrial sectors (NJBPU, 2019). The program provides financial rebates and incentives to New Jersey's businesses for installation of energy efficient equipment that lowers their utility costs while at the same time reducing emissions. The NJCEP tracks the related emission reductions, and in their most recent fiscal year 2019 data, emissions savings from the commercial and industrial sectors were 113,000 metric tons annually (NJBPU, 2019). Additionally, the NJCEP's Large Energy Users Program encourages participants to streamline investment in large-scale energy efficiency projects such as combined heat and power projects, facilitating GHG emission reductions at these facilities.

## Business-as-Usual Projection

If New Jersey stays on a Business-as-Usual (BAU) path, emissions from the industrial sector would see small reductions (4%) from 7.2 MMT $CO_2$e in 2018 to 6.9 MMT $CO_2$e in 2030 (Figure 4.2). The BAU projection assumes flat growth in the industrial sector between 2018 and 2024 and takes into account reductions from continued energy efficiency improvements in natural gas consumption mandated by the Clean Energy Act (CEA) until 2030, holding it at that level forward into 2050.

***Figure 4.2. New Jersey Industrial Sector Emissions 2020-2050 Business-As-Usual Projection (MMT $CO_2$e).***
*Emissions would drop only slightly, from 7.2 MMT $CO_2$e in 2018 to 6.9 MMT $CO_2$e in 2030 due to natural gas efficiency improvements.*



## THE PATH FORWARD

Industry is considered one of the harder to abate emissions sectors. Industrial processes vary immensely and are technically difficult to decarbonize. Few scalable methods exist today for generating large quantities of high temperature heat, other than burning fossil fuels and using process gases—both of which are emissions-intensive (McKinsey, 2017). Several industrial processes generate emissions directly, such as manufacturing ammonia and cement. And other processes like refining, are highly integrated, so much so, that changing a single step in the process requires other steps to be modified, usually at great cost (McKinsey, 2017).

Petroleum refineries are the largest industrial source of both $CO_2$ and methane required to report under DEP's Emission Statement Program, accounting for approximately 4 MMT $CO_2e$ annually. While there is limited opportunity to reduce direct emissions from in-state petroleum refineries, significant emission reductions will be realized with the economy-wide transition away from fossil fuel use envisioned in the 2019 Energy Master Plan (NJBPU, 2020a).

Further, industry often uses heavy equipment powered by internal combustion engines for onsite construction, maintenance and to move supplies and personnel at the industrial sites. Diesel engines that power this equipment are one main driver of black carbon emissions in New Jersey. Efforts to mitigate the emissions impact of these sources have been largely successful, and New Jersey's continued commitment to existing strategies is key. However, additional regulatory and policy tools could achieve even greater emission reductions. One option for addressing non-road sources that remain at an industrial site for extended periods of time is to regulate them as stationary sources under the DEP Air Permitting Program. Regulating these non-road sources as stationary sources would be one area where the State could achieve additional $CO_2$ and black carbon reductions.

Considering many industrial sites are located in urban areas with overburdened communities, doing this would also reduce health impacts in those communities. Regulating these sources as stationary sources is discussed further in the Black Carbon subsection of the Short Live Climate Pollutant Chapter.

Due to the complexity of mitigating emissions from the industrial sector only one pathway has been identified that can achieve modest emissions reductions in New Jersey's (Figure 4.3).

- Pathway 1, Energy efficient operations and investments, assesses the emissions impacts of the CEA energy efficiency mandates.

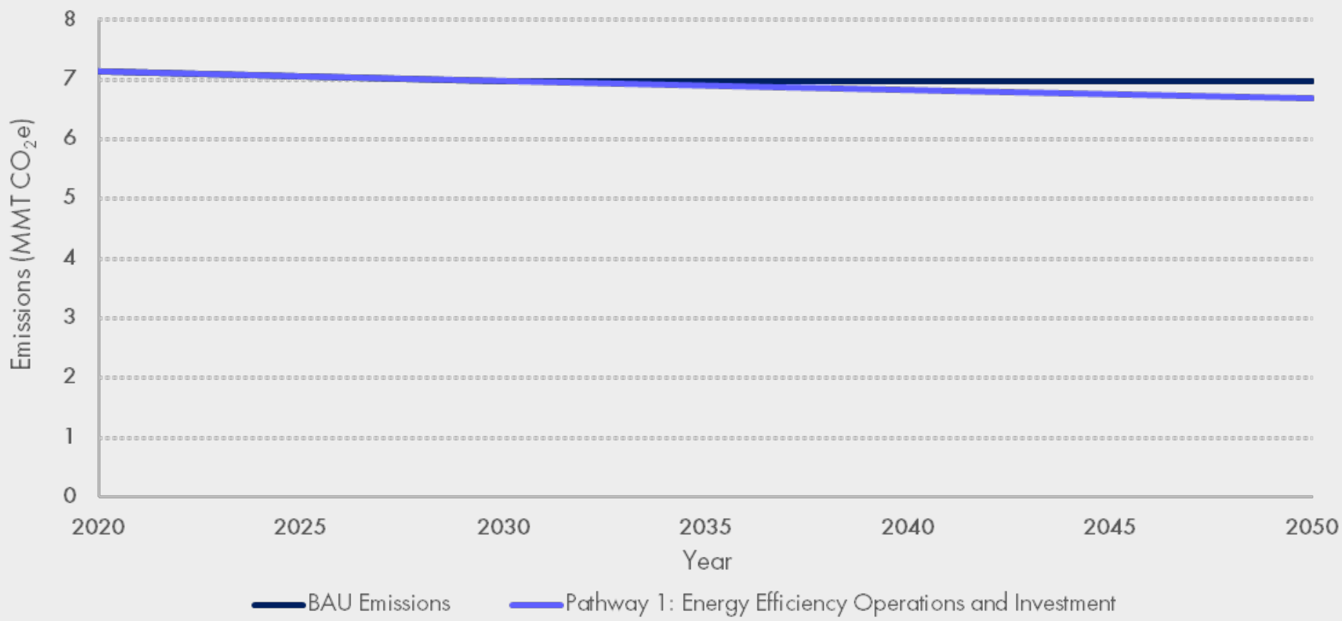
### EMISSION ACTIVITES

- On-Site Generation
- Process Energy
- Non-Process Energy
- Off-Road Equipment

### EMISSIONS REDUCTION PATHWAY

1. Energy efficient operations and investment

*Figure 4.3. Industrial Sector 2050 Pathway Projection.*
*Enhanced strategies for efficiency improvement can result in slightly greater emissions reductions.*




## **Emissions Reduction Pathway 1:** Energy efficient operations and investment

In 2019, the BPU commissioned a study evaluating the potential for energy efficiency across the residential, commercial, and industrial sectors in the state (Optimal Energy, 2019). Within the industrial sector, process and non-process measures such as process loads related to motor systems, interior lighting, process heating, and space heating were found to have significant opportunities for energy efficiency (Optimal Energy, 2019). The study also found that for every dollar invested in energy efficiency for the commercial and industrial sector, New Jersey would gain $2.74 dollars in benefits (Optimal Energy, 2019). The projection for this pathway accounts for annual decreases in natural gas used by the sector in alignment with the 0.75% required decline mandated in the CEA. Overall, the DEP estimates that this pathway could achieve up to 0.5 MMT $CO_2$e reduction in GHG emissions by 2050. This is a conservative estimate, as BPU has recently established a more ambitious energy efficiency target of 1.1% for gas distribution companies (NJBPU, 2020b). Furthermore, industrial facilities with office building or warehousing onsite could employ the energy efficiency opportunities outlined in the Commercial and Residential Chapter in this report. These strategies include conducting energy audits and retrofitting existing buildings.

## 2050 RECOMMENDATIONS

Decarbonizing the industrial sector is considered more technically challenging than other sectors because emissions not only originate from heat and power, but also from the unique processes employed. While tremendous effort would be needed to evaluate industry-specific processes for emission reductions, progress has been made throughout the industrial sector to increase efficiencies and adopt pollution prevention measures. Examples of recent pollution prevention measures that have been employed within the petrochemical industry include installing leak-tight connectors on liquid petroleum gas loading racks, installing domes on floating roof tanks, improved flaring operation and increased equipment leak standards.

In the near term, it is pragmatic to seek GHG reductions by further promoting the benefits of energy efficiency programs including reductions in operational costs and improving profitability. Industrial sites can also provide strategic siting opportunities for renewable distributed power generation. State agencies, such as the New Jersey Economic Development Authority (EDA), the DEP and the BPU must make a concerted effort to work with industry to understand how best to facilitate strategies that achieve statewide GHG reductions cost-effectively. New Jersey should investigate additional tools to encourage development of renewable energy power generation into its existing industrial facilities either through solar PV panels on production facilities, solar thermal, or other sources of renewable energy. The vast rooftop spaces available in the industrial real estate market are good candidates for large scale solar energy projects.

The state should also consider requiring benchmarking[2] by industrial facilities. The CEA currently requires commercial properties over 25,000 sq.ft. to benchmark energy usage via the United States Environmental Protection Agency Energy Star Portfolio Manager program. This requirement could be extended to industrial facilities to help track energy use, emissions and best practices across similar sector processes. Benchmarking is valuable because it increases the availability of industrial efficiency data so that businesses can more effectively identify and implement improvements. The New Jersey Sustainable Business Registry (NJSBR) program and the NJCEP can utilize this information to assist industries across the state to pursue sustainability initiatives and make efficiency investments. Furthermore, through the New Jersey Protecting Against Climate Threats (NJ PACT), DEP will consider regulating various industrial processes to achieve greater GHG emissions reductions.

*Table 4.2. Industrial Sector Recommendations for reducing GHG emissions.*

| Actions | Entity | Timeframe[3] | References |
|---|---|---|---|
| Increase awareness of and access to New Jersey's Clean Energy Program and its suite of statewide programs. Improve marketing, education, awareness and program management. | BPU | Throughout | 2019 EMP Goal 3.1.2 and 3.1.6 |
| Establish strategic and targeted energy efficiency programs to increase energy reductions and customer engagement. | BPU | Throughout | 2019 EMP Goal 3.1.3 |
| Expand CEA requirement for benchmarking energy use in the EPA Energy Star Portfolio manager program to industrial facilities. | Legislature, BPU | Throughout | 2019 EMP Page 6. |
| Adopt equitable clean energy financing mechanisms (Green Bank, On-bill financing, Rebates) that enable greater penetration of energy efficiency measures. | EDA, BPU | Throughout | 2019 EMP Goal 3.1.5 |
| Develop programs to increase the deployment of solar thermal technologies. | BPU, DEP | Throughout | 2019 EMP Goal 2.3.4 |
| Investigate opportunities to reduce industrial $CO_2$ emissions through NJ PACT regulations. | DEP | Near-term | NJPACT |

These complementary recommendations are found in other chapters of the 80x50 report. These specific actions will reduce emissions associated with other source areas.

*Table 4.3. Complementary Recommendations.*

| Actions | Entity | Timeframe | References |
|---|---|---|---|
| Upgrade diesel vehicle and equipment fleet to reduce onsite emissions of fine particulate as discussed in the black carbon subsection of Short-Lived Climate Pollutant Chapter. | DEP | Near-term | NJPACT |

[2] Benchmarking is the practice of comparing the measured performance of a device, process, facility, or organization to itself, its peers, or established norms, with the goal of informing and motivating performance improvement (USDOE, 2020).

[3] Near-term: now through 2030. Mid-term: 2030-2040. Long-term: 2040-2050. Throughout: Ongoing now through 2050.

| | | |
|---|---|---|
| Expand distributed renewable energy on industrial properties as discussed in the Electric Generation Chapter. | BPU, DEP | Near-term |

## WORKS CITED

ACEEE. (2020). *The State Energy Efficiency Scorecard.* Retrieved from https://www.aceee.org/state-policy/scorecard

McKinsey. (2017). *Energy transition: Mission (Im)possible for industry.* Retrieved from https://www.mckinsey.com/~/media/McKinsey/Business%20Functions/Sustainability/Our%20Insights/Energy%20transition%20mission%20impossible%20for%20industry/Energy-transition-mission-impossible-for-industry-final.pdf

NJBPU. (2019). *New Jersey's Clean Energy Program Report: 4QFY19 Final Report.* Retrieved from https://www.njcleanenergy.com/files/file/FINAL%20REPORT%20-%204QFY19(1).pdf

NJBPU. (2020a). *2019 New Jersey Energy Master Plan.* Retrieved from https://www.nj.gov/emp/docs/pdf/2020_NJBPU_EMP.pdf

NJBPU. (2020b). *Energy Efficiency Board Order.* Retrieved from https://www.nj.gov/bpu/pdf/boardorders/2020/20200610/8D--Order%20Directing%20the%20Utilities%20to%20Establish%20Energy%20Efficiency%20and%20Peak%20Demand%20Reduction%20Programs.pdf

NJDEP. (2019). *2018 Statewide Greenhouse Gas Emissions Inventory.* Retrieved from https://www.nj.gov/dep/aqes/pdf/GHG%20Inventory%20Update%20Report%202018_Final.pdf

NJDEP. (2020, January 28). *NJDEP AIR TOXICS PROGRAM*. Retrieved from https://www.nj.gov/dep/airtoxics/njatp.htm

NJEDA. (2019). *New Jersey Advanced Manufacturing.* Retrieved from https://www.njeda.com/getattachment/OET/Advanced-Manufacturing-(1)/Advanced-Manufacturing.pdf.aspx

Optimal Energy. (2019). *Energy Efficiency Potential in New Jersey.* New Jersey Board of Public Utilities. Retrieved from https://s3.amazonaws.com/CandI/NJ+EE+Potential+Report+-+FINAL+with+App+A-H+-+5.24.19.pdf

USDOE. (2019a, May 15). *Static Sankey Diagram of onsite Generation in U.S. Manufacturing Sector (2010 MECS).* Retrieved February 25, 2020, from Office of Energy Efficiency & Renewable Energy: https://www.energy.gov/eere/amo/static-sankey-diagram-onsite-generation-us-manufacturing-sector-2010-mecs

USDOE. (2019b, May 15). *Static Sankey Diagram of Nonprocess Energy in U.S. Manufacturing Sector (2010 MECS).* Retrieved from https://www.energy.gov/eere/amo/static-sankey-diagram-nonprocess-energy-us-manufacturing-sector-2010-mecs

USDOE. (2020, August 19). *Building Energy Use Benchmarking*. Retrieved from https://www.energy.gov/eere/slsc/building-energy-use-benchmarking

USEIA. (2019). *2019 Annual Energy Outlook.*

USEIA. (2020, February 26). *Glossary*. Retrieved from https://www.eia.gov/tools/glossary/index.php?id=I

USEPA. (2020, February 26). *Sources of Greenhouse Gas Emissions*. Retrieved from https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions#industry

CHAPTER 5

# WASTE AND AGRICULTURE

# WASTE AND AGRICULTURE SECTOR SNAPSHOT

## 2018 EMISSION DATA

- The waste sector emitted **5.3 MMT $CO_2$e** and the agriculture sector emitted **0.4 MMT $CO_2$e** in 2018.

## EMISSIONS ACTIVITIES

- Waste management emission activities include decomposition of food waste in landfills, venting and flaring of landfill gas and digester gas. Agriculture sources include enteric fermentation and over-application of nitrogen-rich fertilizer.

## GHGs OF CONCERN

- Methane ($CH_4$)
- Nitrous Oxide ($N_2O$)
- Carbon Dioxide ($CO_2$)

## EMISSIONS REDUCTION PATHWAYS

1. Reduce and recover food waste.
2. Optimize energy recovery in wastewater treatment.
3. Improve soil management practices.

## RECOMMENDATIONS

1. Adopt regulations to implement requirements of the Food Waste Recycling and Waste-to-Energy Production Act (P.L. 2020, c.24).
2. Promote the development of food waste processing facilities, markets and best practices for sectors of the economy generating food waste.
3. Promote and support energy recovery efforts from wastewater treatment operations. Expand on successful demonstration projects that introduce food organic wastes into the wastewater treatment process.
4. Expand education and outreach efforts about climate friendly agricultural practices.

## AGENCY STAKEHOLDERS

- New Jersey Board of Public Utilities
- New Jersey Department of Agriculture
- New Jersey Department of Environmental Protection
- New Jersey Economic Development Authority

## OVERVIEW

Waste management is the largest source of non-energy greenhouse gas (GHG) emissions in New Jersey. It consists of two separate subsectors; municipal solid waste (MSW) management and wastewater treatment (WWT), both of which are sources of methane and carbon dioxide ($CO_2$) in New Jersey. MSW is generated by over 8.9 million residents and various commercial establishments such as businesses, restaurants, warehouses, public buildings, universities and hospitals. There are currently 12 active commercial landfills in the state accepting waste. Emissions are largely attributed to the decomposition of the organic portion of the MSW stream. New Jersey also has 77 WWT facilities treating over 500 million gallons of municipal, commercial and industrial wastewater every day. These facilities emit GHGs through aerobic processes[1] which produce $CO_2$ and anaerobic processes[2] that primarily produce methane.[3] The Intergovernmental Panel on Climate Change (IPCC) notes that while methane has a shorter lifespan than $CO_2$ in the atmosphere, it has a global warming potential 25 times greater than $CO_2$ over a 100-year period (IPCC, 2007).[4]

Agricultural practices also contribute a small amount (less than 0.5%) to New Jersey's GHG emissions. Enteric fermentation or digestion of food in ruminant animals such as cattle, and animal wastes are the leading sources of methane from agricultural activities. New Jersey's agricultural sector also generates nitrous oxide and a small amount of $CO_2$ emissions, from the nitrogen fertilization of soils and the burning of crop residues. For the purposes of the 80x50 report, the waste and agriculture sectors are combined as their main emissions source is organic wastes and their mitigation strategies are closely aligned.

Emissions generated from ancillary operations related to waste management facilities, such as the collection and transport of waste, and the consumption of electricity and energy to run these facilities, are accounted for in other chapters in this report. Additionally, industrial wastewater emissions (less than 0.2%) are accounted for in the waste management sector emissions of the Statewide Greenhouse Emissions Inventory but strategies to reduce emissions from these operations are not discussed in this report.

[1] Aerobic digestion is a process in which microorganisms break down biodegradable material in the presence of oxygen.
[2] Anerobic digestion is a process in which microorganisms break down biodegradable material in the absence of oxygen.
[3] Anaerobic processes also produce $CO_2$ depending on the composition of the feedstock.
[4] While the IPCC Fifth Assessment Report has slightly higher GWP for $CH_4$, the USEPA still uses the AR4 value for its national GHG Inventory. Likewise, this report uses the same value.

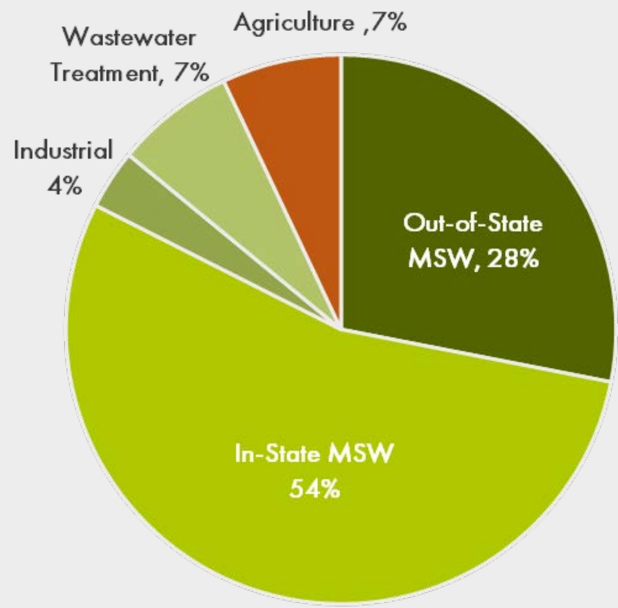
## WHERE WE STAND

In 2018, the state's waste management and agricultural sectors collectively emitted 5.7 million metric tons (MMT) $CO_2e$ contributing to New Jersey's net GHG emissions of 97.0 MMT $CO_2e$ or 6% (NJDEP, 2019a). Waste management is the largest source of non-energy GHG emissions in the state at 5.3 MMT $CO_2e$, while emissions from agriculture are 0.4 MMT $CO_2e$.

MSW is responsible for 82% of the total GHG emissions from the waste management sector. This includes GHG emissions from MSW processed and landfilled in New Jersey and the emissions from MSW landfilled out-of- state.[5] Emissions from WWT and agricultural sources contribute 7% each and industrial wastewater processing is responsible for 4% of the waste sector's total emissions (Figure 5.1).

New Jersey currently uses the United States Environmental Protection Agency's State Inventory Tool[6] to calculate emissions from the waste and agriculture sectors. New Jersey also collects emissions data from some landfills through the New Jersey Department of Environmental Protection (DEP) Emissions Statement Program.

***Figure 5.1. New Jersey Waste and Agriculture Sector Emissions in 2018.*** *Combined, these waste and agricultural activities produced 5.7 MMT $CO_2e$.*




*Source:* (NJDEP, 2019a)

### Waste Management

#### *Municipal Solid Waste*

Between 2006 and 2018, emissions from MSW increased by 4.2% (Table 5.1). In 2018 alone, over 23 million tons of MSW was generated in New Jersey.

***Table 5.1. Annual Municipal Solid Waste Greenhouse Gas Emissions 2006 – 2018 (MMT $CO_2e$).***

| 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4.7 | 4.8 | 4.7 | 4.6 | 4.6 | 4.5 | 4.5 | 4.2 | 4.6 | 5.0 | 4.9 | 4.9 | 4.9 |

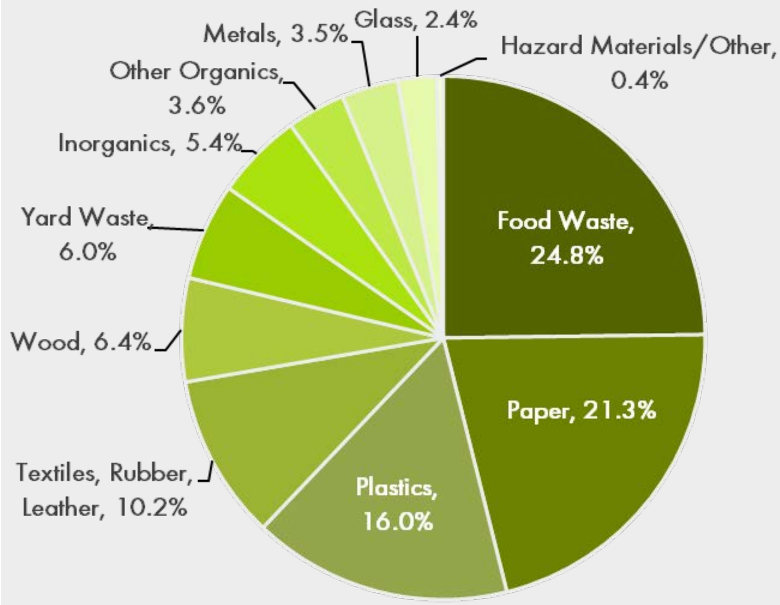
The main source of methane emissions from MSW is attributed to the decomposition of the organic portion[7] of the waste. Microbes breakdown the organic materials releasing methane through the digestion process. Food waste is a major source of the organic matter that is landfilled and is estimated to be about 25% of the MSW stream[8] (Figure 5.2). Food waste that is landfilled anaerobically decomposes into biogas (also known as landfill gas).[9] The composition of

[5] Emissions from resources recovery facilities are accounted for in the electric generation chapter of this report.
[6] The DEP used the USEPA State Inventory Tool Solid Waste Module, Wastewater Treatment Module and Agriculture Module to calculate emissions from these sectors.
[7] The organic portion includes food waste, yard waste, and biomass waste, but does not include agricultural waste such as crop residues (which is accounted for separately).
[8] DEP utilized the Mercer County Improvement Authority Solid Waste and Recycling Quantification and Characterization Study to make statewide assumptions.
[9] Biogas is produced from biomass through the process of anaerobic decomposition.

landfill gas varies greatly depending on the make-up of the trash. Typically, New Jersey's landfill gas consists of equal amounts of methane and $CO_2$ with trace amounts of hydrogen sulfide, siloxanes, and moisture. Alternatively, food waste can also be aerobically processed through composting, which primarily releases $CO_2$.

Landfill gas is either vented, flared or combusted to generate electricity. Venting is an intentional release of the gas directly into the atmosphere and is done to avoid dangerous buildup of landfill gas that could potentially migrate offsite. Flaring is the combustion of landfill gas captured in collection systems to convert methane into $CO_2$ which helps to eliminated odors and reduces climate impacts. Combustion of landfill gas in engines, microturbines or boilers also helps to eliminate odors and further reduces climate impacts by lowering energy demand by converting the gas into electricity or useful process steam. Eight of the twelve operating commercial landfills in the New Jersey have installed these energy producing systems to help meet their energy needs and supply electricity to the grid. These energy recovery systems usually require the removal of impurities, and moisture to produce a useable fuel and prevent local air quality issues (Barlaz, Chanton, & Green, 2009).

***Figure 5.2. Composition of MSW by Percentage in Mercer County in 2013.***
*Sorted by weight, food waste accounted for almost a quarter of the materials arriving at the Mercer County Improvement Authority's tipping station. Paper, wood, and yard waste accounted for an additional 34%.*




*Source:* (MCIA, 2015)

### *Wastewater Treatment*

Between 2006 and 2018, emissions from WWT almost doubled (Table 5.2). Nearly 90% of New Jersey's residents, along with commercial facilities, rely on public wastewater systems to collect and treat their sewage. In New Jersey, 37 large WWT facilities utilize anaerobic digesters to process the sludge that is produced from processing more than 450 million gallons of wastewater a day. Additionally, there are over 40 facilities that aerobically treat more than 50 million gallons a day of wastewater and its resulting sludge.

***Table 5.2. Annual Wastewater Treatment Greenhouse Gas Emissions 2006 – 2018 (MMT $CO_2e$).***

| 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.4 | 0.4 | 0.2 | 0.4 | 0.4 | 0.4 |

Ninety percent of sludge produced in the New Jersey is treated through anaerobic digestion which generates digester gas comprised mostly of methane and $CO_2$, and residual sludge; whereas, aerobically processed sludge only releases $CO_2$ and a larger volume of residual sludge. Anaerobic digester gas is produced in a contained environment to minimize methane leakage. Some anaerobic WWT facilities (11 out of 37 total) have energy recovery systems generating electricity or heat from the produced digester gas that is fed back into the process helping to defray operational costs. Facilities that do not have these systems or produce too much or too little digester gas, use flaring which converts methane into $CO_2$ to dispose of the gas. A 2019 DEP survey of WWT facilities found additional opportunities existed to increase the beneficial use of produced methane (NJDEP, 2019b).[10]

### *Agricultural Activities*

New Jersey's agriculture sector has experienced a decline in emissions by about 20% between 2006 and 2018 (Table 5.3). This decrease parallels the reduced yields per acre for certain key crops noted in USDA's 2017 Annual Report for New Jersey (NJDA, 2017). New Jersey's agricultural sector includes 9,900 farms totaling 750,000 acres. While the state has successfully preserved more than 236,000 acres of farmland for agricultural use, there have been steep declines in dairy farms. Between 1997 and 2017 New Jersey lost 198 dairy farms, which could also have contributed to reduced emissions (NJDA, 2017).

***Table 5.3. Annual Agriculture Greenhouse Gas Emissions 2006 – 2018 (MMT $CO_2e$).***

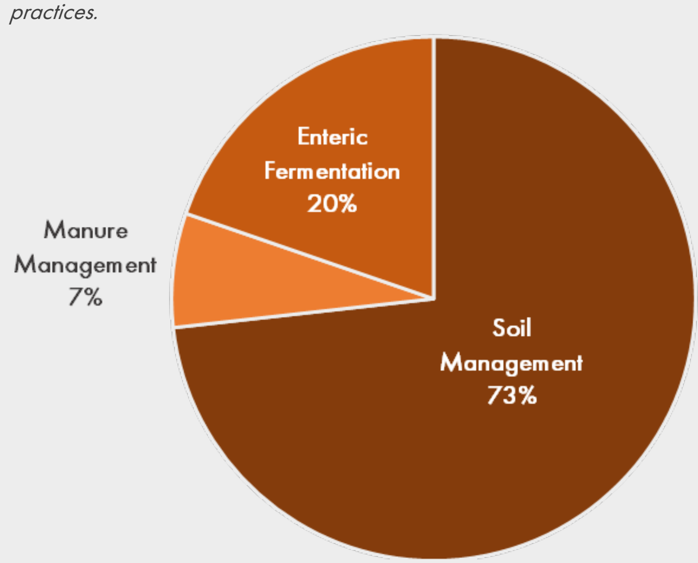
| 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.5 | 0.5 | 0.5 | 0.5 | 0.4 | 0.4 | 0.4 | 0.4 | 0.3 | 0.3 | 0.3 | 0.4 | 0.4 |

Agricultural activities that contribute to emissions include enteric fermentation, livestock manure management and soil management practices. Burning of crop residues also contributes to black carbon, methane and nitrous oxide emissions, though not in significant quantities (USEPA, 2020a).

In 2018, soil management practices contributed about 73% of the total agriculture emissions, 20% resulted from enteric fermentation, while animal manure management accounted for 7% of the total subsector emissions (Figure 5.3) (NJDEP, 2019a).

***Figure 5.3. New Jersey Agriculture Subsector Emissions in 2018 (MMT $CO_2e$).***

*The majority of emissions from the agriculture sector is due to soil management practices.*




*Source: (NJDEP, 2019a)*

The bulk of emissions in this sector are due to various management practices on agricultural soils that increase the nitrogen content in the soil and result in nitrous oxide emissions (USEPA, 2020b). These practices include application of synthetic and organic fertilizers, growth of nitrogen-fixing crops and irrigation, drainage, tillage practices (USEPA, 2020c). Enteric fermentation is a natural part of the digestive process in ruminant animals[11] such as cattle that produces methane. According to the United States Environmental Protection Agency enteric fermentation represents over a quarter of the emissions in the agricultural sector nationally. Manure management contributes to methane and nitrous oxide emissions in varying amounts depending upon how it is processed (USEPA, 2020c). However, the aggregate agricultural emissions of 0.4 MMT $CO_2e$ in 2018 is not a large contributor to New Jersey's GHG inventory.

[10] The survey had a 50% response rate.

[11] A ruminant is a mammal with hooves and a complicated system of stomach compartments whose digestion works by chewing partly digested food a second time in order to soften it. Cows, moose, giraffes, and goats are all ruminants.

## Existing Emissions Reduction Policies

New Jersey's existing emissions reduction efforts consists of laws, rules, and policies seeking to reduce the generation and disposal of organic and non-organic wastes, and limit emissions from agricultural activities. DEP regulates efforts to reduce MSW through food waste reduction, and recent mandatory food waste recycling. DEP also requires the reporting of emissions from WWT plants. The New Jersey Board of Public Utilities (BPU) regulations incentivize the utilization of biogas produced from wastes for beneficial purposes such as electricity generation through the eligibility of renewable energy credits. Emissions related to crop farming and livestock rearing are regulated by the New Jersey Department of Agriculture (NJDA) through composting and waste management programs.

### *Food Waste Laws*

Over the last three years, New Jersey has passed a series of laws aimed at reducing the amount of food waste from being generated and entering the MSW stream. In 2017 the Food Waste Reduction Act (P.L. 2017, c.136) and the School Food Waste Guidelines legislation (P.L. 2017, c.210) were signed into law. The Food Waste Reduction Act establishes a goal of 50% reduction of food waste generated by 2030 and requires the DEP to develop and implement a plan to meet this goal. The plan was developed in conjunction with the NJDA, and other interested parties and was released in draft in 2019 (NJDEP, 2019c). The School Food Waste Guidelines law requires the DEP, in conjunction with other state agencies, to develop voluntary guidelines for K-12 schools and universities. These guidelines were completed in 2019 (NJDEP, 2019d; NJDEP, 2019e).

In 2020, the Food Waste Recycling and Waste-to-Energy Production Act (P.L. 2020, c.24) was passed, requiring large food waste generators (who produce 52 tons or more of food waste per year) located within 25 road miles of an approved recycling facility to source separate and recycle their food waste. The DEP will adopt rules and regulations to implement the law. Food waste recycling facilities that utilize the methane produced from their operations for electric generation are also eligible for the same Class I Renewable Energy Credits as the WWT facilities discussed earlier.

### *Emissions Reporting*

Wastewater treatment facilities and landfills that meet the thresholds of DEP's emissions statement rule (N.J.A.C. 7:27-21), must annually report $CO_2$ and methane emissions. Facilities that use flares to control emissions of hazardous air pollutants such as hydrogen sulfide ($H_2S$) and noxious off-site odors are required to obtain air pollution control permits. The combustion of methane in these flares also provides a GHG reduction benefit, since it converts a higher Global Warming Potential (GWP) GHG (methane) into a lower GWP GHG ($CO_2$).

### *Waste-to-Energy*

Electricity generated by the combustion of methane gas from landfills, or from the anaerobic digestion of food waste and sewage sludge, qualifies as a Class I renewable energy under New Jersey's Renewable Portfolio Standards (RPS). This incentivizes the capture and beneficial usage of methane.

### *Animal Waste Management & Composting*

The NJDA has rules (N.J.A.C.2:91) for the development and implementation of self-certified Animal Waste Management Plans for farms that generate, handle or receive animal waste. The rules require the use of best management practices and include application of manure using proper nutrient management practices, optimizing the beneficial use of nutrients from manure and minimizing odors from storage and application.

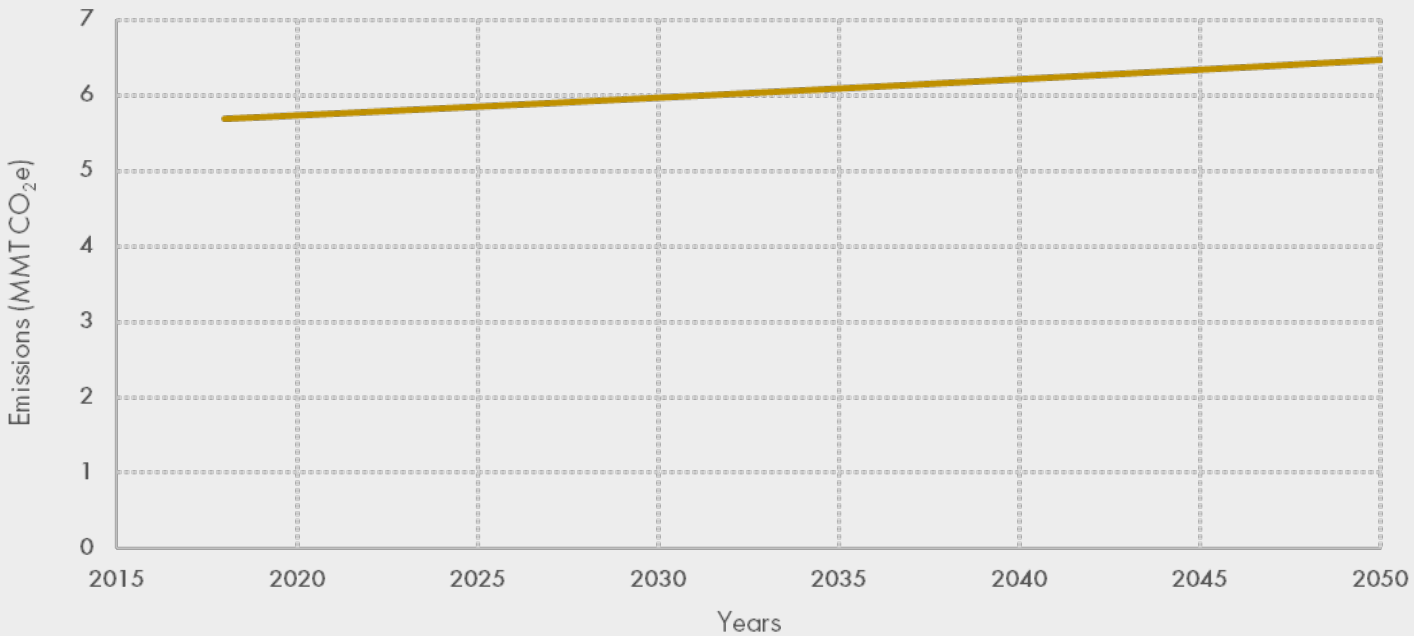
As part of Best Management Practices for nutrient management of the soil, NJDA recommends composting of manure, leaves and crop residue. This helps to conserve nutrients produced on the farms and reduces the application of commercial fertilizer. NJDA works in partnership with the USDA Natural Resources Conservation Service and the Soil Conservation Districts to provide technical and financial assistance for the installation of conservation practices including cover cropping, contouring and strip cropping, animal waste storage and composting and nutrient management planning. Further, NJDA requires farmers conducting onsite composting to take the on-farm composting certification course every three years to maintain certification.

DEP also regulates composting, based on type and volume of materials processed (N.J.A.C. 7:26A). DEP regulates all compost operations either through general approvals issued pursuant to N.J.A.C. 7:26A-3 or through requirements specified for facilities exempt from obtaining a general approval pursuant to N.J.A.C. 7:26A-1.4.

## Business-as-Usual Projection

The Business-as-Usual (BAU) scenario projects an increasing trend in emissions from MSW and WWT that follows the population growth of 0.43% annually (NJDLWD, 2013) (Figure 5.4). The emissions from agricultural sources are forecasted to remain constant at 0.4 MMT per year through 2050. Overall, emissions increase by about 15% from 2018 levels and are projected to be 6.5 MMT $CO_2$e in 2050.

***Figure 5.4. Business-As-Usual Waste Management and Agriculture Emission Trends, 2018-2050 (MMT $CO_2$e).***
*Without reduction strategies, emissions will gradually increase through 2050 based on anticipated population growth.*



## THE PATH FORWARD

The BAU scenario shows that if no action is taken, the emissions from the waste management sector will be 6.5 MMT $CO_2e$, which is more than 25% of the total 2050 emissions goal of 24.1 MMT $CO_2e$. The state must act swiftly to curtail emissions from this sector in its efforts to attain its 80x50 goal.

Three pathways have been identified as integral to reducing emissions in these sectors.

- Pathway 1, Reduce and recover food waste, evaluates strategies to limit landfills emissions;
- Pathway 2, Optimize energy recovery in wastewater treatment, examines biomass to energy projects; and
- Pathway 3, Improve soil management practices, considers methods to reduce fertilizer use on agricultural lands.

### EMISSION ACTIVITES

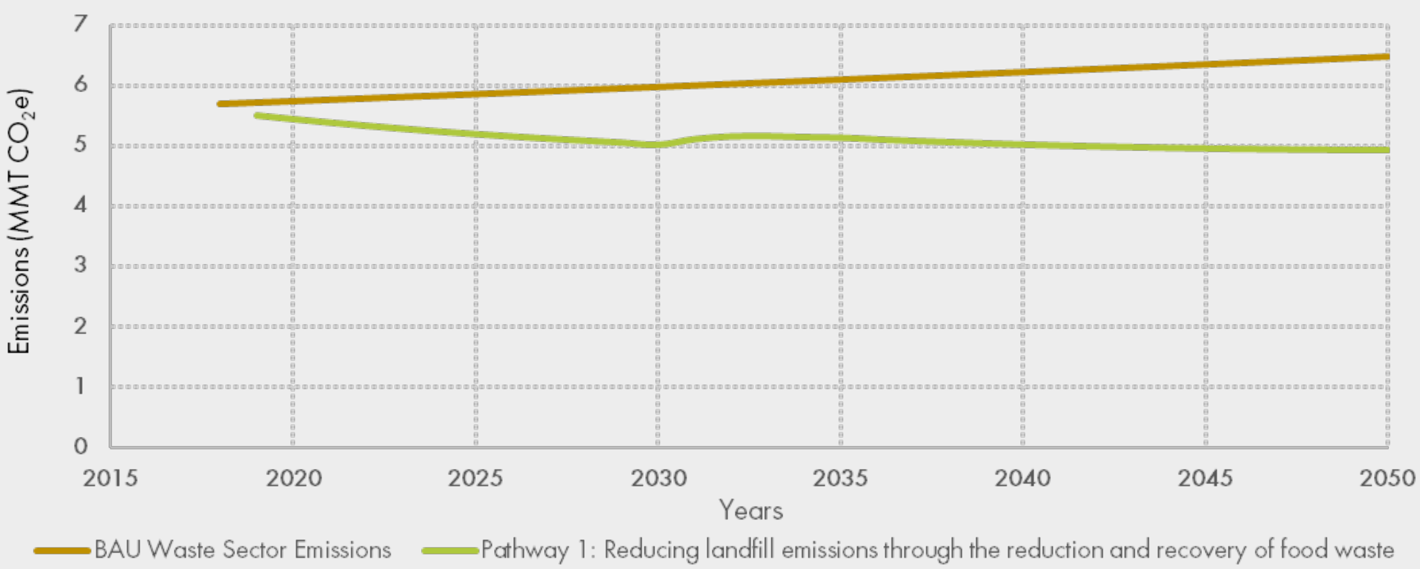
- Food waste disposal in landfills
- Flaring of Landfill and Digester Gas
- Application of Fertilizers

### EMISSIONS REDUCTION PATHWAYS

1. Reduce and recover food waste
2. Optimize energy recovery in wastewater treatment
3. Improve soil management practices

Collectively, a combination of policies based on the above strategies can accelerate emissions reductions from the waste and agriculture sectors. DEP estimates that emissions can be held to 5 MMT $CO_2e$ in 2050 (Figure 5.5). Due to data limitations, DEP has not quantified emission reductions from all three pathways, thus this is a conservative estimate. Future iterations of the 80x50 report should reassess and reevaluate these pathways.

***Figure 5.5. Waste and Agriculture Sectors 2050 Pathways Projection (MMT $CO_2e$).***
*Diverting food waste from landfills will reduce emissions by 1.6 MMT $CO_2e$ annually by 2050. Food waste can also potentially be used to make renewable biofuels for use in other sectors.*



## Emissions Reduction Pathway 1: Reduce and recover food waste

DEP estimates that reducing current food waste disposal in landfills 50% by 2030 can eliminate 1.6 MMT $CO_2e$ annually by 2050 (Figure 5.5). Achieving this scale of food waste reduction and recovery by 2030 will require residents, businesses, and other entities to generate less food waste as well as the creation of a food waste recycling industry in New Jersey. Siting food waste recycling facilities close to large food waste generators or at landfills and encouraging community-based programs that source separate will facilitate the reduction. This projection accounts for increased production of food wastes due to population and economic growth[12] into 2050. Overall, this pathway alone can reduce 30% of the emissions in this sector.

In order to divert food waste from disposal facilities, it needs to be separated from the waste stream and processed for beneficial use. Food waste processing sites can accept materials from nearby residential communities and large food waste generators and use suitable recycling, composting or anaerobic digestion to transform it into other beneficial uses such as compost or renewable biogas. Examples of large food waste generators include industrial food processors, supermarkets, conference centers, restaurants, educational institutions, military establishments, prisons, hospitals, sports complexes and casinos. The close proximity of processing facilities to large generators ensures a sustainable supply of feedstock to the facilities and reduces transportation costs and emissions from transporting wastes to landfills located at longer distances. The availability of Class I Renewable Energy Credits helps to incentivize installation of anaerobic digesters where applicable. DEP should create guidelines to assist in siting and permitting such facilities to support the goals of the Food Waste Reduction Law (P.L. 2020, Chapter 24).

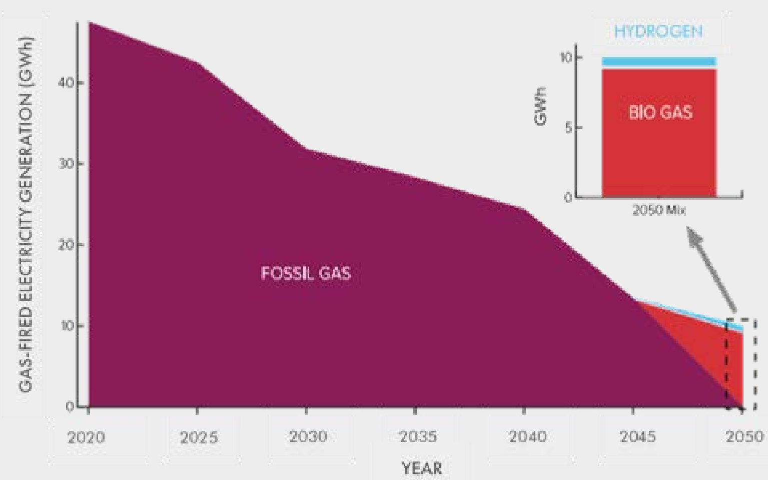
Community composting programs that allow residents to drop off food waste at no or low cost at a local composting sites should also be incentivized. Neighborhood composting programs promote a culture of environmental awareness among residents and have the potential to keep many tons of organic waste out of the waste stream. The City of Philadelphia is implementing a community composting program in 2020 which could serve as guidance for these programs in New Jersey. Proper siting and permitting that addresses environmental impacts must be designed into approved sites. The DEP is currently investigating solid waste rules to facilitate community composting programs.

## Emissions Reduction Pathway 2: Optimize energy recovery in wastewater treatment

The 2019 Energy Master Plan's (2019 EMP) Goal 2.3.7 encourages biomass to energy projects that reduce GHG emissions from WWT operations. Co-digesting wastewater biosolids with food wastes or animal manure would vastly improve the specific methane yield for beneficial energy production, further increasing the Btu content of the gas. (Shen, Linville, Urgan-Demirtas, Mintz, & Snyder, 2015; USEPA, 2012). Implementing these efforts would increase the energy output and opportunities to produce energy at WWT facilities. This would further improve the resiliency of these critical infrastructure facilities, permitting them to operate in an island mode as a distributed energy resource (DER) in the event of grid failure. As noted above, caution should be taken to prevent local air quality issues (Barlaz, Chanton, & Green, 2009). The gas that is currently flared is a missed opportunity for additional energy

***Figure 5.6. Gas-fired dispatchable electricity generation in the Least Cost Scenario (2019 EMP Figure K).***

*The state's goal of 100% clean electricity will rely on zero-emission resources such as wind, solar and batteries, paired with dispatchable resources powered by renewable biogas and hydrogen.*




*Source: (NJBPU, 2020)*

[12] Economic growth of 1.3% is accounted for 2031-2050, population growth of 0.43% annually is assumed and the 2030 reduction goal is projected beyond 2030 through 2050.

production and emission reductions. According to a survey of anaerobic facilities conducted by DEP in 2019, nineteen facilities reported flaring about 202 million cubic feet of digester gas annually (NJDEP, 2019b). This relates to an approximate energy content of 131 billion Btus[13] and the potential of generating about 38 GWh[14] of electricity, which could power 4,000 homes annually.[15] The electricity generated can serve local loads, placing less demand on the grid. Further, the renewable biogas generated from these sources would help address the projected energy supply from firm capacity deficiency beyond 2045, as discussed in the 2019 EMP (Figure 5.6).

### **Emission Reduction Pathway 3:** Improve soil management practices

Utilizing sound soil conservation and nutrient management practices is important to reducing emissions and improving soil health. Under this pathway, promoting better soil management through incentives for good crop rotation practices, cover cropping, and no-till practices have been identified as strategies that reduce GHG emissions and increase carbon sequestration (Fargione, 2018). On-farm and upstream nitrous oxide emissions can be reduced by using nitrogen fertilizers more efficiently. Improving the quantity and timing of applications, switching from anhydrous ammonia to urea and reducing whole-field applications are effective strategies for nutrient management. Precision agriculture[16] should be encouraged and incentivized to allow for variable rate applications. Connecting New Jersey's farming community with technology can make farming more sustainable without sacrificing productivity (USDA, 2020). Further education and outreach activities such as increased participation in the Rutgers Composting Education Program, support for the development of regional composting facilities for equine manure and incentives for smaller on and off farm composting facilities are recommended.

## 2050 RECOMMENDATIONS

The main actions for reducing emissions from these sectors involve reduction of and better management of food wastes, optimizing WWT processes and employing effective land management practices. Preliminary efforts should focus on developing a regulatory driver that requires food waste reduction and recovery. This will directly reduce GHG emissions and provide a feedstock for the generation of renewable biogas. The 2019 EMP indicates that New Jersey will rely on biogas near the mid-century to meet its decarbonization goals. Utilizing local organic waste to the greatest extent possible provides the most sustainable path to attaining a biogas supply. The DEP should continue its work to promote food waste reduction, finalize the food waste reduction plan and embark on related rule development as necessary. Further the state should create guidelines and recommendations for county siting and streamlined permitting for food waste recycling facilities. Community efforts to source separate organic wastes should also be encouraged.

There is also opportunity to optimize the waste-to-energy conversion process in WWT facilities. GHG emission reductions can be achieved by supporting beneficial reuse of biogas and ensuring digester gas upgrades are prioritized. The state should look to build upon successful pilot projects. DEP and NJDA should work to identify waste streams and receiving facilities to improve beneficial energy production. DEP should also develop guidelines to assist facilities considering these technologies.

Agricultural practices offer opportunities to reduce GHG emissions. Expanded educational and outreach efforts to the agricultural community about climate friendly agricultural practices should be prioritized. To enhance these efforts NJDA should amplify its outreach efforts to enroll farmers in the USDA's Environmental Quality Incentives Program (EQIP)[17], the Conservation Reserve Enhancement Program (CREP)[18] and the utilization of precision agriculture. Farmers would

[13] Calculations assume digester gas composition of 65% methane.
[14] 1 standard cubic feet = 0.2931 KWh
[15] Calculations utilized the USEPA Greenhouse Gas Equivalencies Calculator (USEPA, 2018) https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator
[16] Precision agricultural refers to the use of sensing and information technologies, and mechanical systems to enable sub-field crop management. It avoids over- and under-applications of herbicides, pesticides, irrigation, and fertilizers (USDA, 2020).
[17] EQIP offers incentives for cover crop adoption, conservation tillage practices, integrated pest management and other climate friendly practices in New Jersey.
[18] CREP offers financial incentives to encourage farmers to create stream buffers on existing farmland and will cover 100% of the cost to establish the conservation practices and annual rental and incentive payments to the landowner.

benefit from technical assistance with the application processes and implementation. Moreover, the DEP and NJDA should work to identify opportunities to connect farmers with facilities that can beneficially reuse agricultural waste.

*Table 5.4. Recommendations for achieving emissions reductions from waste and wastewater management.*

| Actions | Entity | Timeframe[19] | Reference |
|---|---|---|---|
| Finalize the food waste reduction plan. | DEP | Near-term | Pursuant to P.L. 2017, c.136 |
| Adopt food waste reduction rules. | DEP | Near-term | Pursuant to P.L. 2017, c.136 |
| Adopt food waste recycling rules for large generators. | DEP | Near-term | Pursuant to P.L. 2020, c. 24 |
| Create guidelines/recommendations for county siting and streamlined state planning and permitting of food waste recycling facilities. | DEP | Near-term | |
| Create incentives to site organic waste recycling, composting or anaerobic digestion operations. | Legislature, DEP, EDA, | Near-term | |
| Adopt a community composting rule to streamline the approval process across the DEP. | DEP, NJDA | Near-term | |
| Educate residents about the environmental, financial and societal issues of wasted food. | DEP | Throughout | |
| Disseminate emerging management practices to reduce wasted food. | DEP | Throughout | |
| Create incentives to encourage utilization of biogas at WWT facilities for beneficial re-use such as electricity generation, heating or pipeline injection. | Legislature, DEP, BPU | Throughout | EMP Goal 2.3.7 |
| Develop guidelines for improving and verifying gas quality at WWT facilities. | DEP, NJCAT | Near-term | EMP Goal 3.1.3 |
| Create incentives for use of animal manure and food waste in WWT facilities. | Legislature, DEP, NJDA | Throughout | |
| Promote programs targeting the supply chain for incentivizing food donation, waste audits. | DEP, other state entities | Throughout | |
| Increase participation in the Rutgers Composting Education class. | NJDA | Throughout | |
| Support the development of Regional Composting Facilities that function free of off-site odors for Equine Manure and incentives for smaller on and off farm composting facilities. | DEP, NJDA | Throughout | |

[19] Near-term: now through 2030. Mid-term: 2030-2040. Long-term: 2040-2050. Throughout: Ongoing now through 2050.

*Table 5.5. Recommendations for achieving emissions reductions from agriculture.*

| Actions | Entity | Timeframe | Reference |
|---|---|---|---|
| Encourage and incentivize precision agriculture. | DEP, NJDA | Throughout | |
| Create guidelines for efficient fertilizer application. | DEP, NJDA | Throughout | |
| Amplify promotion of the Conservation Reserve Enhancement Program and the USDA's Environmental Quality Incentives Program. | NJDA | Throughout | |

## WORKS CITED

Barlaz, M. A., Chanton, J. P., & Green, R. B. (2009). Controls on Landfill Gas Collection Efficiency: Instantaneous and Lifetime Performance. *J Air Waste Manag Assoc Actions*, 1399-404.

Fargione, J. a. (2018, November 14). Natural Climate Solutions for the United States. *Science Advances*. Retrieved from https://advances.sciencemag.org/content/4/11/eaat1869

IPCC. (2007). *Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* Geneva, Switzerland. Retrieved from https://ar5-syr.ipcc.ch/ipcc/ipcc/resources/pdf/IPCC_SynthesisReport.pdf

MCIA. (2015). *Solid Waste and Recycling Quantification and Characterization Study", Mercer County Improvement Authority.* Retrieved from http://www.mcianj.org/filestorage/133/154/T%26M_Final_Waste_Study_-_Sept._2015.pdf

NJBPU. (2020). *2019 New Jersey Energy Master Plan: Pathway to 2050.* Retrieved from https://www.nj.gov/emp/docs/pdf/2020_NJBPU_EMP.pdf

NJDA. (2017). *2017 Annual Report and Agricultural Statistics.* Retrieved from https://www.nass.usda.gov/Statistics_by_State/New_Jersey/Publications/Annual_Statistical_Bulletin/2017/2017NJAnnualReportFinal-CF.pdf

NJDEP. (2019a). *2018 Statewide Greenhouse Gas Emissions Inventory.* Retrieved from https://www.nj.gov/dep/aqes/pdf/GHG%20Inventory%20Update%20Report%202018_Final.pdf

NJDEP. (2019b). *Survey of Wastewater Treatment Facilities using Anaerobic Digestion.*

NJDEP. (2019c). *Draft Food Waste Reduction Plan.* Retrieved from https://www.nj.gov/dep/dshw/food-waste/food_waste_plan_draft.pdf

NJDEP. (2019d). *The State of New Jersey School Food Waste Guidelines, K-12 Schools Edition.* Retrieved from https://www.nj.gov/dep/seeds/sfwg/docs/K-12.pdf

NJDEP. (2019e). *The State of New Jersey School Food Waste Guidelines, Higher Education Edition.*

NJDLWD. (2013). *Population and Labor Force Projections for New Jersey:2010-2030.* Retrieved from www.nj.gov/labor/lpa/content/njsdc/2013WU%20PopLFProj2030.pdf

Shen, Y., Linville, J., Urgan-Demirtas, M., Mintz, M., & Snyder, S. (2015). An overview of biogas production and utilization at full-scale wastewater treatment plants (WWTPs) in the United States: Challenges and opportunities towards energy-neutral WWTPs. *Renewable and Sustainable Energy Reviews*.

USDA. (2020). *Precision, Geospatial & Sensor Technologies Programs*. Retrieved from Precision, Geospatial & Sensor Technologies Programs

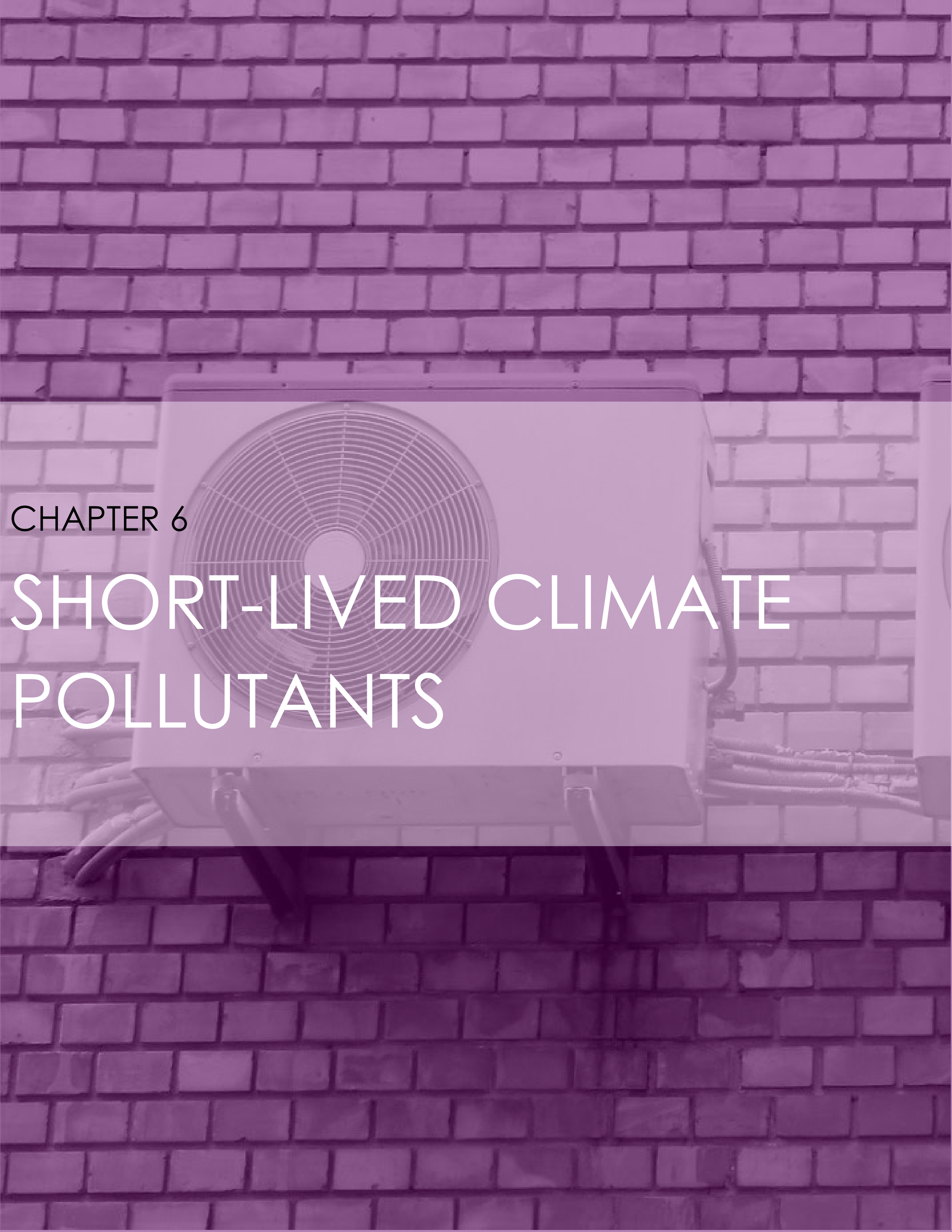
USEPA. (2012). *Increasing Anaeerobic Digester Performance with Codigestion.* Retrieved from https://www.epa.gov/sites/production/files/2014-12/documents/codigestion.pdf

USEPA. (2018). *Greenhouse Gas Equivalencies Calculator*. Retrieved from https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

USEPA. (2020a). *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2018.* Retrieved from https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2018

USEPA. (2020b). *Inventory of U.S. Greenhouse Gas Emissions and Sinks.* Retrieved from https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks

USEPA. (2020c, April 11). *Sources of Greenhouse Gas Emissions*. Retrieved from https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions



CHAPTER 6

# SHORT-LIVED CLIMATE POLLUTANTS

# SHORT-LIVED CLIMATE POLLUTANTS SECTOR SNAPSHOT

## 2018 EMISSION DATA

- Collectively, short-lived climate pollutants emitted an estimated **16 MMT $CO_2e$** in 2018.

## EMISSIONS ACTIVITIES

- Methane leaks occur from natural gas pipelines, service lines, compressor stations, equipment and operations such as blowdowns for maintenance of pipelines.
- Halogenated gas emissions are associated with the use of these substances in air conditioning, heat pumps, refrigeration, fire suppressants and blowing agents.
- Black carbon emissions come from the burning of biomass, forest fires, cooking and fossil fuels, particularly diesel fuel, in on-road and non-road equipment.

## GHGs OF CONCERN

- Methane ($CH_4$)
- Halogenated Gases (Hydrofluorocarbons (HFCs)
- Perfluorocarbons (PFCs)
- Sulfur Hexaflouride ($SF_6$)
- Black Carbon

## AGENCY STAKEHOLDERS

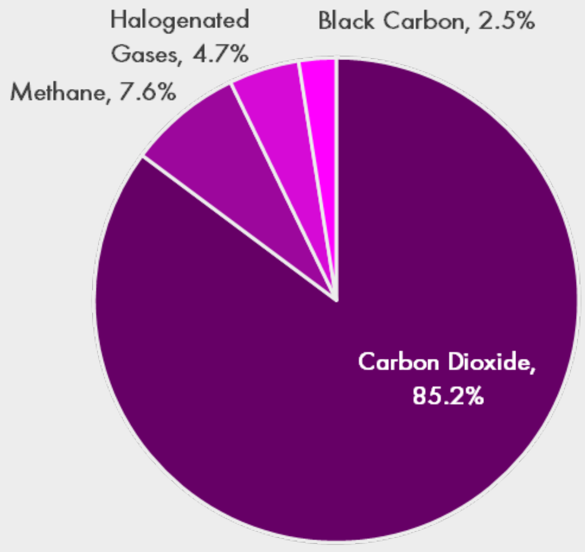
- New Jersey Board of Public Utilities
- New Jersey Department of Community Affairs
- New Jersey Department of Environmental Protection
- New Jersey Department of Transportation
- New Jersey Economic Development Authority
- New Jersey Motor Vehicle Commission
- New Jersey Transit
- Port Authority of New York and New Jersey

# INTRODUCTION

New Jersey's Global Warming Response Act (GWRA) amendments of 2019 direct the New Jersey Department of Environmental Protection (DEP) to evaluate Short-Lived Climate Pollutants (SLCPs), including methane, halogenated gases and black carbon, as part of the state's comprehensive strategy to mitigate climate change. SLCPs have greater impacts on climate change in the near term which is accounted for in their global warming potential compared to longer-lived greenhouse gases (GHGs) like carbon dioxide ($CO_2$). Collectively, SLCPs contribute 16 MMT $CO_2e$ or 14.8% of the state's total climate pollutant emissions (Figure 6.1.1).

***Figure 6.1.1. Greenhouse Gas Emissions Plus Black Carbon in New Jersey by Percentage, 2018, (Gross Total 107.8 MMT $CO_2e$).***

*SLCPs will have a greater impact on climate than the same weight of $CO_2$, but SLCPs are released at significantly lower amounts and remain in the atmosphere for less time.*




Methane accounts for over half of the SLCPs released in the state (Figure 6.1.2). The biggest methane sources are in-state and out-of-state landfills and leaks from the natural gas transmission and distribution system. Halogenated gases are the next largest category of SLCPs and are associated with hydrofluorocarbons and perfluorocarbons used in air conditioning, refrigeration, and heat pumps. Halogenated gases are also found in consumer products such as propellants, firefighting foams and expanding insulating foams. Sulfur hexafluoride ($SF_6$), a chemical used as an insulating gas in high voltage transformers, is not consider a SLCP as it is a long-lived highly warming halogenated gas. In New Jersey's 2018 Greenhouse Gas Inventory, $SF_6$ was represented in the highly warming gas category, in this report its emissions are captured under the Halogenated Gases subsection. Black carbon is produced from the incomplete combustion of both anthropogenic (fossil fuels) and non-anthropogenic activities (wildfires) sources.

New Jersey's 2018 Greenhouse Gas Inventory did not include estimates for the SLCP black carbon since it is not a gas. For the purpose of the 80x50 report, DEP is relying on black carbon estimates developed on behalf of the U.S. Climate Alliance for its member states (CARB, 2018) (Figure 6.1.2 and 6.1.3).

***Figure 6.1.2. Short-Lived Climate Pollutants by Percentage of Total MMT $CO_2e$, 2018, New Jersey.***

*SLCPs include methane, halogenated gases (including $SF_6$), and black carbon.*

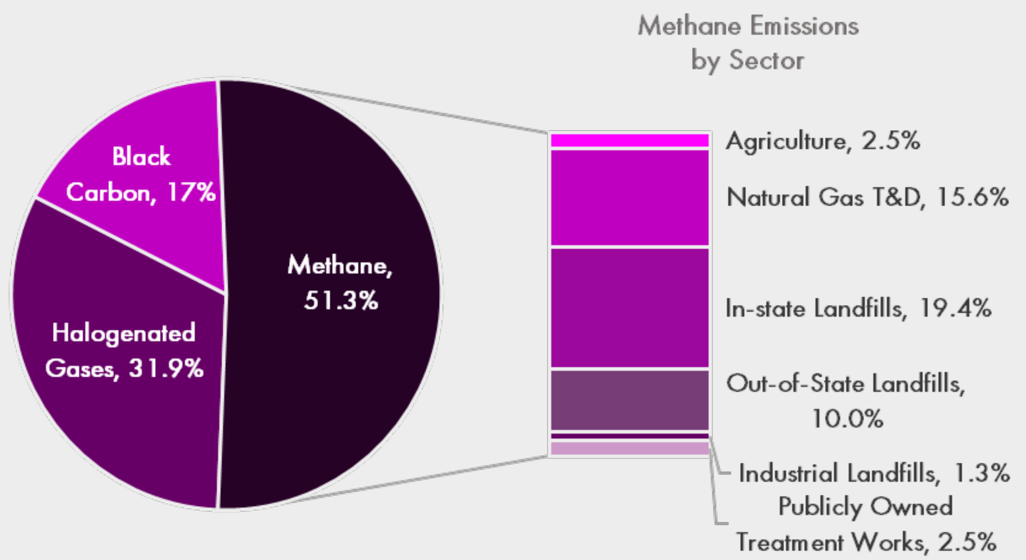
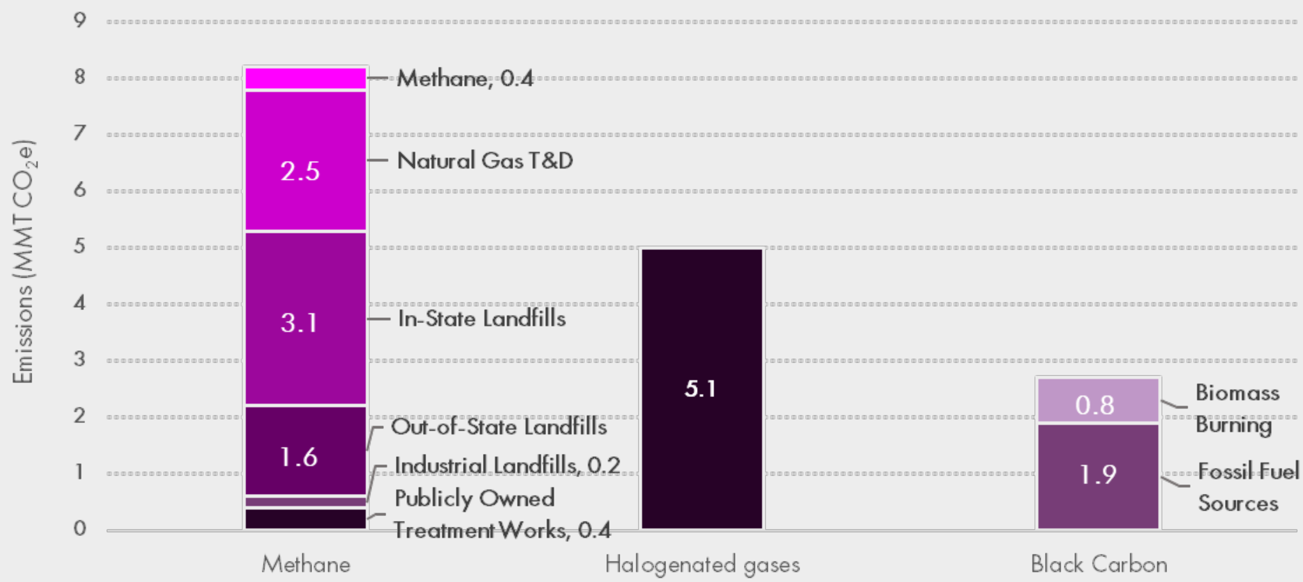


*Figure 6.1.3. Short Lived Climate Pollutants in MMTCO2e, 2018, New Jersey (total emissions 16 MMT CO2e).*
*A wide range of sources contribute to SLCP emissions.*




SLCPs can be reduced in the near term, at reasonable cost, as policies seek to address the larger challenge of reducing $CO_2$ emissions throughout the economy. Fortunately, the state has already taken many actions that have set it on the path towards declining SLCP emissions. Successful state efforts include pipeline modernization plans to reduce methane emissions from natural gas distribution, strong efforts to reduce on-road vehicle diesel particulate matter emissions (reducing black carbon), and recently adopted legislation that establishes the statutory phase-down of HFCs in products and equipment sold in New Jersey based upon their end-use. This chapter goes into further detail about SLCPs from Natural Gas Transmission and Distribution, Halogenated Gases and Black Carbon. Methane from waste and agriculture is addressed in Chapter Five of this report.

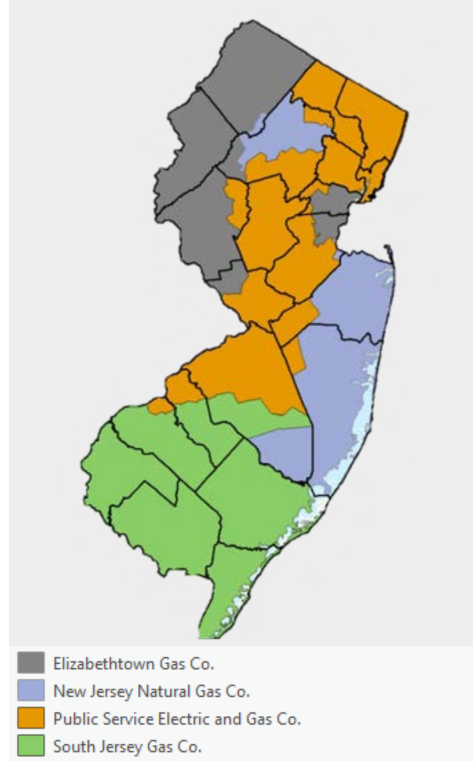
# METHANE FROM NATURAL GAS TRANSMISSION & DISTRIBUTION

# OVERVIEW

Methane leaks from oil and gas production, distribution and transmission significantly contribute to climate change. The International Panel on Climate Change (IPCC) notes that methane has a global warming potential[1] (GWP) 25 times greater than $CO_2$ over a 100-year period (IPCC, 2007a).[2] Methane is the largest component of natural gas, typically making up 78 to 92% of its composition. It is a powerful, short-lived climate pollutant (SLCP) that is more efficient in trapping radiation (IPCC, 2014).

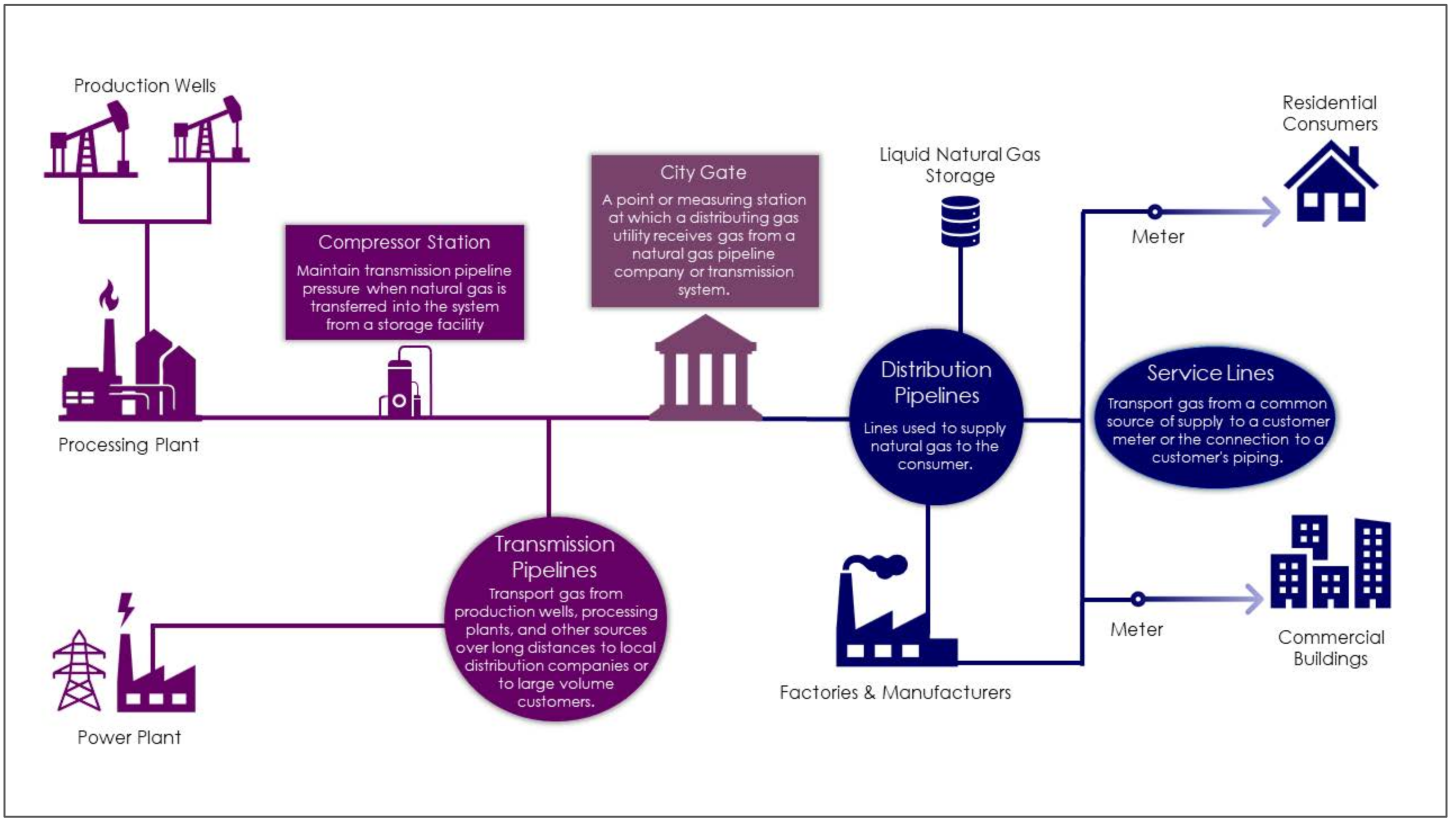
While New Jersey has no known natural gas reserves and does not produce or process natural gas (USEIA, 2019), the state does have several high-pressure natural gas transmission pipelines, four natural gas local distribution companies (LDCs) (Figure 6.2.1). and a number of liquid natural gas storage facilities (NJBPU, 2020; PHMSA, 2020a). Interstate natural gas transmission pipelines transport natural gas from production basins, such as the Marcellus Shale in Pennsylvania, to customers in New Jersey and through New Jersey to neighboring states. LDCs receive natural gas from transmission pipelines, step down the pressure at city gate stations, and then deliver natural gas through a distribution pipeline network to residential, commercial and industrial customers. Some large industrial customers, such as manufacturing and gas-fired electric power generation facilities, are served directly by transmission pipeline companies. Combined, the state's transmission and distribution companies own and operate over 1,500 miles of transmission and over 34,900 miles of distribution pipelines in New Jersey serving approximately 3 million residential, commercial, industrial and electric power generation customers (PHMSA, 2020b).

*Figure 6.2.1. Map of New Jersey Local Distribution Companies.*




[1] The Global Warming Potential (GWP) was developed to allow comparisons of the global warming impacts of different gases. It is a measure of how much energy the emissions of 1 ton of a gas will absorb over a given period of time, relative to the emissions of 1 ton of carbon dioxide ($CO_2$).
[2] While the IPCC Fifth Assessment Report has slightly higher GWP for $CH_4$, the USEPA still uses the AR4 value for its national GHG Inventory. Likewise, this report uses the same value.

*Figure 6.2.2. Diagram of Natural Gas Infrastructure.*
*Production and delivery of natural gas relies on a complex network of facilities and pipelines.*




Methane emissions occur during every stage of the natural gas supply chain. Natural gas leaks can be accidental, caused by malfunctioning or aging equipment as well as fugitive emissions from properly operating equipment. Natural gas may also be released intentionally through blowdowns[3] when performing process maintenance operations, although the industry takes steps to minimize emissions from these activities.

Reducing demand for natural gas is critical to meeting New Jersey's climate goals. The 2019 Energy Master Plan's (EMP) least cost modeling scenario showed that New Jersey should gradually reduce demand for natural gas by 75% over the next 30 years. However, modeling has also shown that gas infrastructure such as compressor stations and transmission pipelines may be vital, even if the fuel source changes, to providing reliable and dispatchable power generation in times of low renewable output. In order to reduce emissions from natural gas, New Jersey should immediately focus on repairing existing leaky natural gas equipment and infrastructure and limiting the growth of new natural gas connections. This chapter addresses methane emissions associated with natural gas transmission and distribution systems in New Jersey. The chapters on New Jersey's industrial sector, residential and commercial buildings and electric generation each address $CO_2$ emissions associated with natural gas as a fuel source (combustion of natural gas in end use).

## WHERE WE STAND

In 2018, methane emissions from all New Jersey sources totaled 8.2 MMT $CO_2e$. Natural gas transmission and distribution systems collectively emitted 2.5 MMT $CO_2e$ of the total 16 MMT $CO_2e$ emissions from SLCPs (approximately 16% of SLCP emissions) and 2.4% of the total $CO_2e$ emissions in the state. The remaining 5.7 MMT $CO_2e$ of methane emissions come from waste management and agricultural activities. Emissions from those sectors are discussed in the Waste and Agriculture Chapter of this report as the strategies to control these methane emissions are markedly different than those addressing methane emissions from natural gas transmission and distribution.

[3] Clearing lines to perform maintenance and repairs.

Much of New Jersey's natural gas distribution infrastructure was installed prior to the 1950s, and these older pipelines are typically made of cast iron and unprotected steel which are more likely to leak than newer protected steel and durable plastics phased in after that time (Matthau, 2016). The leaks themselves are caused by disturbances resulting from earth movement, the breakdown of joints, and corrosion of unprotected steel pipelines; and from the natural process of 'graphitization' of iron pipelines. Graphitization is the process of iron degrading over time to softer elements. This process makes iron pipelines more prone to cracking. Leaks are much less likely to occur from plastic and protected steel pipelines (USEPA, 2014).

**In 2018, Natural Gas T&D was estimated to release 2.5 million metric tons of $CO_2$e. This represents 16% of New Jersey's net SLCPs emissions.**

New Jersey has almost 4,000 miles of older cast iron pipelines, and these older lines are responsible for 23% of the emissions from the natural gas transmission and distribution sector. In fact, New Jersey has 17% of the total remaining inventory of cast iron distribution pipelines in the United States, more than any other state in the country (PHMSA, 2020c).

New Jersey estimates emissions from the natural gas transmission and distribution system located within its borders using the EPA State Inventory Tool. This tool estimates New Jersey's emissions using emissions factors (Table 6.2.1) assigned to miles of transmission pipeline,[4] number of compression stations,[5] miles of distribution pipeline,[6] and number of service lines.[7] New Jersey's emission inventory differentiates pipeline material to account for the likelihood of leaking, assigning a higher emission factor to cast iron and unprotected steel pipe compared to protected steel and plastic. Emissions from maintenance operations like blowdowns or accidental releases are not currently calculated as part of the inventory.

***Table 6.2.1. Emission Factors for Distribution Pipelines.***

*Older cast iron pipes represent significantly greater potential for leakage than pipes made of newer materials.*

| Distribution Pipeline | Emission Factor* |
|---|---|
| Cast Iron | 5.80 |
| Unprotected steel | 2.12 |
| Protected steel | 0.06 |
| Plastic | 0.37 |
| *Metric tons methane per year per activity unit | |

*Source: EPA State Inventory Tool*

The 2018 Statewide GHG Emissions Inventory estimated that 87% of the 2.5 MMT $CO_2$e methane emissions from natural gas systems are from distribution operations and 13% are from transmission facility operations (Figure 6.2.3). Leaks from distribution service lines account for the majority of emissions (1.3 MMT $CO_2$e), followed by distribution pipelines (0.8 MMT $CO_2$e).

[4] Transmission pipelines are large diameter, high-pressure lines that transport gas from production fields, processing plants, storage facilities, and other sources of supply over long distances to local distribution companies or to large volume customers (USEPA, 2019).
[5] Compression Stations maintain transmission pipeline pressure when natural gas is transferred into the system from a storage facility. (USEPA, 2019)
[6] A distribution line is a line used to supply natural gas to the consumer. A distribution line is a network of piping located downstream of a natural gas transmission line. As defined in natural gas pipeline safety regulations, a distribution line is a pipeline other than a gathering or transmission line (PHMSA, 2020d).
[7] Service lines transport gas from a common source of supply to a customer meter or the connection to a customer's piping (PHMSA, 2020d).

*Figure 6.2.3. Natural Gas Transmission & Distribution Emission Sources by Percentage, 2018, New Jersey.*
*Distribution service lines and old cast iron distribution pipes are responsible for 87% of emissions on a $CO_2e$ basis.*

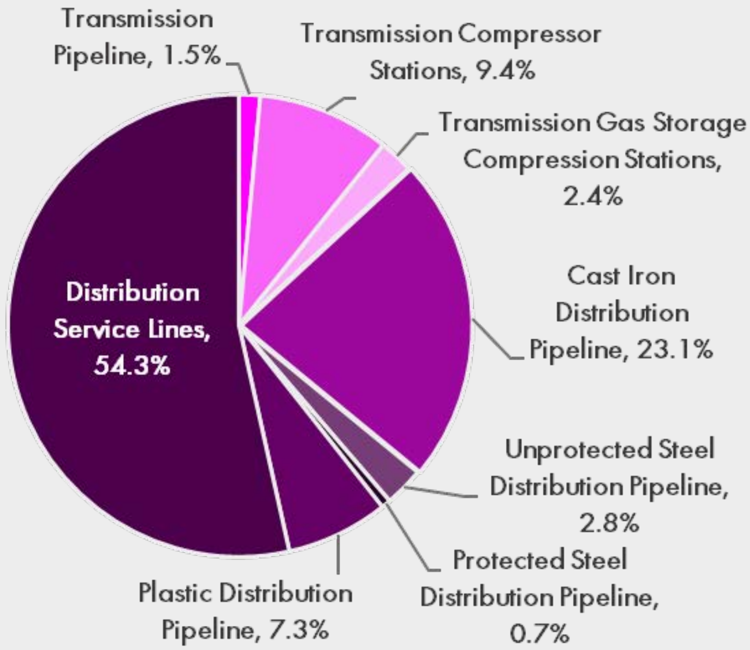



*Table 6.2.2. Annual Natural Gas Transmission and Distribution Greenhouse Gas Emissions 2006 – 2018 (MMT $CO_2e$).*

| 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.6 | 2.6 | 2.6 | 2.5 | 2.5 | 2.5 | 2.5 | 2.3 | 2.3 | 2.6 | 2.6 | 2.5 | 2.5 |

GHG emissions from natural gas transmission and distribution have held constant despite the uptake and expansion of natural gas use in New Jersey over the last decade. Over the last 14 years, New Jersey has experienced an increase in its natural gas infrastructure buildout, with 216 miles of distribution pipeline and 12,359 new service lines added per year (PHMSA, 2020c). The slight reduction in emissions, despite increasing infrastructure, is most likely due to the replacement of pipeline materials. All regulated utilities are replacing leak-prone steel, iron, and copper pipelines with polyethylene (Urena, 2020). Overall, polyethylene is the preferred material for pipeline replacement for distribution networks with lower operating pressures (e.g. under 100 psig). All transmission pipelines, whether intrastate or interstate, are replaced with steel pipe.

## Existing Emissions Reduction Policies

The New Jersey Board of Public Utilities (BPU) oversees distribution pipeline construction and safety standards for the state. Natural gas transmission pipeline construction and safety standards are established by federal authorities (United State Department of Transportation, Pipeline and Hazardous Materials Safety Administration). Transmission companies that utilize large compressors and distribution facilities that employ combustion equipment are required to have approved air emission operating permits from the DEP and must report emissions from these sources through the DEP's Emissions Statement Program.

### *Infrastructure Modernization Investments*

New Jersey's LDCs are regulated utilities and must receive authorization from the BPU to undertake capital improvement programs, such as pipe repair and replacement. Capital improvements are subject to cost recovery regulations that allow the utilities to pass those costs on to their consumers through rate increases. Maintenance, repair and replacement of natural gas infrastructure has historically been driven by safety and reliability considerations, rather than to minimize product losses. Safety is the primary driver in part because the costs associated with these capital improvements typically far exceed the economic value of avoiding losses of natural gas from leaking infrastructure absent environmental cost considerations (USDOE, 2017).

Altogether, New Jersey's LDCs plan to invest over $3 billion in infrastructure improvement programs (PSE&G, 2019; NJNG, 2019; National Association for Clean Air Agencies, 2019; Elizabethtown Gas, 2019; South Jersey Gas, 2019) over the next five years to modernize and minimize leak prone areas. These efforts will help mitigate fugitive emissions and improve system integrity.

### *Leak Detection and Control Innovations*

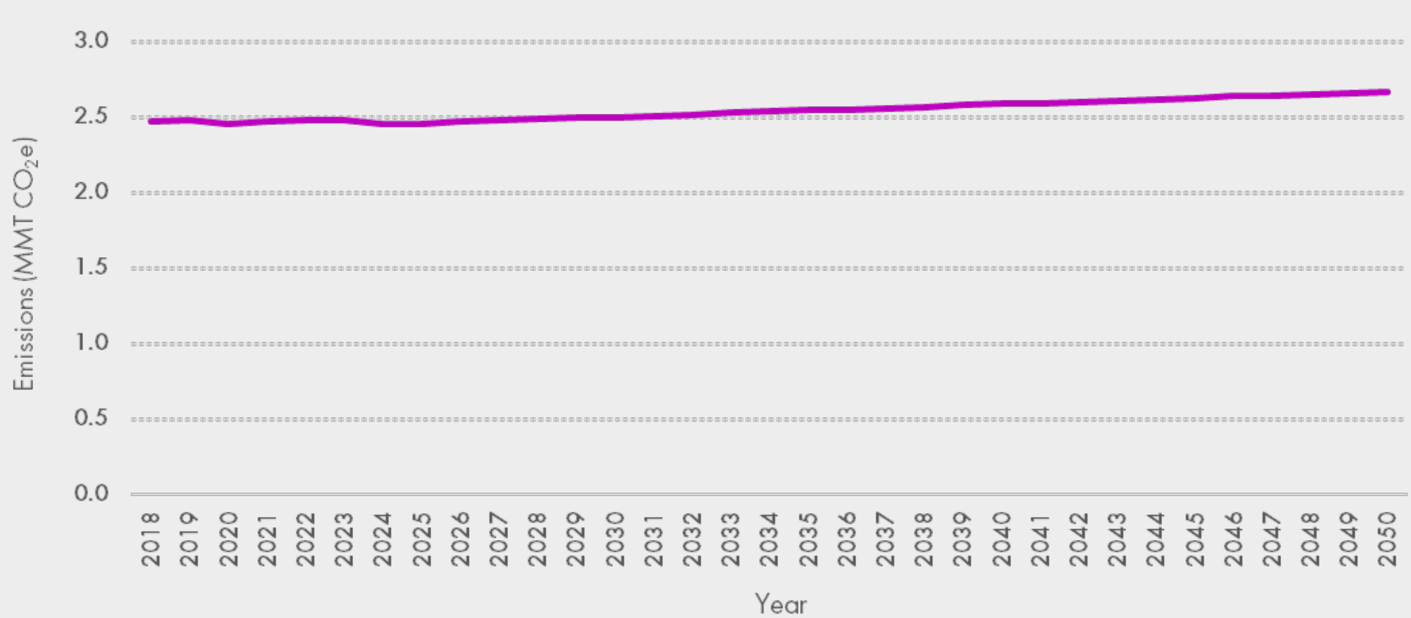
The state has piloted innovative leak detection technology and controls. In 2016, PSE&G partnered with the Environmental Defense Fund, Google Earth, and Colorado State University to test new methane sensing technology to measure natural gas flux associated with leaks. PSE&G paired the new technology with its existing leak grading system and reported successfully reducing methane emissions by 83% from targeted iron pipe replacement areas. This technology helped to prioritized pipeline replacement efforts by identifying the most problematic leaks, where 9% of pipelines examined were found to contribute 37% of methane emissions of all pipes surveyed (EDF, 2020).

In 2014, New Jersey Natural Gas's Reinvestment in System Enhancements program funded the installment of "excess flow valves" to prevent and reduce the escape of gas during unplanned releases by limiting the gas flow when a service or meter is damaged or disrupted. More than 50% of NJNG's system now has excess flow values installed, resulting in a reduction of 92,000 million cubic feet of methane, equaling 0.05 MMT $CO_2$e (Hanna, 2020).

## Business-as-Usual Projection

If New Jersey were to continue its current rate of natural gas infrastructure expansion without continuing to replace older infrastructure, the state would experience a 0.2 MMT $CO_2$e increase in GHG emissions by 2050 (Figure 6.2.4). This projection is based on the historical averages for new service lines and miles of distribution mains.

***Figure 6.2.4. New Jersey Natural Gas Transmission and Distribution System 2018-2050 Business-as-Usual Projection (MMT $CO_2$e).***
*Expanding the distribution networks without replacing older infrastructure would lead to a gradual increase in emissions.*



## THE PATH FORWARD

Current dependence on natural gas to meet New Jersey's energy demands is likely to continue over the next decade. The 2019 EMP modeling shows that to meet the 80x50 objectives New Jersey would need to gradually reduce demand for natural gas by 75% over the next 30 years under the preferred, least cost scenario (Figure 6.2.5).

Under this scenario, a significant reduction in natural gas demand is not expected to occur until 2030 and will only be achieved through considerable electrification of the building sectors combined with a transition to 100% carbon-neutral electric power generation.

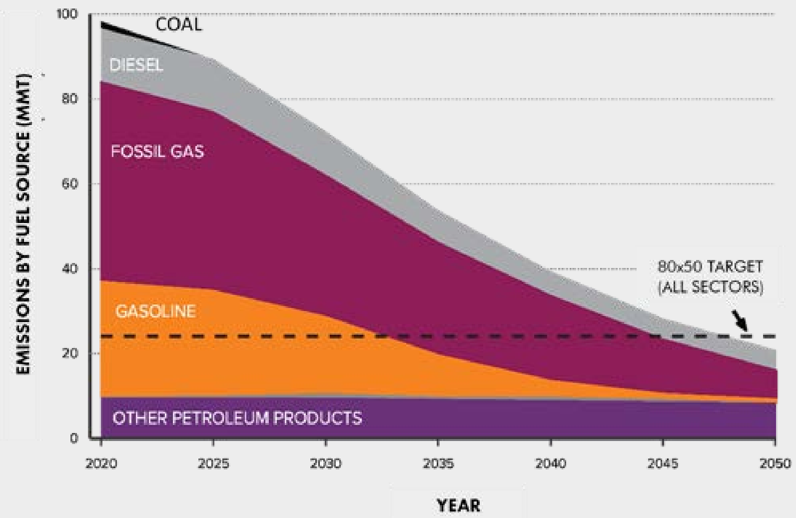
Recognizing New Jersey's continued dependence on natural gas infrastructure, three pathways have been identified to reduce GHG emissions from this sector.

- Pathway 1, Modernize natural gas infrastructure, considers efforts to repair and replace existing leaky equipment and infrastructure;
- Pathway 2, Improve operations through advance leak detection, evaluates practices to identify and prioritize repairs; and
- Pathway 3, Non-pipeline solutions[8] to eliminate the need for new pipelines, examines limiting expansion of natural gas infrastructure.

Pathway 1, modernizing natural gas infrastructure, could provide up to a 0.6 MMT $CO_2e$ reduction in GHG emissions by 2042. While the potential emissions reductions from Pathway 2, improved operations through advanced leak detection, have not been quantified, it is anticipated that this pathway will allow utilities to better prioritize and expedite methane emission reductions through identification of cost-effective leakage mitigation. Pathway 3, non-pipelines solutions, would eliminate the

***Figure 6.2.5. Energy emissions by fuel source for the Least Cost scenario (2019 EMP Figure 7).***

*The 2019 EMP anticipated a continuous decrease in reliance on natural gas, with very small amounts still used for difficult-to-replace applications in 2050.*




### EMISSION ACTIVITES

- Leak-prone pipes and equipment
- Operational release of gases (blowdowns)
- Accidental release

### EMISSIONS REDUCTION PATHWAYS

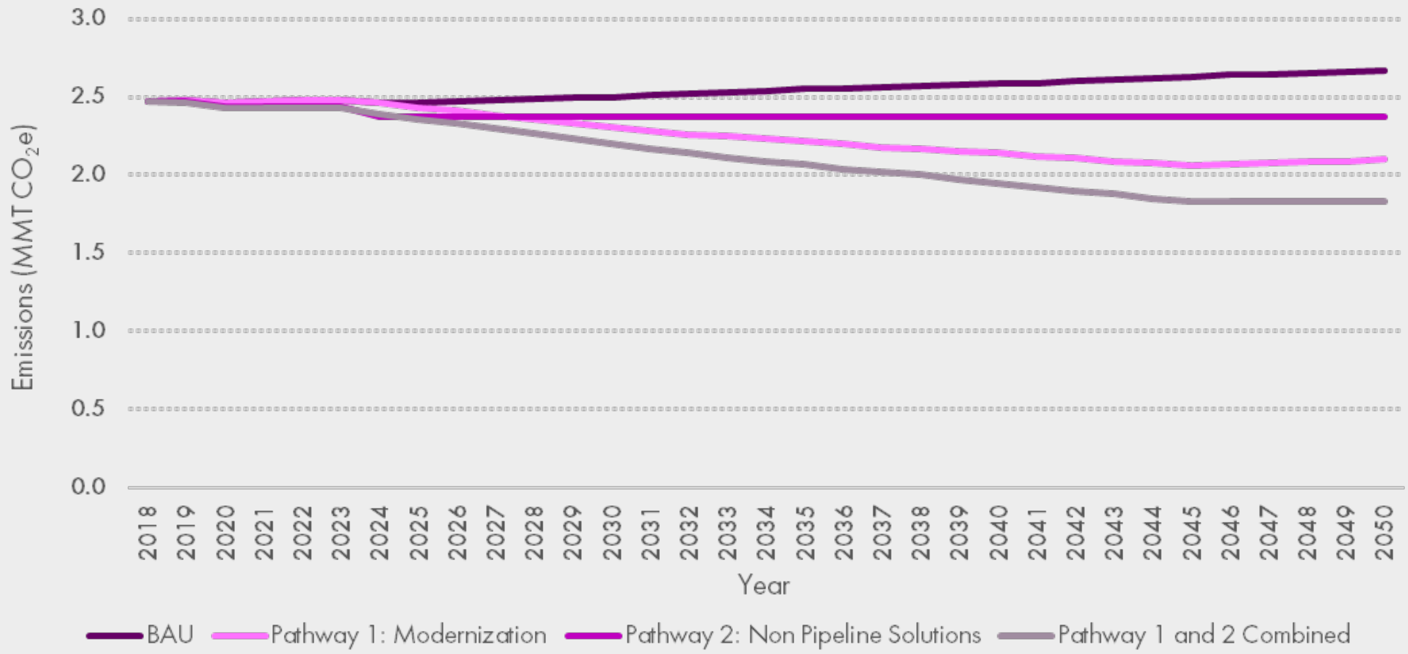
1. Modernize natural gas infrastructure
2. Improve operations through advanced leak detection
3. Non-pipeline solutions to eliminate the need for new pipelines

[8] Non-pipeline solutions are alternatives to meeting on-system natural gas demand storage capacity, winter-peaking services, and distribution system infrastructure.

need for new pipelines, avoiding future emissions. It is estimated that this pathway will avoid 0.3 MMT $CO_2e$ by 2050, assuming expansion of natural gas distribution or transmission systems. When the non-pipeline solutions pathway (Pathway 3) is analyzed together with infrastructure modernization (Pathway 1), GHG emissions from this sub-sector are projected to decrease to 1.83 MMT CO2e in 2045 and hold flat through 2050, without considering any decommissioning of pipelines. If in addition, some portion of pipelines were decommissioned, the projected reductions would be even greater (Figure 6.2.6).

***Figure 6.2.6. Natural Gas Transmission and Distribution Sector 2050 Pathways Projection (million metric tons of $CO_2e$).***

*Modernizing equipment and pipelines, improving leak detection, and avoiding the need for expanded infrastructure can lead to reductions in emissions from natural gas infrastructure.*




## **Emissions Reduction Pathway 1:** Modernize natural gas infrastructure

New Jersey has already taken steps to phase-out older pipeline materials to modernize its gas utility infrastructure. The DEP evaluated the rate of pipeline replacement by the local distribution companies over the last 8 years and used the average replacement rates to project emissions out to 2050.[9] If these replacement rates hold constant, by 2032 unprotected steel distribution mains will be eliminated from New Jersey's natural gas infrastructure and by 2045 cast iron will be eliminated.[10] GHG emissions from the sector will decrease to 2.10 MMT $CO_2e$ in 2050. Actual emissions savings could be underestimated since it does not include possible decommissioned pipelines or reductions in service needs. Further the EPA SIT Tool does not provide a way to calculate emission reductions due to service line replacements. Overall, the DEP estimates that this pathway could achieve up to a 0.6 MMT $CO_2e$ reduction in GHG emissions by 2050.

Accelerating pipeline replacement schedules will realize these savings sooner, though it should be noted that costs can be a significant challenge for LDCs. This must be taken into consideration when crafting policies to reduce emissions from natural gas, as costs are passed through to the consumer. Main replacement programs can cost $1 to $5 million per mile to replace pipe (USDOE, 2017). Urban areas with large inventories of cast iron and unprotected steel pipe face higher costs due to congestion, multiple (sometimes poorly documented) underground utilities, limited construction seasons due to weather, and high labor costs (USDOE, 2017).

[9] Assumes that 163 miles of cast iron pipelines are replaced with plastic pipe per year and 167 miles of unprotected steel pipelines are replaced with plastic pipe per year.
[10] These projections assume average replacement rates starting in 2025, after the closing of the latest round of LDC Modernization Plans.

## **Emissions Reduction Pathway 2:** Improve operations through advanced leak detection

New technologies exist for real time monitoring of methane emissions that can help pinpoint and prioritize leaks. Advanced leak detection and quantification methods assist utility companies in prioritizing leak repairs and pipeline replacement. Natural gas utilities can incorporate leak flow rate data into existing replacement and repair prioritization frameworks to more quickly and efficiently reduce leakage. Through ranking and ordering leak flow rate data, utilities can better identify which repairs will result in capturing more gas per dollar spent. PSE&G has demonstrated the viability of this approach through their partnership with the Environmental Defense Fund. They utilized methane mapping to inform their construction priorities (EDF, 2020).

As discussed in the New Jersey Clean Air Council's 2019 recommendations report, DEP and BPU should encourage gas utilities to analyze leak detection systems to determine whether more effective leak detection and control methods or equipment are available for implementation in the near-term without unreasonable impacts to ratepayers (Clean Air Council, 2019). The use of cutting-edge leak detection and quantification methods and more frequent leak surveys will result in repairs and replacement to reduce methane leaks. Also, as New Jersey transitions away from natural gas as the source of residential and commercial heating, additional reductions will be realized from the retirement of those distribution and service lines.

## **Emissions Reduction Pathway 3:** Non-pipeline solutions to eliminate the need for pipeline expansion

Non-pipeline solutions are alternatives to meeting natural gas demand. The use of non-pipeline solutions reduces the need for investment in traditional resources like pipelines, storage capacity, winter-peaking services, and distribution system infrastructure (ICF, 2019). Non-pipeline solutions include supply side solutions, for example, operations that utilize renewable natural gas to supply distributed energy resources serving local demand. Demand side non-pipeline solutions match pathways discussed in the residential, commercial, and industrial chapters, including:

- Targeted energy efficiency that achieves peak day savings;
- Beneficial electrification that utilizes more efficient technologies such as heat pumps; and
- Net-zero energy residential and commercial buildings.

Utilizing non-pipeline solutions can reduce natural gas demand and emissions in the long term. DEP analyzed the growth in natural gas infrastructure in the state from 2004 to 2018. On average, New Jersey added 216.5 miles of distribution mains and 12,359 total new service lines every year. By transitioning to non-pipeline solutions, the state would avoid future build out of new natural gas infrastructure, thereby avoiding future emissions of 0.3 MMT $CO_2e$ by 2050.[11]

# 2050 RECOMMENDATIONS

Reducing New Jersey's methane leak rate will require a collaborative effort between industry and government. The LDCs already have approved active pipeline replacement programs to upgrade infrastructure. In the near term, the BPU should continue to pursue ambitious replacement schedules for cast iron and unprotected steel pipes, mitigating the leakiest pipeline materials. Other state models exist that New Jersey could emulate to further bolster this effort. For example, some states have established specific targets either in terms of miles of pipeline to replace each year or as a deadline for completing targeted replacement. Massachusetts requires companies to establish a plan to either completely replace cast iron and unprotected steel pipe within 20 years or justify an extension. As discussed above, if New Jersey continues its current rate of replacement it will take 23 years, until 2045, for all cast iron and unprotected steel pipes to be phased out. The BPU should set an accelerated timeline to replace those pipes at the greatest risk for leak while evaluating cost effectiveness and impacts to ratepayers.

[11] This projection is based on the average annual natural gas distribution system growth rate between 2004-2018. It does not include estimates about growth in transmission systems.

Despite federal uncertainty, New Jersey has shown leadership in piloting programs to reduce methane from the natural gas system. Utilities in the state have implemented BPU-approved infrastructure modernization plans and piloted innovative leak detection and controls. New Jersey must build on these experiences to encourage all state utilities to employ these proven strategies to gain further immediate emissions reductions systemwide. There are also new technologies and strategies adopted by other states which could help New Jersey's utilities fill gaps in emissions data and prioritize leak repair and replacement. Local distribution companies use historical leak information and other data to inform priorities for pipeline repair and replacement. In recent years there have been significant technological advances with vendors offering sensing technologies and associated analytics packages that may be used to enable emissions abatement and provide cost savings (Picarro, 2019). In concert with recommendations made in the 2019 New Jersey Clean Air Council Recommendations Report, LDCs should adopt advanced leak detection to find leaks and prioritize leak abatement efforts based on the relative size of leaks within each respective distribution system (after safety considerations). DEP and BPU should encourage gas utilities to analyze leak detection systems to determine whether more effective leak detection and control methods or equipment are available for implementation without unreasonable impacts to ratepayers (Clean Air Council, 2019). Utilities should pursue pilot programs with implementation timelines and evaluate enhanced methane detection practices (e.g. gas speciation, mobile methane detection and/or aerial leak detection). If these pilots demonstrate success, the LDCs should adopt these new technologies and approaches in full.

In the long term, pursuing carbon-free electric generation will mitigate the gas system's fugitive emissions as pipelines are decommissioned. Adopting non-pipeline solutions that reduce natural gas demand will help minimize the growth of natural gas infrastructure in the state in the interim. As noted in the 2019 EMP New Jersey will need to evaluate if continued expansion and support of natural gas with incentives aligns with its effort to decarbonize the energy sector. Policies could be developed that encourage gas public utilities to propose and adopt non-pipeline solutions when seeking expansion or upgrade of the distribution system.

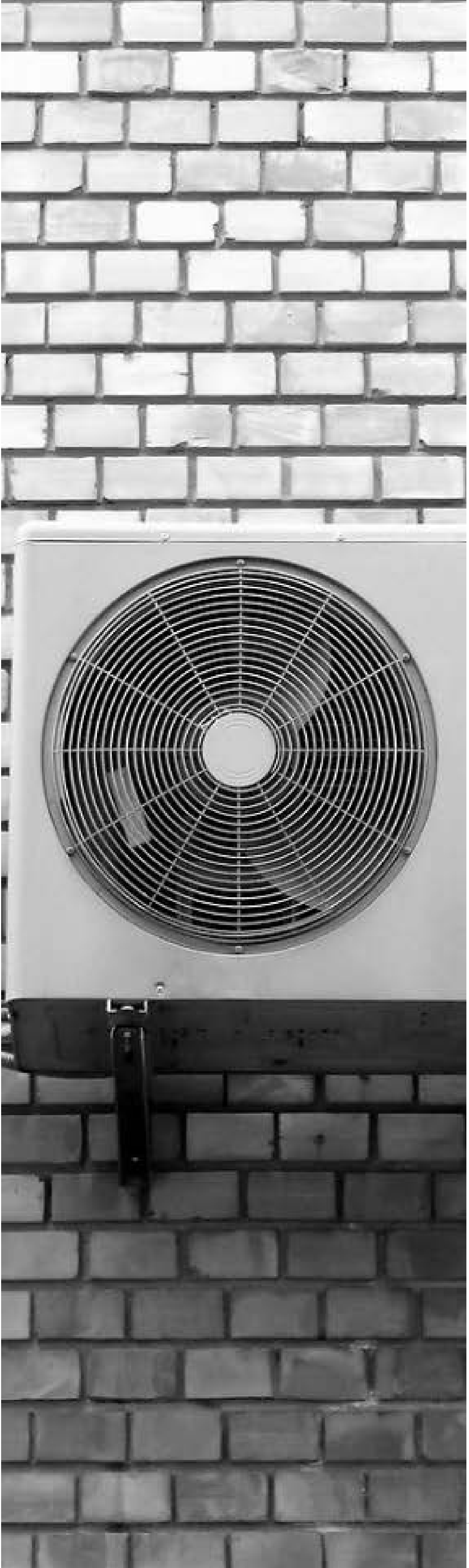
*Table 6.2.3. Recommendations for reducing emissions from Natural Gas Transmission and Distribution Infrastructure*

| Actions | Entity | Timeframe[12] | References |
|---|---|---|---|
| Incorporate advanced leak detection technology into natural gas operations to find, quantify, report, and prioritize gas pipeline repair and replacement and to file repair, replacement or retirement plans with BPU. | BPU, DEP | Near-term | 2019 EMP Goal 5.4.4<br><br>California's "26 Best Practices" for methane leak detection, quantification and elimination. |
| Evaluate requiring leak prone pipes and equipment to be replaced or retired on an established schedule. | BPU, DEP | Near-term | Massachusetts has established a 20-year timeframe to replace all leak prone infrastructure |
| Evaluate establishing emission limits from natural gas transmission and distribution systems. | BPU, DEP | Near-term | Massachusetts set a declining cap from 2018-2020 to help meet the state's 2020 GHG emissions limit. |
| Evaluate mandating abatement of environmentally significant non-hazardous leaks (by leak flow volume). | BPU, DEP | Near-term | Massachusetts has existing regulations. |
| Evaluate the need to expand natural gas infrastructure and evaluate existing incentive structures for phaseout. | BPU | Near-term | 2019 EMP Goal 5.4.1 |

[12] Near-term: now through 2030. Mid-term: 2030-2040. Long-term: 2040-2050. Throughout: Ongoing now through 2050.

| | | | |
|---|---|---|---|
| Encourage gas public utilities to propose and adopt non-pipeline solutions when seeking expansion or upgrade of the distribution system. | BPU | Throughout | 2019 EMP Goal 5.4.2 |
| Oppose federal rollbacks and continue to advocate for sufficient federal standards regulating emissions from the oil/gas industry. | DEP | Throughout | |

# HALOGENATED GASES



## OVERVIEW

Halogenated gases are organic compounds onto which a halogen (e.g., fluorine, chlorine, bromine or iodine) is attached. One group of halogenated gases, hydrofluorocarbons (HFCs), are the fastest growing source of greenhouse gases (GHGs) (Velders, 2014), both globally and in New Jersey. This is due to the prevalent use of HFCs in air conditioning, heat pumps and refrigerants as a replacement for ozone depleting substances (ODS) such as chlorofluorocarbons (e.g., R-12[13]) and hydrochlorofluorocarbons (e.g., R-21). Under a federal regulatory schedule consistent with the 1987 Montreal Protocol, ODS will be completely phased out of production in the United States by 2030, driving the increased use of HFCs. However, HFCs are considered short-lived climate pollutants (SLCPs) with high global warming potentials[14] (GWP) compared to $CO_2$ and are frequently referred to as highly warming gases. For example, R-410a has a global warming potential 2,800 times greater than $CO_2$ according to the Intergovernmental Panel on Climate Change (IPCC) fourth assessment report (IPCC, 2007b).[15]

HFC compounds are currently used in residential and commercial refrigerants, firefighting agents, and propellants for aerosols. Without action, HFC emissions are projected to increase at the greatest rate of all pollutant sectors evaluated in this report. Requiring manufacturers to switch to climate-safe alternatives can change the trajectory of HFC emissions globally. Recent United States Climate Alliance efforts and newly enacted New Jersey legislation are working to put those requirements in place.

With cooling, heating and refrigeration being the primary use of HFCs in New Jersey, cross-sector strategy coordination with the residential and commercial sectors' decarbonization recommendations outlined in those chapters is essential. For example, one strategy for the buildings sector includes the electrification of heating and cooling through applications such as heat pumps. Given the lifespan of heat pumps and air conditioning equipment, simultaneously phasing out high GWP HFC refrigerant used in this equipment is crucial. Also, programs to recapture, recycle and dispose of HFCs from retired equipment must be in place to avoid the negative climate impacts of their release.

[13] Refrigerants are represented by the letter R (as in Refrigerants) followed by a two- or three-digit number and, in some cases, one or two letters.
[14] The Global Warming Potential (GWP) was developed to allow comparisons of the global warming impacts of different gases. It is a measure of how much energy the emissions of 1 ton of a gas will absorb over a given period of time, relative to the emissions of 1 ton of carbon dioxide ($CO_2$).
[15] USCA SLCP Emissions Tool uses the IPCC Fourth Assessment Report for HFCs and methane, and the Fifth Assessment Report for black carbon

## WHERE WE STAND

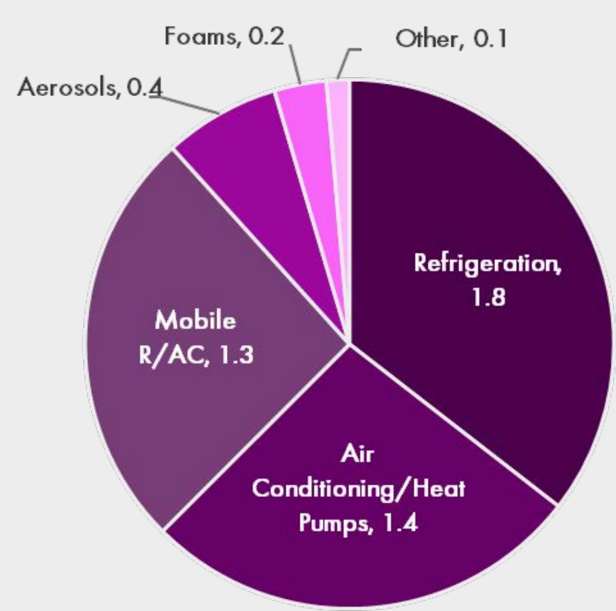
In 2018, emissions from halogenated gases alone contributed 5.1 MMT $CO_2e$ of New Jersey's net 97.0 MMT $CO_2e$ emissions. Table 6.3.1 provides a breakdown of emissions from halogenated gases, associated end-use activities, and their status in New Jersey's emissions inventory.

***Table 6.3.1. Breakdown of emissions from highly warming gases, end-use activities, and status in New Jersey's emissions inventory.***
*Halogenated gases are used in a variety of applications, most notably for cooling and refrigeration.*

| Halogenated Gas Category | Emission activity/end-use | Status in New Jersey Emissions Inventory 2018 |
|---|---|---|
| Hydrofluorocarbons (HFCs) | Primarily used for cooling and refrigeration; replacement for ozone depleting substances. | 5.0 MMT $CO_2e$. |
| Perfluorocarbons (PFCs) | Cleaning solvents in the semi-conductor industry. | No longer an issue with no reported emissions in recent years. |
| Sulfur hexafluoride ($SF_6$) | Specialized use as an insulating fluid in high voltage electrical equipment. | Very small portion; minute amount (0.1 MMT $CO_2e$) but needs to be monitored. Not considered an SLCP. |
| Nitrogen Trifluoride ($NF_3$) | Cleaning gas in semi-conductor manufacturing as well as etchant for certain materials. | No reported emissions from relevant sector (semi-conductor industries). |
| Chlorofluorocarbons (CFCs) | Used in manufacture of aerosol sprays, blowing agents for foam, as solvents, and as refrigerants. Ozone depleting substance controlled under the Montreal Protocol. | Already phased out. |
| Hydrochlorofluorocarbons (HCFCs) | Replacement for CFCs in refrigeration and air-conditioning, aerosol propellants, and foam manufacture. | Being phased out. |

HFC emissions vary depending on their use in end-products and the handling policies in place for their end of life (Figure 6.3.1). Air conditioning and refrigeration equipment use refrigerant materials R-410, R-404A and R-507A. These refrigerants mainly contain HFC-143a and HFC-32, which globally, are the HFC emissions of greatest concern (USEIA, 2011). R-410 has overtaken R-22 in air conditioning units and heat pump units sold in New Jersey. In 2019 over 188,000, R-410 air conditioning/heat pump units were sold in the state compared to 126 R-22 units (Ayers, 2020) (Figure 6.3.2). Both air conditioning refrigerants R-22 and R-410A are in common use throughout the world. R-22 refrigerant, also known as Freon, is an ozone depleting product and has a high global warming potential. In 2004, the United States Environmental Protection Agency (EPA) began phasing out R-22 air conditioning refrigerant with the expectation that it will be completely eliminated by the year 2030. R410A, commonly known as Puron, has become the common replacement for Freon despite its high

***Figure 6.3.1. Breakdown of $CO_2e$ emissions by end use in 2018 (MMT $CO_2e$).***
*Refrigeration and air conditioning represent the greatest sources of halogenated gas releases.*

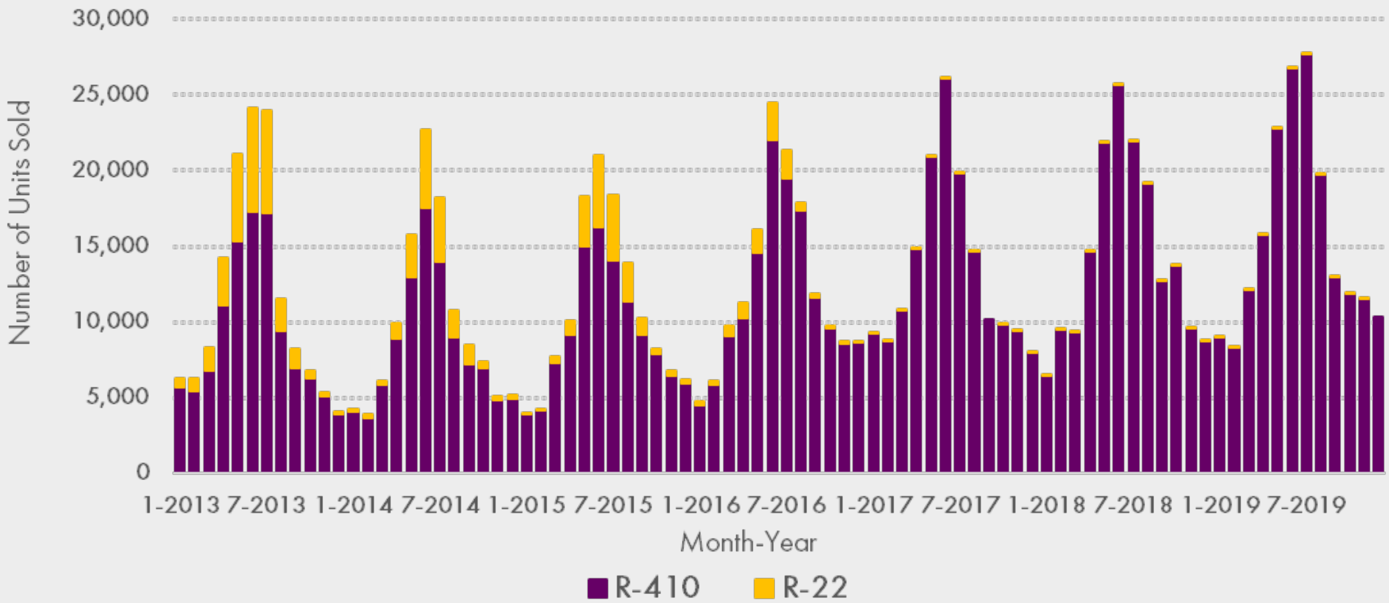



*Source: EIA*

GWP. Requiring sales of new appliances that use low global warming substitutes will avoid increased stores of HFCs that could potentially be released at some point in the lifecycle of equipment.

***Figure 6.3.2. Total number of R-410 and R-22 AC/heat pumps sold in New Jersey from 2013-2019.***

*R-410 has largely replaced the ozone-depleting R-22, but both have high global warming potentials. New refrigerants with lower global warming potentials will significantly reduce climate impacts while protecting the ozone layer.*




*Source: Heating, Air-conditioning, & Refrigeration Distributors International*

Climate-safe alternatives are emerging, some of which are already available on the market from major manufacturers. For example, $CO_2$ and hydrocarbons are natural refrigerants that can be used as a substitute for the HFCs in use today. Synthetic options are also available. Equipment using alternative products have also shown to reduce electricity demand, offering energy reduction co-benefits (Igusky, 2015).

**In 2018, Halogenated Gases were estimated to release 5.1 million metric tons of $CO_2e$. This represents 32% of New Jersey's net SLCPs emissions.**

In addition to replacement of high GWP HFCs with low GWP HFCs, managing refrigerant material throughout the lifecycle of equipment is necessary to control releases to the atmosphere. Emissions usually occur during the installation, servicing and disposal of equipment. Residential and commercial equipment can have emission releases as high as 70 to 99% (CARB, 2018). According to New Jersey's 2018 GHG Inventory, emissions of halogenated gases increased almost 60% from 2006 to 2018, tracking closely with national trends where HFC emissions have more than doubled from 2005 to 2018 (USEPA, 2018) Table 6.3.2.

***Table 6.3.2. Annual Halogenated Gas (including $SF_6$) Greenhouse Gas Emissions 2006-2018 (MMT $CO_2e$).***

| 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.2 | 3.2 | 3.3 | 3.4 | 3.9 | 4.0 | 4.1 | 4.6 | 4.8 | 5.0 | 4.7 | 4.9 | 5.1 |

Historical growth of HFC emissions has been driven by the transition from ODS to non-ODS used in refrigerant material, and the growing use of refrigeration and air conditioning. Air conditioning and refrigeration use is growing faster than the population. From 2006 to 2018 the U.S. population and households grew just under 1%. During the same period, the share of U.S. households with heat pumps increased 6%, central air conditioning 1%, and room air conditioning 2%.[16] Additionally, the growth of industries and commercial enterprises which require air conditioning and refrigeration contributed to increased HFC usage. New Jersey has experienced growth in data processing and data centers (212%), food services (10%), and warehousing and storage (125%) which all have large cooling requirements (USBEA, 2020).

## Existing Emission Reduction Policies

In 2016, the Montreal Protocol Kigali Amendment was introduced. Under this international accord, countries committed to cut the production and consumption of HFCs by more than 80% over 30 years. The ambitious phase down schedule was expected to avoid more than 80 billion metric tons of $CO_2$ equivalent emissions by 2050.

The U.S. Environmental Protection Agency adopted the Significant New Alternatives Policy (SNAP) program rules 20 and 21 in 2015 and 2016, respectively. In part, these rules set a schedule to phase down the use of certain HFCs that had previously been listed as acceptable substitutes for ODS in refrigeration and air conditioning equipment, foam, and aerosol propellants. However, in 2017 a successful legal challenge in the U.S. Court of Appeals vacated certain portions of the SNAP program. Following the court's partial vacatur, the Trump EPA has taken various actions to further roll back the SNAP rules. In response to the federal ruling and subsequent EPA actions, New Jersey and other states enacted state legislation in an effort to retain the phase out of highly warming HFCs. New Jersey's legislation, Public Law 2019, c.507, prohibits the use of HFCs, or other similar substances, in all new equipment or products for sale, lease, rent, or to be installed or entered into commerce in the state according to the timeframe established in the legislation (Table 6.3.3).

Additionally, the legislation prescribes requirements for persons who install, repair, maintain, service, replace, recycle or dispose of stationary refrigeration or air conditioning appliances. The legislation further authorizes the DEP to adopt rules and regulations to further regulate HFC use in the state.

***Table 6.3.3. Summary of HFC Phase Down Schedule per P.L. 2019, c.507.***
*Current New Jersey law will phase out the use of specified highly warming HFCs in new equipment and products as listed below.*

| Effective Date for Restrictions | Applicable Materials |
|---|---|
| July 1, 2020 | Propellants; rigid polyurethane applications and spray foam, flexible polyurethane, integral skin polyurethane, flexible polyurethane foam, polystyrene extruded sheet, polyolefin, and phenolic insulation board and bunstock; and supermarket systems, remote condensing units, stand-alone units, and for all other applications and end uses for substitutes not covered elsewhere in this table; |
| January 1, 2021 | Refrigerated food processing and dispensing equipment; compact residential consumer refrigeration products; and polystyrene extruded boardstock and billet, and rigid polyurethane low-pressure two component spray foam; |
| January 1, 2022 | Residential consumer refrigeration products, other than compact and built-in residential consumer refrigeration products, vending machines; |
| January 1, 2023 | Cold storage warehouses; and built-in residential consumer refrigeration products; and |
| January 1, 2024 | Centrifugal chillers and positive displacement chillers. |

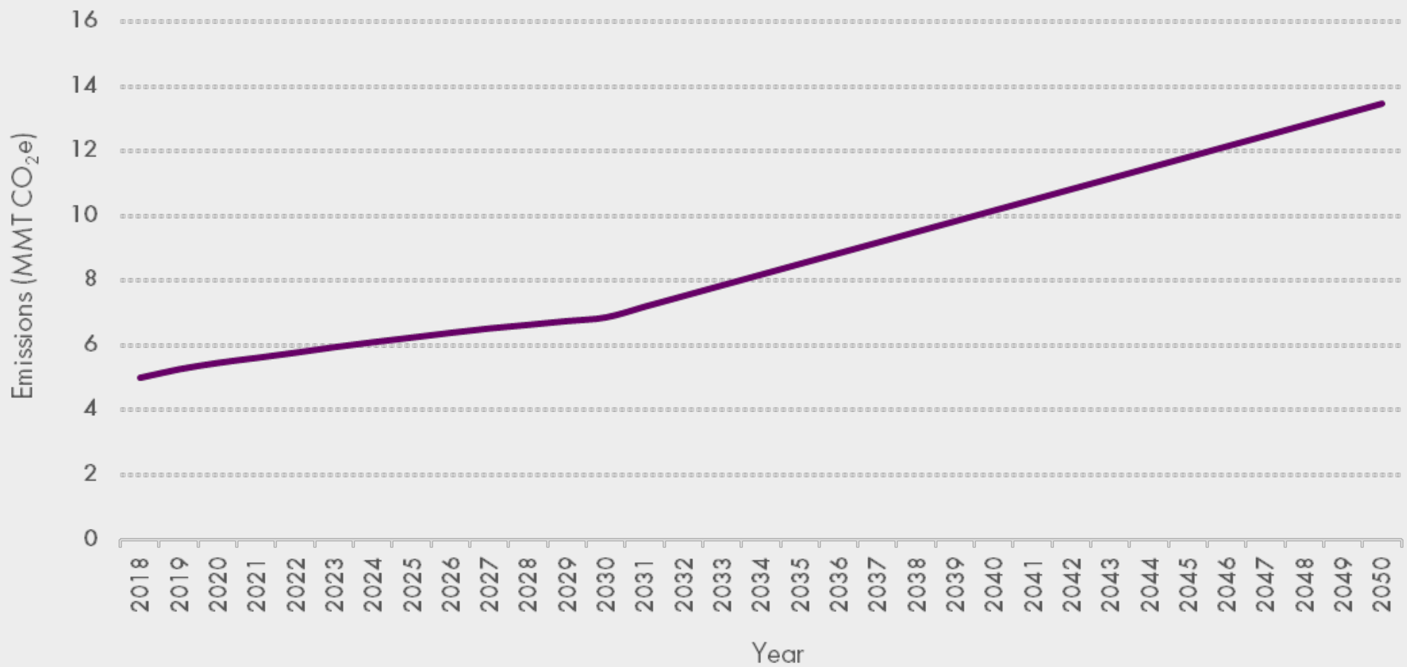
[16] Analysis of data compiled by the U.S. Climate Alliance (USCA) from various sources: (a) Population Projections, United States, 2004 - 2030, by state, age and sex, on CDC WONDER Online Database; (b) Annual Estimates of Housing Units for the United States, Regions, Divisions, States, and Counties: April 1, 2010 to July 1, 2017 on US Census Bureau American Fact Finder Online Database; and (c) 2015 Residential Energy Consumption Survey (RECs) Survey Data on U.S. Energy Information Administration (EIA) Webpage.

## Business-as-Usual Projection

Assuming New Jersey continues at its current rate of increased deployment of refrigeration and heating/cooling technologies, emissions from HFCs are projected to increase at a rate of 4.8% annually through 2030, reaching 6.8 MMT $CO_2e$ by 2030[17] and could reach 13.5 MMT $CO_2e$ by 2050 (Figure 6.3.3). This projection assumes current emission trends, technologies, and conditions, excluding any needed regulations in response to Public Law 2019, c.507, and assumes no future regulations impacting HFC emissions will occur.

***Figure 6.3.3. New HFCs 2018-2050 Business-as-Usual Projection (MMT $CO_2e$).***

*Allowing highly-warming HFC use to expand without planned phaseouts and refrigerant management policies would result in markedly increased emissions.*




[17] Halogenated gases projections' methodology utilizes the US Climate Alliance SLCP Tool (based on the USEPA Vintaging Model)

## THE PATH FORWARD

The 2019 EMP outlines a strategy for maximum decarbonization of New Jersey's residential, commercial and industrial sectors by converting fossil fuel heating applications to electric heat pumps that utilize HFCs as its heating/cooling transfer medium. Specifically, the 2019 EMP's least cost scenario estimates that by 2050, 94% of commercial buildings, 86% of residential buildings and 87% of industrial buildings will have installed heat pump technology. The expected life of HVAC equipment using these refrigerant materials is 15-20 years (ASHRAE, 2015; CARB, 2018), resulting in an increase in New Jersey's HFC inventory with every new HFC unit sold. It is critical that New Jersey simultaneously phase out the HFCs with higher GWPs and replace them with new low-global-warming-potential alternatives if the state is to realize its 80x50 emissions goal (Table 6.3.4).

***Table 6.3.4. 2019 EMP Least Cost Scenario, rate of heat pump adoption between 2020-2050.***
*As envision in the 2019 EMP, the transition from fossil-powered technologies for space heating and hot water will greatly increase the number of electric heat pumps throughout the economy.*

| Sector | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|
| Commercial | 7% | 51% | 86% | 94% |
| Residential | 5% | 21% | 63% | 86% |
| Industrial | 0% | 11% | 61% | 87% |

DEP utilized the USCA SLCP Emissions Tool to compare various policy-based HFC emission reduction scenarios[18] specific to New Jersey (USCA, 2019) (Figure 6.3.4). Five policy-based mitigation scenarios were considered, three of which focused on possible outcomes for emissions reductions based on policies the state could choose to adopt. Two additional scenarios assume the federal government ratifies the Kigali Amendment (CARB, 2018). The Kigali Amendment would provide the most emission reductions but cannot be legally adopted at the state level.

***Deploying Refrigerant Management* Programs Scenario (Policy Scenario I):** In this scenario, it is expected that leak rates from commercial and industrial refrigeration will decrease 25% annually between 2019 and 2025 resulting in overall HFC emissions (all end-uses) declining by 9 to 10% annually by 2030. Projected 2030 emissions from this scenario are 6.4 MMT $CO_2e$.

***Adopting and implementing regulations to phasedown HFCs in favor of low-Global Warming Potential alternatives, consistent with the 2020 legislation* scenario (Policy Scenario II)**: This scenario assumes that if implemented successfully, SNAP rules would result in emissions reductions 20% below Business-as-Usual projection by 2030. Projected 2030 emissions from this scenario are 5.4 MMT $CO_2e$.

***Combination Reduction (Refrigerant Management Program plus SNAP)* scenario (Policy Scenarios I and II):** Policy Scenarios I and II are modeled together in this composite scenario. The emissions from the SNAP are used as a starting

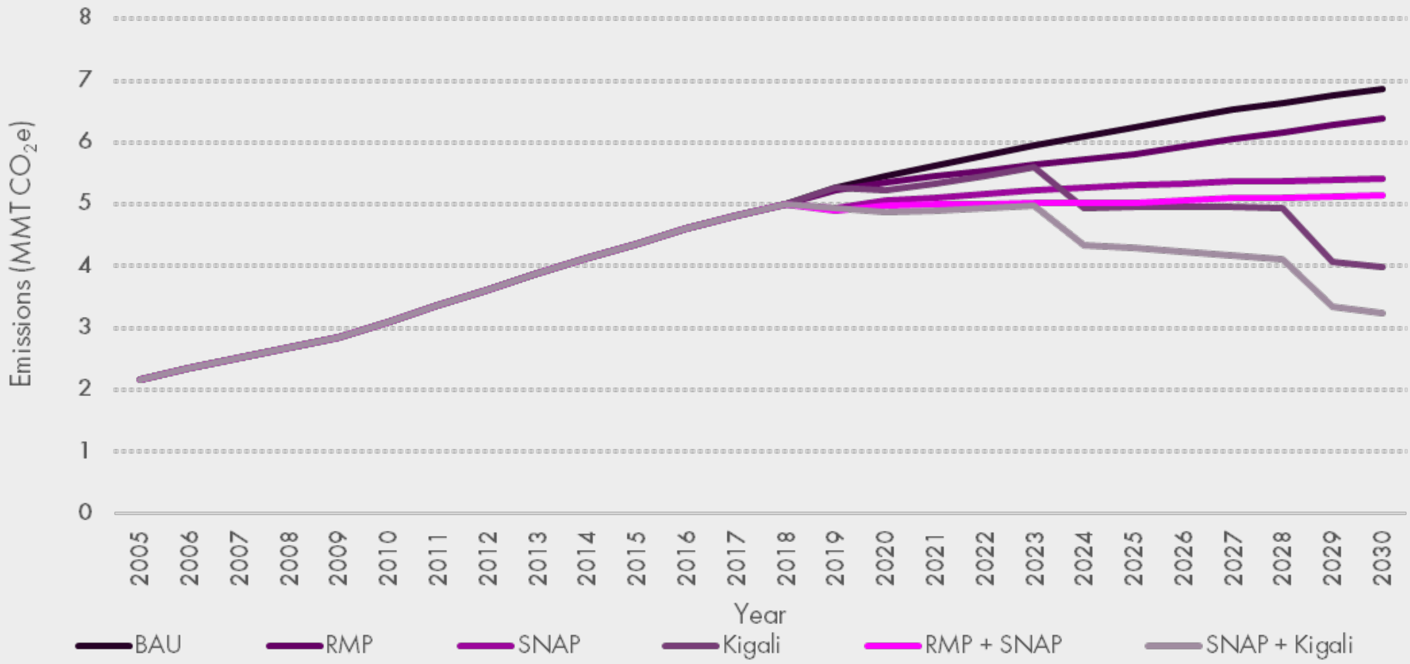
[18] Projections consider population growth, sector growth trends, expected uptake of heat pumps, and increases in air conditioning use.

point. The lowest leak rates due to the Refrigerant Management Program are then applied. Finally, Kigali reduction factors are applied to the remaining emissions. Projected 2030 emissions from this scenario are 5.1 MMT $CO_2$e.

***Pursuing the Montreal Protocol-Kigali Amendment phasedown (Kigali)* scenario (Federal action):** If the Kigali phasedown schedule is followed by the federal government of the United States, HFC emissions reductions are estimated to be 30 to 60% below business-as-usual projection by the year 2030. Projected 2030 emissions from this scenario are 3.9 MMT $CO_2$e.

***Combination Reduction (SNAP plus Kigali)* scenario (Policy Scenario II and federal action):** Policy Scenario II and the Federal Action Scenario are modeled together in this composite scenario. The emissions from the SNAP are used as a starting point. The lowest leak rates due to the Refrigerant Management Program are then applied. Finally, Kigali reduction factors are applied to the remaining emissions. Projected 2030 emissions from this scenario are 3.2 MMT $CO_2$e.

***Figure 6.3.4. New Jersey's HFC 2030 Projection for Business-as-Usual and Mitigation Scenarios.***
*Policy alternatives consider a range of emissions reduction outcomes. The most assertive can reduce emissions by nearly 4 MMT $CO_2$e per year by 2030 compared to a no-action alternative.*




Based on these scenarios, two pathways have been identified as critical to reducing GHG emissions from this sector.

- Pathway 1, containment through leak repairs, strict materials handling, and recycling aligns with the *deploying refrigerant management programs* policy scenario I above.
- Pathway 2, product phase out, involving outright bans by regulation, aligns with the *adopting and implementing regulations to phasedown HFCs in favor of low-Global Warming Potential alternatives* policy scenario II above.

When both pathways are implemented together, New Jersey can effectively stop growth in emissions out to 2030, holding emissions at 5.1 MMT $CO_2$e (see

## EMISSIONS ACTIVITES

- Aerosols
- Air conditioning
- Refrigeration
- Foams
- Mobile Refrigeration/ Air conditioning

## EMISSIONS REDUCTION PATHWAYS

1. Containment through leak repairs, strict materials handling, and recycling
2. Product phase out, involving outright bans by law or regulation

combined reduction scenario). If the policies are adopted now, a stable level of emissions is projected for the mitigation pathways from 2030 until 2050 with maximum mitigation benefits obtained within a decade. These emission reduction pathways will provide an opportunity for innovation for HFC alternatives, development of workforce and job creation, and incentives to retire or retrofit old equipment, with higher energy efficiency appliance replacements, such as refrigerators and air conditioners.

### **Emissions Reduction Pathway 1:** Containment through leak repairs, strict materials handling and recycling

Containment strategies are often most effective in reducing HFC emissions in the short run. One-time emissions from disposal, if unabated, can be just as large as the annual emissions from the use of high-GWP HFCs in leaking equipment. To address leaks and disposal of HFCs, the state should implement a certification or licensing program that oversees recordkeeping, maintenance and repair in accordance with P.L. 2019, c,507.

### **Emissions Reduction Pathway 2:** Product phase out, involving outright bans by law or regulation

Phase out strategies are more likely to provide long term solutions than containment strategies. Further, early and quick implementation of phase out strategies could lead to important reductions in cumulative HFC emissions by preventing stock build up.

New Jersey's P.L. 2019, c.507, establishes an end-use phase out schedule which prohibits specific HFCs in new equipment and products entering into commerce in New Jersey. The schedule is based upon Federal SNAP Rules 20 and 21 but was modified in consultation with stakeholders. As more states adopt model rules and best practice programs, close coordination with manufacturers, users, and innovators in the field will be necessary. The transition from the use of high GWP HFCs to climate safe alternatives must be done in a way that ensures that the alternatives meet the criteria for safety and address any environmental concerns. This transition may require revisions to universal codes and standards, including building codes.

## 2050 RECOMMENDATIONS

Without action, emissions from HFCs will continue to increase, almost tripling by 2050. However, there is ample opportunity to avoid these emissions through implementing New Jersey's existing law to phasedown HFC use and implement training and licensing requirements for installation, repair, and maintenance personnel, and updating building codes to support the selection of low GWP substances in appliances and equipment.

The DEP has the authority under P.L. 2019 c. 507, to begin the phase down of HFCs and to launch a complementary Refrigeration Management Program. A Refrigeration Management Program should require owners and operators of appliances with significant quantities of refrigerant to track leak rates and make necessary repairs if leaks go above a certain level. NJ PACT efforts to develop a GHG emissions reporting rule will also require the tracking of quantities of refrigerants captured, installed and disposed of and will aid in efforts to reduced HFC emissions from these sources. This would ensure oversight of owners, operators and the repair and maintenance of these systems, putting New Jersey in the best position to halt the projected increase in emissions of these highly warming gases.

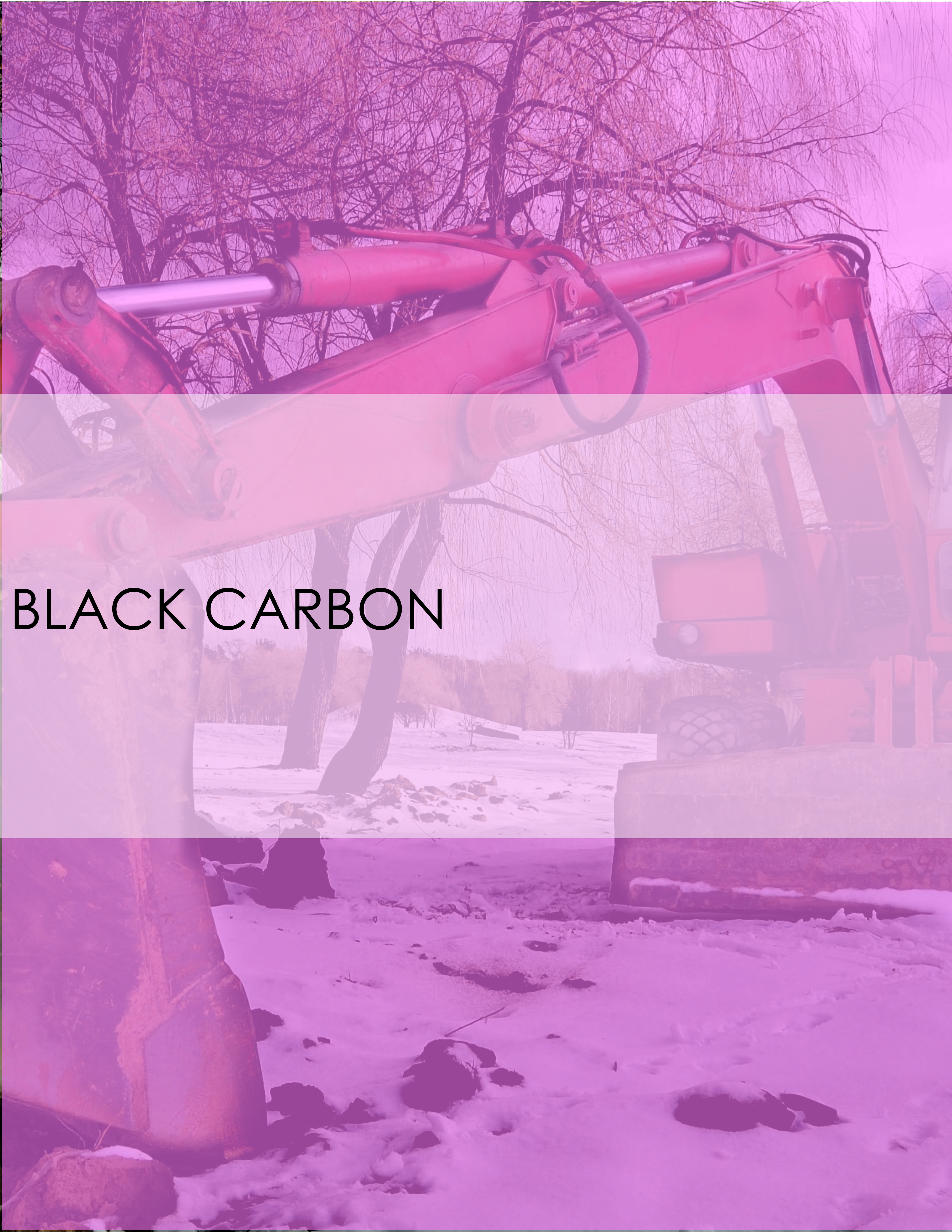
To be effective, state agencies must also work together to address challenges like safety and building codes to enable the timely adoption of low GWP products and equipment. The creation of incentives for early adopters of HFC alternatives would help to galvanize the market. Additionally, building codes and standards will need to be evaluated to determine how best to meet new requirements for the use of alternative substances with low GWP in heating/cooling, heat pump, and refrigeration appliances deployed in buildings.

***Table 6.3.5. 2050 Recommendation for HFC Emission Reduction.***

| Actions | Entity | Timeframe[19] | References |
|---|---|---|---|
| Develop a program, to phasedown the use of HFCs, including the modification of deadlines when necessary, evaluate the potential risk of substitutes, and approve substitutes for end-uses. | DEP | Near-term | Pursuant to P.L. 2019, c.507 |
| Develop a program, pertaining to the disposal, leak repair, maintenance, recycling, and technical certification requirements for those who install, repair, or maintain stationary refrigeration or air conditioning appliances. | DCA | Near-term | Pursuant to P.L. 2019, c.507 |
| Develop a Refrigerant Management Program, which require the owners and operators to track leak rates and submit a plan to make necessary repairs if leaks go above a predetermined level. | DEP | Near-term | Pursuant to P.L. 2019, c.507 |
| Develop a reporting program for manufacturers, distributors, and users, who sell, distribute or install products or equipment that contain a significant amount of HFC-containing raw material. | DEP | Near-term | Pursuant to N.J.S.A. 26:2C-41 |
| Develop an incentive program to facilitate the early adoption of HFC alternatives through an established funding source. Include an education component focused on HFC impacts, the new statutory and regulatory requirements, incentives, and benefits of replacing equipment/products. | Legislature, DEP, BPU | Near-term | For example, the California Cooling Act (SB 1013) created an incentive program to facilitate early adoption of HFC alternatives through the State Greenhouse Gas Reduction Fund. |
| Examine and update building codes and standards to meet new requirements for the use of alternative substances with low global warming potential in heating/cooling, heat pump, and refrigeration appliances deployed in buildings. | DCA | Near-term | |
| Provide additional incentives to energy efficient systems that also use low global warming potential substances. | BPU | Near-term | |
| Provide funding towards research and development of new low GWP product options. | EDA | Near-term | |

[19] Near-term: now through 2030. Mid-term: 2030-2040. Long-term: 2040-2050. Throughout: Ongoing now through 2050.

# BLACK CARBON



# OVERVIEW

Black carbon, or soot, is an aerosol component of particulate matter (PM), not a gas. It is formed in varying concentrations with other particulate matter through the incomplete combustion of fossil fuels and biomass burning (Minjares, Wagner, & Akbar, 2014). It contributes to climate warming differently than GHGs; it absorbs sunlight directly and releases heat energy into the atmosphere. Unlike $CO_2$ that remains in the atmosphere for hundreds of years, it is quickly removed by rain and by deposition in a few days or weeks (CARB, 2018). Its global warming potential[20] (GWP) is widely debated and varies greatly between publications depending mostly on the time horizons considered. This report applies a black carbon GWP of 910 times that of $CO_2$ over 100 years as reported by the California Air Resources Board (2018).

Sources of black carbon also emit organic carbon (OC) and other cooling aerosols. As stated in California's Short-Lived Climate Pollutant Strategy, "[s]cientists have known for some time that sources that emit black carbon also emit other short-lived particles that may either cool or warm the atmosphere. Lighter colored particles, for example, tend to reflect rather than absorb solar radiation and so have a cooling rather than warming impact" (CARB, 2017). New Jersey's overall strategy for reducing black carbon focuses on sources that emit higher black carbon to organic carbon ratios such as diesel exhaust.

Black carbon is not a significant contributor to New Jersey's climate pollutant inventory and black carbon from stationary sources even less so. However, black carbon compromises local air quality and black carbon resulting from diesel combustion is a known carcinogen. Reducing black carbon therefore has benefits beyond those associated with climate protection.

[20] The Global Warming Potential (GWP) was developed to allow comparisons of the global warming impacts of different gases. It is a measure of how much energy the emissions of 1 ton of a gas will absorb over a given period of time, relative to the emissions of 1 ton of carbon dioxide ($CO_2$).

## WHERE WE STAND

The New Jersey GHG inventory historically has not quantified black carbon emissions, since they are not GHGs. However, based on the 2014 National Emissions Inventory (NEI) and other analyses, the U.S. Climate Alliance estimated New Jersey's black carbon emissions to have decreased in recent years, dropping from 3.3 MMT $CO_2e$ in 2014 to 2.7 MMT $CO_2e$ in 2018 (Table 6.4.1). These reductions are attributed in large part to New Jersey's stringent standards for fine particulate matter emissions from stationary sources as well as state and federal regulations targeting on-road vehicles. Resulting in New Jersey attaining the National Ambient Air Quality Standards for PM2.5.

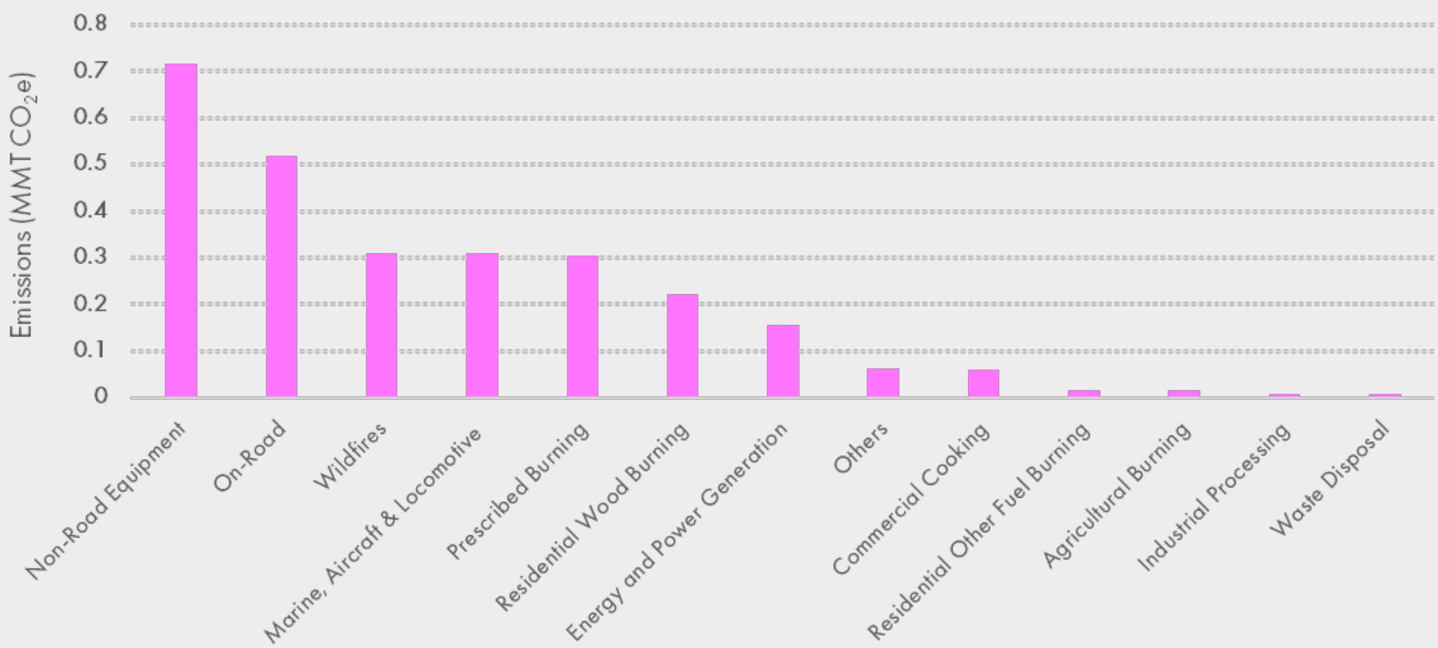
*Table 6.4.1. Annual Black Carbon Emissions in New Jersey 2014-2018 (MMT $CO_2e$)*

| 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|
| 3.3 | 3.2 | 3.0 | 2.8 | 2.7 |

Further, the USCA identified individual contributions by source type (Figures 6.4.1). The majority of these emissions (1.7 MMT $CO_2e$, approximately 63%) were from fossil fuel sources, such as on-road and off-road vehicles, industrial processing, waste disposal and energy and power generation (USCA, 2019). Biomass burning accounted for a smaller portion (1.0 MMT $CO_2e$, approximately 37%). This category includes releases from wood burning, wildfires, agricultural burning, prescribed burning and commercial cooking (USCA, 2019).[21]

***Figure 6.4.1. Black Carbon by Source (Total 2.7 MMT CO2e), 2018, New Jersey.***

*Non-road equipment and on-road transportation were the two greatest sources of black carbon.*




*Source: United States Climate Alliance Black Carbon Emissions for 2014 and 2030 (MMT $CO_2e$, $GWP_{100\text{-}yr}$ = 910) (CARB, 2018).*

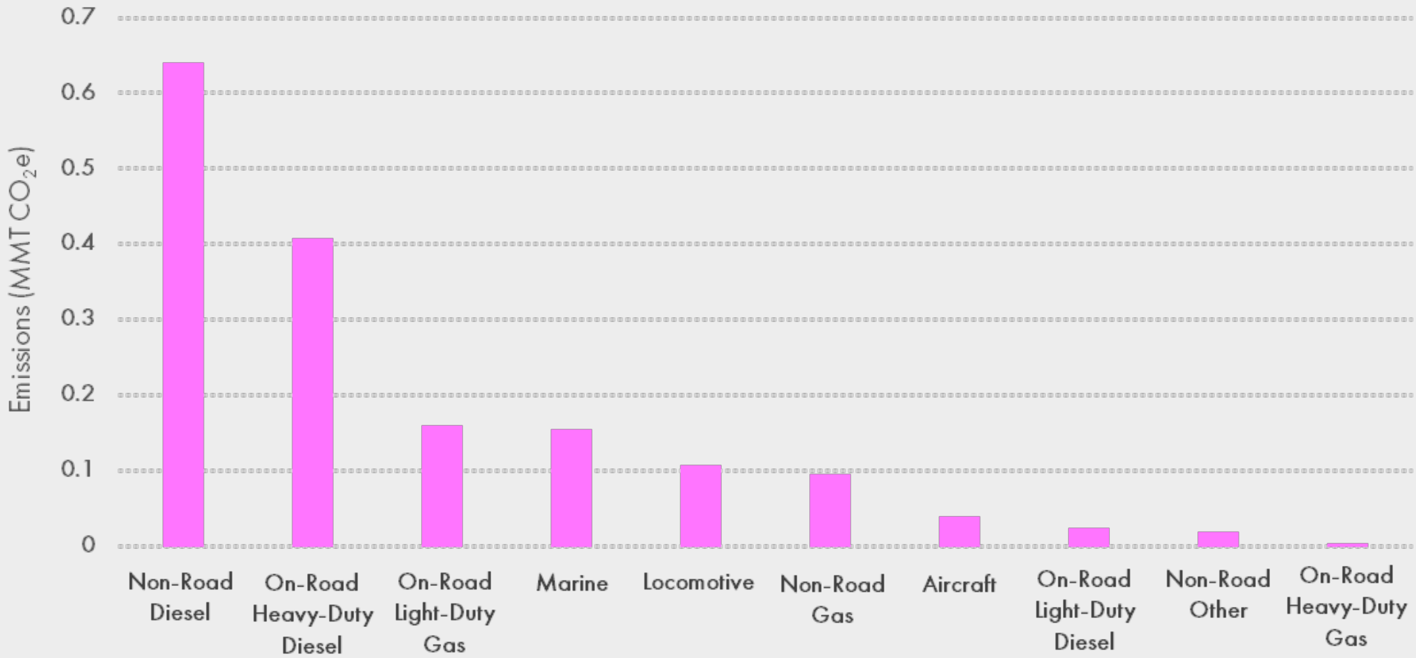
[21] USCA did not develop projected emissions estimates for wildfires and prescribed burns. In the analysis presented here, 2014 emissions estimates for wildfires and prescribed burns taken from the 2014 NEI were assumed to remain constant throughout the study period. Future climate change may necessitate reconsideration of this assumption.

The analysis performed by the U.S. Climate Alliance discussed above is built on the core data of the USEPA's 2014 NEI. The NEI, released every three years, provides detailed estimates of air emissions of black carbon and other hazardous air pollutants from sources in all states during a given year. In April 2020, USEPA released data for the 2017 NEI, shedding new light on black carbon emission in the state (Figure 6.4.2). Consistent with past estimates, non-road diesel equipment made up almost 40% of the estimated fossil fuel black carbon emissions at 0.6 MMT $CO_2e$. The remaining two large contributors of fossil fuel black carbon emissions, on-road heavy-duty diesel and on-road light-duty gas vehicles also have a combined total 0.6 MMT $CO_2e$. Non-road diesel equipment has a slower turnover rate, therefore incentivizing engine replacement in these vehicles can accelerate future black carbon reductions.

***In 2018, Black Carbon was estimated to release 2.7 million metric tons of $CO_2e$. This represents 17% of New Jersey's net SLCPs emissions.***

***Figure 6.4.2. NEI 2017 Black Carbon Inventory for Mobile Sources in New Jersey.***

*In the NEI, non-road equipment is included in the mobile sources category, but these devices are not principally used for transportation.*

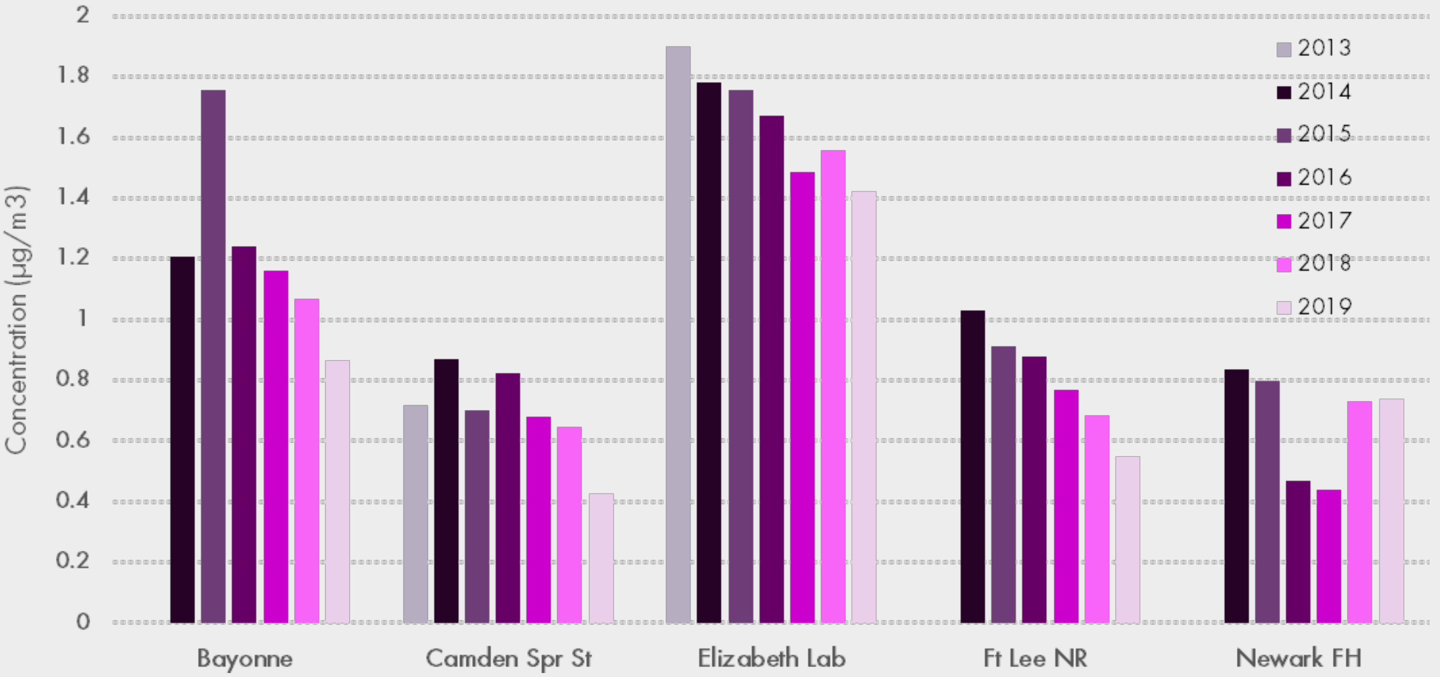



*Source: U.S Environmental Protection Agency, NEI 2017*

In addition to these national assessments, New Jersey also has several sites that directly measure black carbon via aethalometers or through speciation of $PM_{2.5}$ (NJDEP, 2018). Specifically, five sites in DEP's air monitoring network collect samples of $PM_{2.5}$ that are analyzed to determine the chemical makeup of the particles (Figure 6.4.3). These are part of USEPA's Chemical Speciation Network. This data is consistent with the CARB study, illustrating a downward trend of $PM_{2.5}$ and black carbon, and can be used to focus future diesel black carbon emission reduction strategies in densely populated areas subject to high concentrations of black carbon.

*Figure 6.4.3. Black Carbon Annual Average Concentrations by Site 2013-2019.*

*New Jersey also has several sites that directly measure black carbon via aethalometers or through speciation of PM2.5. Average results at the Elizabeth lab were higher than averages at the other sites.*




*Source: DEP Division of Air Quality*

The IPCC cautions about including black carbon emissions in inventories as their warming potential is highly variable based on the source of the emissions, the location of where the emissions were generated and local transport phenomena that ultimately determines its effect on climate. As research continues, the DEP anticipates reporting black carbon estimates in future inventories but will track progress in reducing these emissions outside of the emission reduction goals for the Global Warming Response Act.

## Existing Emissions Reduction Policies

New Jersey has realized great success in reducing particulate emissions from stationary sources by establishing strict emission standards for fine particulate matter, of which black carbon is a subset. In 2005, New Jersey adopted a fine particulate matter standard, 12 ug/m$^3$, which was 20% lower than the federal National Ambient Air Quality Standard (NAAQS) at that time. By establishing permanent enforceable reductions in fine particulate matter and its precursors, nitrogen oxides (NOx) and sulfur dioxide ($SO_2$), ambient air concentrations of particulate matter dropped from 19.6 to 11.1 ug/m$^3$ between 1999 and 2018. State efforts include the $NO_x$ Budget Program, consent decrees with power plants, strict emission limits on boilers, and lowering the sulfur content in fuels (NJDEP, 2018).

New Jersey also regulates mobile sources of black carbon through strict idling and tampering regulations at N.J.A.C. 7:27-14 and N.J.A.C. 7:27-15, a mandatory retrofit program for diesel engines at N.J.A.C. 7:27-32 and emission testing for cars and trucks at N.J.A.C. 7:27-14 and N.J.A.C. 7:27-15.

### *Clean Car Program*

In January 2004, New Jersey enacted the Clean Car Program under N.J.S.A. 26:2C-8.15 et seq., and as a result DEP promulgated rules at N.J.A.C. 7:27-29 implementing the terms of California's Low Emission Vehicle (LEV) program. These requirements reduce criteria pollutant emissions and GHGs and are applicable to 2009 and newer light-duty motor vehicles less than or equal to 8,500 lbs. gross vehicle weight rating that are sold or registered in New Jersey.

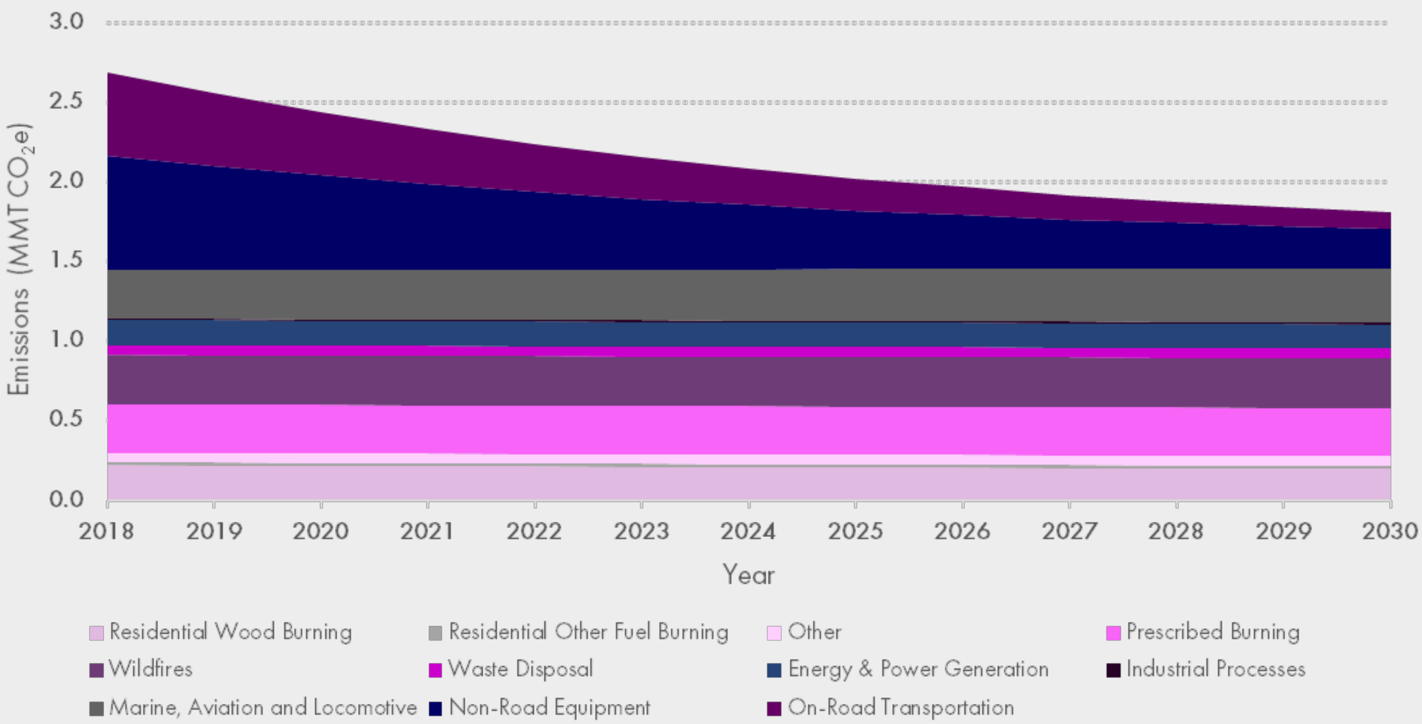
### *Federal Corporate Average Fuel Economy (CAFE) Standards*

Refer to CAFE standard discussion in the Transportation Chapter of this report.

## Business-as-Usual Projection

Assuming the continuation of existing federal diesel standards without further policy development, the state would experience a 0.88 MMT $CO_2e$ decrease in black carbon by 2030 (Figure 6.4.4). This projection is derived from the modeling by the United States Climate Alliance based on the 2014 NEI using the assumptions footnoted earlier.

***Figure 6.4.4. Projected Black Carbon Emissions in New Jersey for 2020-2030 Under Existing Policies.***
*Black carbon emissions from non-road equipment and on-road transportation are projected to decrease through 2030 due to existing federal diesel standards.*




*Source: United States Climate Alliance Black Carbon Emissions for 2014 and 2030 ($GWP_{100\text{-}yr}$ = 910) (CARB, 2018). Wildfire and Prescribed Burn emissions assumed constant at NEI 2014 levels.*

Source: Port Authority of NY and NJ

## THE PATH FORWARD

Black carbon is not a large contributor to New Jersey's climate pollutant inventory, and as illustrated in the Business-as-Usual projection above, the state is already on a path to realize significant reductions. However, there is a substantial public health benefit to reducing emissions and efforts should be made to ensure reductions occur.

Three pathways have been identified for reducing black carbon.

- Pathway 1, Continued commitment to existing control technologies, evaluates how EPA Tier 4 standards will impact emissions;
- Pathway 2, Pursue EMP transportation decarbonization strategies, examines how electrification can impact emissions; and
- Pathway 3, Pursue black carbon reductions in non-road diesel equipment, considers new regulations under NJ PACT.

Pathway 1 will realize continued black carbon reductions as diesel engines transition to cleaner engines required under existing EPA Tier 4 emission standards (Figure 6.4.5). The emission reductions are the same as those depicted in the business-as-usual projection. Pathway 2 will realize a negligible decrease in black carbon but has significant $CO_2$ implications as discussed in the Transportation Chapter of this report (Figure 6.4.5). DEP has not yet quantified the potential emissions reductions from Pathway 3, which will pursue black carbon emission reductions in non-road diesel equipment through new NJ PACT $CO_2$ regulations.

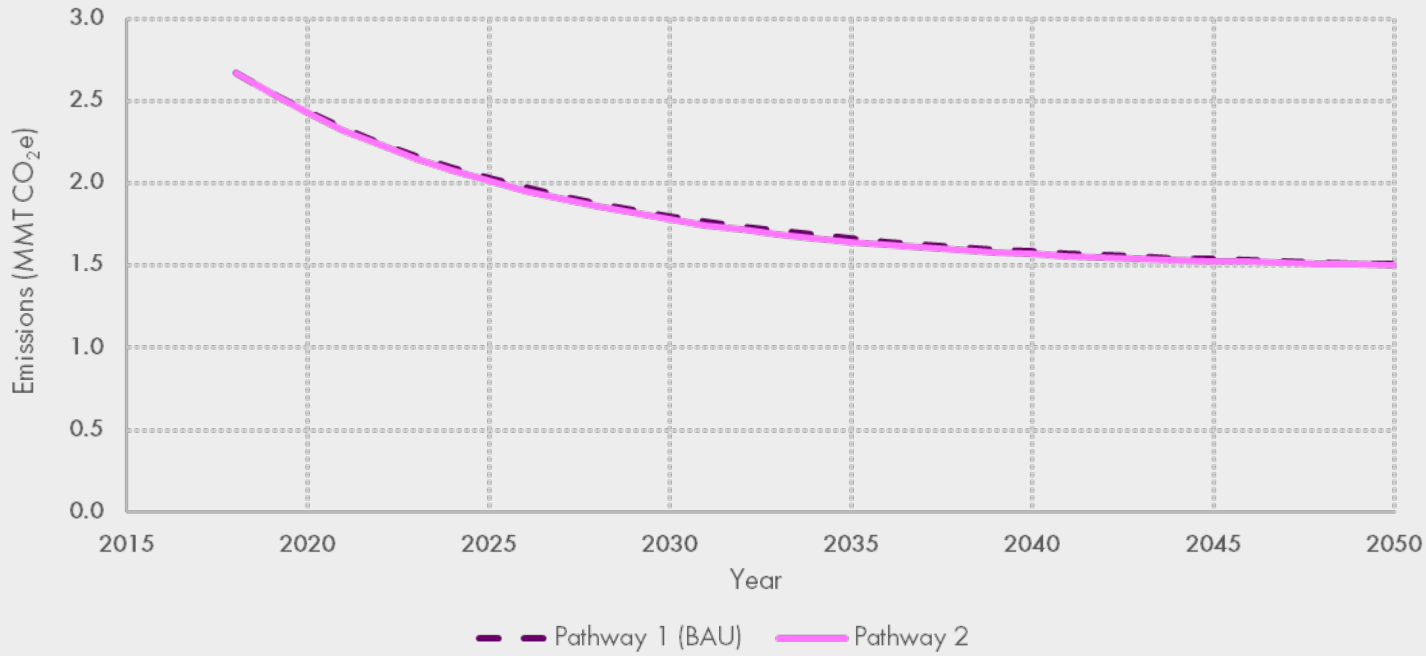
### EMISSIONS ACTIVITES

- On-road and non-road equipment

### EMISSIONS REDUCTION PATHWAYS

1. Continued commitment to existing control technologies
2. Pursue EMP transportation decarbonization strategies
3. Pursue black carbon reductions in non-road diesel equipment

***Figure 6.4.5. Total Black Carbon Emissions from All Sources with and without 2019 EMP Electrification of On-Road Vehicles.***
*Adoption of electric vehicles will not lead to further black carbon reductions but will provide $CO_2$ reductions and other co-benefits.*

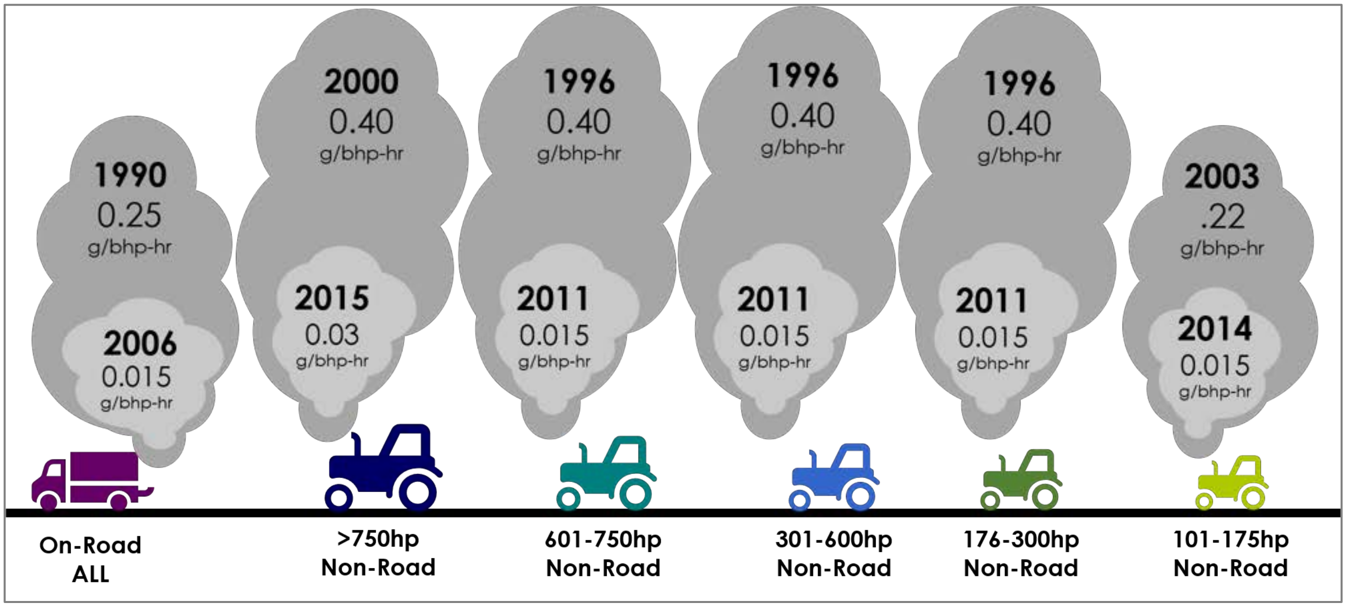



## **Emissions Reduction Pathway 1:** Continued commitment to existing control technologies

Several $PM_{2.5}$ control strategies have proven successful in reducing black carbon emissions from mobile sources. These include Federal and California emission standards for new engines, with emission reductions occurring as the vehicle fleet turns over. All on-road diesel vehicles are required to use ultra-low sulfur diesel and all on-road diesel engines built since 2007 are equipped with diesel particulate filters. The combination of these two technologies reduces black carbon. Also, New Jersey has implemented numerous additional measures that reduce emissions from existing in-use engines, such as the idling restrictions, an inspection and maintenance program and diesel retrofit efforts.

The California Air Resources Board (CARB) projects that a 47% reduction in black carbon emissions from on-road and non-road equipment can be realized through 2030 with a commitment to existing control measures (USCA, 2019). For New Jersey, applying the CARB projected rates through 2050 achieves a 1.2 MMT $CO_2$e reduction (Figure 6.4.6). This will occur largely through replacement of medium- and heavy-duty vehicles with cleaner Tier 4 compliant diesel engines. EPA's adoption of increasingly stringent emission standards for diesel engines introduced cleaner engines into the market resulting in significant reductions in particulate matter including $PM_{2.5}$. Based on an engine's horsepower rating, cleaner emitting engines were phased in over time. Currently, tier 4 diesel engine standards represent the cleanest emissions requirement for diesel engines (Figure 6.4.6). The implementation of EPA tier emission standards has achieved a 99% reduction of PM and NOx compared to 1996 levels.

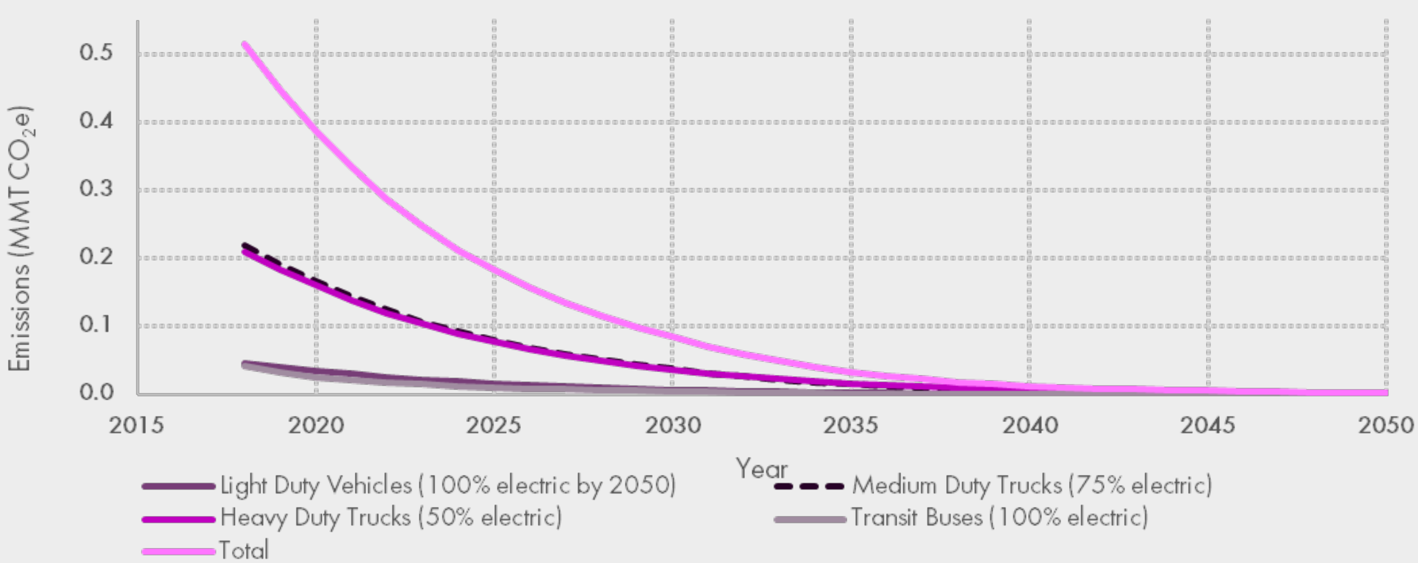
*Figure 6.4.6. Diesel PM Emissions Standards 1990-2014.*
*Diesel emissions standards call for reductions in emissions over time. Different schedules for achieving reductions are applied based on engine horsepower rating. This graphic illustrates emission reductions per engine horsepower from baseline year to the year Tier 4 final emission standards were mandated.*




## **Emissions Reduction Pathway 2:** Pursue EMP transportation decarbonization strategies

The 2019 EMP proposed long term strategies to decarbonize the New Jersey transportation sector, replacing internal combustion engines with electric vehicles. This will result in simultaneous $CO_2$ and black carbon emission reductions. 2019 EMP modeling shows that New Jersey will gradually reduce demand for diesel and gasoline over the next 30 years under the preferred, least cost scenario. Commensurate black carbon emission reductions will be realized as demand for these fuels decrease. Black carbon from on-road vehicles is largely attributed to medium- and heavy-duty trucks, accounting for approximately 80% in 2018 (Figure 6.4.7). Current policies evaluated under Pathway 1 will have a dramatic impact on reducing black carbon through 2050. Implementing the 2019 EMP strategy to electrify 75% of medium-duty trucks and 50% of heavy-duty trucks by 2050 will result in very limited further reductions in black carbon (Figure 6.4.6). For example, the data illustrates that even with a 100% electrification of buses, negligible black carbon reductions will be realized (Figure 6.4.7). This stands in contrast to the substantial decreases in GHG emissions that will result from electrifying medium- and heavy-duty trucks, as discussed in the Transportation Chapter of this report.

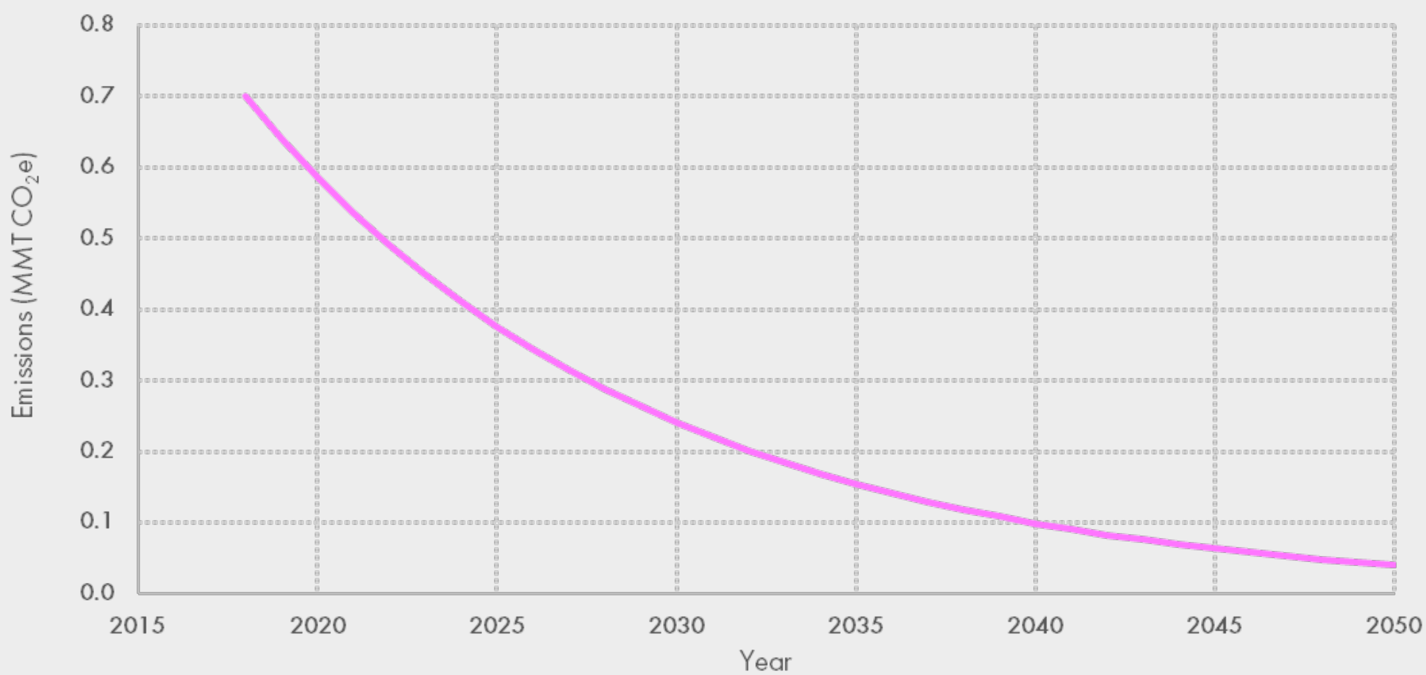
***Figure 6.4.7. On-Road Black Carbon Projections by Vehicle Type based on 2019 EMP Least Co.st Scenario Electrification and Existing Emissions Reductions Policies.***
*Current policies will continue to produce black carbon emission reductions through 2050. Electrification will further those reductions.*



## **Emissions Reduction Pathway 3:** Pursue black carbon reductions in non-road diesel equipment

Diesel engines employed in non-road equipment, like bulldozers and cranes, have historically not been held to the same emissions standards as similar engines used in on-road vehicles such as trucks (Figure 6.4.7). It was not until 2010 that emission standards began to align; however, emission improvements from the non-road equipment are slower to realize due to long equipment life and slow fleet turnover. Currently there is no regulatory driver requiring the replacement of older diesel engines with cleaner Tier 4 engine technology in non-road sources. DEP through its NJ PACT rules is considering regulations to mandate conversion of captive non-road[22] diesel equipment. Another measure that would help move the transition to lower emissions from this sector is to establish standards within state funded construction projects (e.g. roads, building) to use clean construction equipment or fleet averaging requirements on construction equipment owners (CARB, 2020). These initiatives can accelerate the black carbon emission reductions depicted in Figure 6.4.8.

***Figure 6.4.8. Black Carbon Emissions from Non-Road Equipment under Business-as-Usual Policies.***
*Non-road black carbon emissions are projected to drop below 0.05 MMT $CO_2e$ by 2050, reductions are the result of anticipated fleet turnover.*




Additionally, cargo volume at the Port Authority of NY/NJ is predicted to double over the next 30 years (Morley, 2019a; Morley, 2019b). In as much as ports contain both non-road and on-road emission sources, they will experience emission reductions from these policies. As recommended in Strategy 1 of the 2019 EMP, state agencies should support electrification of diesel-powered transportation and equipment at the ports and airports. Aggressive electrification of cargo handling equipment and reduction of idling of ships at berth will provide local air quality benefits in low and moderate income, overburdened communities. DEP through its NJ PACT rules is considering these actions.

## 2050 RECOMMENDATIONS

Internal combustion engines, the largest source of black carbon emissions, are ubiquitous in New Jersey. However, efforts to mitigate the emissions impact of these sources have been largely successful, and New Jersey's continued commitment to existing regulatory strategies is key. Policies and regulations directed at captive non-road sources can achieve greater black carbon reductions, simultaneously addressing health impacts in overburdened communities. Regulating such equipment as stationary sources can reduce the adverse impacts to local air quality and climate. This

[22] Captive non-road sources include construction equipment and other on-site vehicles that support operations which are onsite for an extended period of time.

could be done under the existing air permit rule, simplifying implementation. Additionally, construction equipment operates in concentrated geographic areas for extended periods of time thus presenting increased exposure to diesel emission by nearby residents. A gradual phase-in to cleaner equipment and exploration of low or zero carbon alternatives is warranted.

Other measures could be taken (Table 6.4.2), including requiring medium-duty vehicles to have a periodic emissions inspection. Ensuring the in-use fleet is well maintained and original emissions controls have not been modified or tampered with will result in black carbon reductions and health benefits. New Jersey should also continue to advocate to stop federal rollbacks of emissions standards and be vigilant against future challenges. Finally, full adoption of electric vehicles will eliminate black carbon by the transportation sector.

*Table 6.4.2. Recommendations for Reducing Black Carbon.*

| Actions | Entity | Timeframe[23] | References |
|---|---|---|---|
| Oppose federal rollbacks of emission standards. | DEP | Throughout | |
| Transportation electrification recommendations as contained in the Transportation Chapter of this report should be pursued. | | | |
| Explore regulatory development that would require non-road equipment located at a site for an extended period of time to be regulated as a stationary source. | DEP | Near-term | NJ PACT |
| Explore regulations for ships, cargo handling equipment and drayage trucks. | DEP | Near-term | NJ PACT |
| Establish clean construction equipment standards, such as fleet emissions averaging, within state funded construction projects (roads, building, etc.). | All Government Agencies | Near-term | |
| Require medium-duty vehicles to have a periodic emissions inspection program. | MVC, DEP | Near-term | |
| Provide incentives to accelerate transition and adoption of cleaner equipment, these incentives should target equipment located in overburdened communities, ports and airports. | DEP, BPU, EDA | Near-term | |
| State agencies should work with stakeholders to develop a road map detailing early opportunities to decarbonize diesel engine equipment. | DEP, BPU, EDA | Near-term | |

[23] Near-term: now through 2030. Mid-term: 2030-2040. Long-term: 2040-2050. Throughout: Ongoing now through 2050.

# WORKS CITED

ASHRAE. (2015). ASHRAE Equipment Life Expectancy chart. Retrieved from 2015 ASHRAE Handbook: https://www.naturalhandyman.com/iip/infhvac/ASHRAE_Chart_HVAC_Life_Expectancy.pdf

Ayers, A. (2020, April 30). Personal Communications. Heating, Air-conditioning, & Refrigeration Distributors International.

CARB. (2017). Short-Lived Climate Pollutant Reduction Strategy. California Environmental Protectin Agency. Retrieved from https://ww3.arb.ca.gov/cc/shortlived/meetings/03142017/final_slcp_report.pdf

CARB. (2018). Current and Projected Inventory and Methodology of HFC-Gases, Black Carbon, and Methane in California and Other U.S. Climate Alliance States.

CARB. (2020). Construction & Earthmoving Equipment. Retrieved from https://ww2.arb.ca.gov/our-work/topics/construction-earthmoving-equipment

Clean Air Council. (2019). Global Warming Pollutants in New Jersey: Beyond Carbon Dioxide. Public Hearing, New Jersey Clean Air Council. Retrieved February 7, 2020, from https://www.state.nj.us/dep/cleanair/PPP/2019/2019HR.pdf

EDF. (2020). Collaboration with PSE&G: Data helps prioritize gas line replacement. Retrieved from Environmental Defense Fund: https://www.edf.org/climate/methanemaps/pseg-collaboration

Elizabethtown Gas. (2019, June 13). Elizabethtown Gas to Implement $300M, Five-Year Infrastructure Investment Program. Retrieved from https://www.elizabethtowngas.com/about-us/press-room/2019/elizabethtown-gas-to-implement-$300m,-five-year-in

Hanna, T. (2020, April 9). NJNG Response to NJDEP on Infrastructure Modernization Efforts and Methane Reduction Impacts.

ICF. (2019, March 18). Non-Pipeline Solutions. Retrieved from https://www.icf.com/insights/energy/non-pipeline-solutions

Igusky, K. (2015, March 3). Reducing HFCs in the US Would Benefit Consumers and the Climate. Retrieved February 7, 2020, from World Resources Institute: https://www.wri.org/blog/2015/03/reducing-hfcs-us-would-benefit-consumers-and-climate

IPCC. (2007). Climate Change 2014: Synthesis Report. Contribution of Working Groups I Contribution to the 4th Assessment Report of the IPCC. Retrieved from https://www.ipcc.ch/site/assets/uploads/2018/05/ar4_wg1_full_report-1.pdf

IPCC. (2014). Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Retrieved from https://www.ipcc.ch/site/assets/uploads/2018/02/SYR_AR5_FINAL_full.pdf

USBEA. (2020). State Gross Domestic Product 1997 to 2017. Retrieved from https://www.bea.gov/

Matthau, D. (2016, December 19). PSE&G Teamed up with Google to find Methane Gas Leaks in NJ. Retrieved from https://nj1015.com/pseg-teamed-up-with-google-to-find-methane-gas-leaks-in-nj/

Minjares, R., Wagner, D. V., & Akbar, S. (n.d.). Reducing Black Carbon Emissions from Diesel Vehicles: Impacts, Control Strategies, and Cost-Benefit Analysis. (W. B. Group, Ed.) Washington DC. Retrieved from http://documents.worldbank.org/curated/en/329901468151500078/Reducing-black-carbon-emissions-from-diesel-vehicles-impacts-control-strategies-and-cost-benefit-analysis

Morley, H. (2019a, November 14). NY-NJ enters big-ship era in stride with energized leadership. Journal of Commerce. Retrieved from https://www.joc.com/port-news/port-productivity/ny-nj-faces-big-ship-era-new-and-active-leadership_20191112.html

Morley, H. (2019b, July 9). NY-NJ port preps for cargo volume doubling by 2050. Retrieved from https://www.joc.com/port-news/us-ports/port-new-york-and-new-jersey/ny-nj-port-preps-cargo-volume-doubling-2050_20190709.html

National Association for Clean Air Agencies. (2019, November 22). NACAA Comments on Proposed Oil & Gas NSPS Changes. Retrieved from National Association for Clean Air Agencies: http://4cleanair.org/news/details/nacaa-comments-proposed-oil-gas-nsps-changes-0

NJBPU. (2020). Gas Utilities Territory Map. Retrieved from New Jersey's Clean Energy Program: https://www.njcleanenergy.com/main/public-reports-and-library/links/gas-utilities-territory-map

NJDEP. (2018). 2018 New Jersey Air Quality Report. Retrieved from https://nj.gov/dep/airmon/pdf/2018%20NJ%20AQ%20Report-bookmarked.pdf

NJNG. (2019, February 27). New Jersey Natural Gas - Infrastructure Improement Program. Retrieved from https://www.njng.com/regulatory/pdf/NJNG%20IIP%20Petition.pdf

PHMSA. (2020a). Find Who's Operating Pipelines in Your Area. Retrieved from U.S. Department of Transportation:: https://www.npms.phmsa.dot.gov/FindWhosOperating.aspx

PHMSA. (2020b). Gas Distribution, Gas Gathering, Gas Transmission, Hazardous Liquids, Liquefied Natural Gas (LNG), and Underground Natural Gas Storage (UNGS) Annual Report Data. Retrieved from U.S. Department of Transportation: https://www.phmsa.dot.gov/data-and-statistics/pipeline/gas-distribution-gas-gathering-gas-transmission-hazardous-liquids

PHMSA. (2020c). Gas Distribution Cast/Wrought Iron Pipelines. Retrieved from U.S. Department of Transportation: https://portal.phmsa.dot.gov/analytics/saw.dll?PortalPages&PortalPath=%2Fshared%2FPDM%20Public%20Website%2FCI%20Miles%2FGD_Cast_Iron

PHMSA. (2020d). Pipeline Glossary. Retrieved from https://primis.phmsa.dot.gov/comm/glossary/#DistributionLine

Picarro. (2019). Pipe Replacement Prioritization. Retrieved from https://naturalgas.picarro.com/support/library/documents/pipe_replacement_prioritization_whitepaper

PSE&G. (2019, October 23). PSE&G Named PMINJ's 2019 Project of the Year for GSMP . Retrieved from https://nj.pseg.com/newsroom/newsrelease110

S. 2754: American Innovation and Manufacturing Act of 2019. (2019, October 30). Retrieved from Civic Impulse, LLC: https://www.govtrack.us/congress/bills/116/s2754/text

Section 608 of the Clean Air Act: Stationary Refrigeration and Air Conditioning. (2020, February 7). Retrieved from United States Environmental Protection Agency: https://www.epa.gov/sites/production/files/2018-09/documents/section_608_of_the_clean_air_act.pdf

Significant New Alternatives Policy (SNAP). (2020, February 7). Retrieved from United State Environmental Protection Agency: https://www.epa.gov/snap/snap-regulations#notices

South Jersey Gas. (2019, April 13). Approval for Accelerated Infrastructure Improvement Program. Retrieved from https://southjerseygas.com/SJG/media/pdf/SJG-AIRP-II-2019-Annual-Filing.pdf

The Kigali Amendment: The amendment to the Montreal Protocol agreed by the Twenty-Eighth Meeting of the Parties. (2016, October 15). Retrieved February 7, 2020, from United Nations Environment Programme:

https://ozone.unep.org/treaties/montreal-protocol/amendments/kigali-amendment-2016-amendment-montreal-protocol-agreed

U.S. Department of State. (2020). The Montreal Protocol on Substances That Deplete the Ozone Layer . Retrieved from U.S. Department of State: https://www.state.gov/key-topics-office-of-environmental-quality-and-transboundary-issues/the-montreal-protocol-on-substances-that-deplete-the-ozone-layer/

USDOE. (2017). Natural Gas Infrastructure Modernization Programs at Local Distribution Companies: Key Issues and Considerations. Retrieved from https://www.energy.gov/sites/prod/files/2017/01/f34/Natural%20Gas%20Infrastructure%20Modernization%20Programs%20at%20Local%20Distribution%20Companies--Key%20Issues%20and%20Considerations.pdf

USEIA. (2011). Emissions of Greenhouse Gases in the U.S. doi:DOE/EIA-0573(2009)

USEIA. Energy Information Administration. (2019, August 15). New Jersey State Profile and Energy Estimates. Retrieved from U.S. Energy Information Administration: https://www.eia.gov/state/analysis.php?sid=NJ

USEPA. (2018, September 26). Ozone Protection under Title VI of the Clean Air Act. Retrieved from The United States Government: https://www.epa.gov/ozone-layer-protection/ozone-protection-under-title-vi-clean-air-act

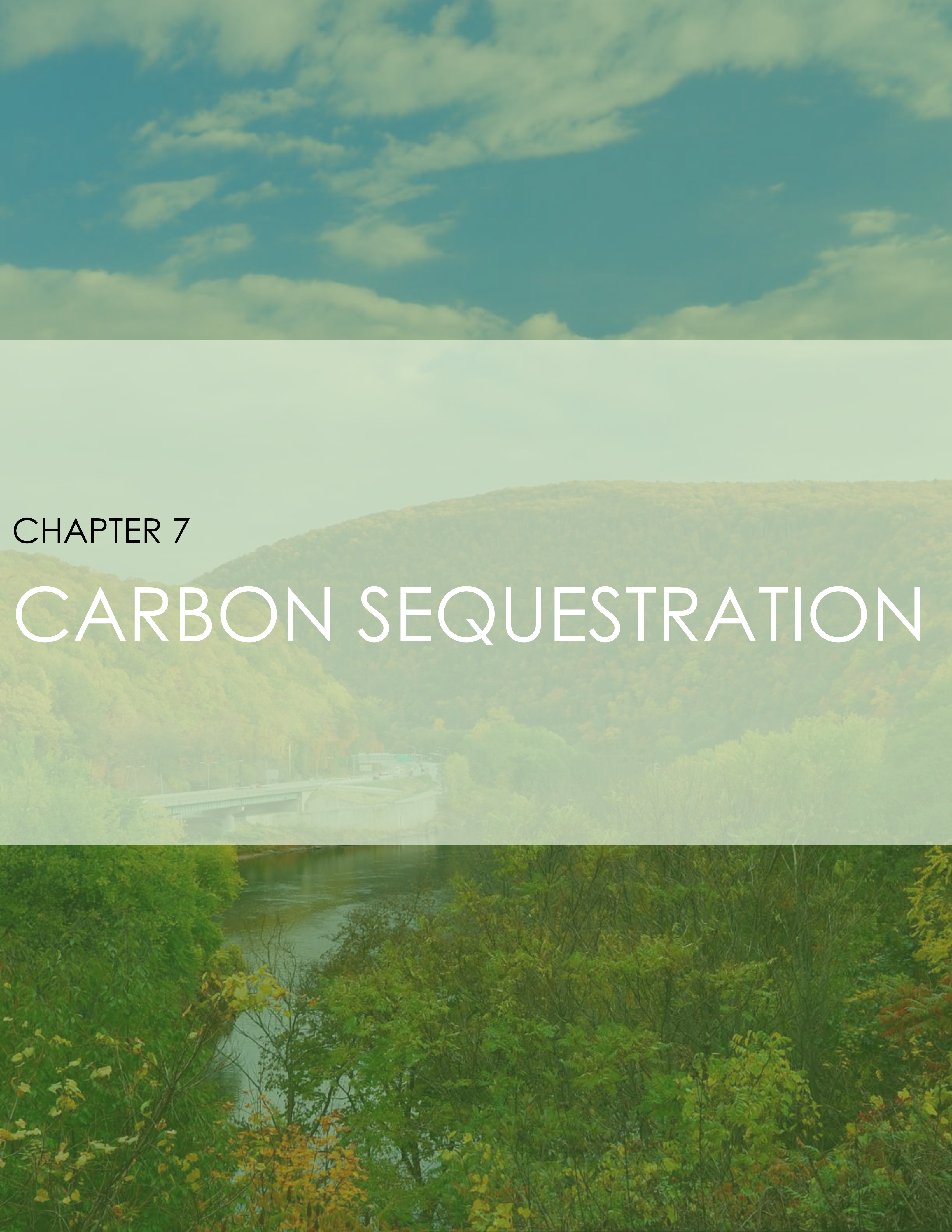
USEPA. (2014). Improvements Needed in EPA Efforts to address Methane Emissions from Natural Gas Distribution Pipelines. EPA.

United States Climate Alliance. (2019, July). US Climate Alliance SLCP Emissions Tool.

USEPA (2018). Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2016. doi:U.S. EPA Report EPA 430-R-18-003

USEPA. (2019). User's Guide for Estimating Carbon Dioxide and Methane Emsisions from Natural Gas and Oil Systems using the State Inventory Tool. EPA. Retrieved from https://www.epa.gov/sites/production/files/2017-

Urena, J. (2020, March 3). Environmental Engineer 3, Bureau of Pipeline Safety, New Jersey Board of Public Utilities. (H. Barr, Interviewer)



CHAPTER 7

# CARBON SEQUESTRATION

# CARBON SEQUESTRATION SECTOR SNAPSHOT

## 2018 EMISSION DATA

- Natural lands sequestered **8.1 MMT $CO_2$e** of New Jersey's greenhouse gas emissions in 2018.

## EMISSIONS ACTIVITIES

- Conversion of natural lands for development and wasteful land management practices can destroy or disrupt natural carbon sinks and reduce the ability of natural lands to store carbon dioxide ($CO_2$) and methane. In addition, as the climate changes, flood inundation, wildfires, and increased pests and diseases present an increased threat of loss to forests, marshes and agricultural lands.

## SEQUESTRATION PATHWAYS

1. Reforestation
2. Avoided Conversion of Natural Lands
3. Salt Marsh and Sea Grass Restoration and Enhancement
4. Conservation Management of Agricultural Lands
5. Proactive Forest Management

## RECOMMENDATIONS

1. Develop a statewide carbon sequestration plan that establishes a 2030 and 2050 target for both blue carbon and terrestrial carbon sequestration.
2. Adopt minimum forest cover objectives for land development, including performance of forest stand delineations and implementation of forest conservation plans.
3. Develop a conservation program for privately held woodlands and forests.
4. Expand the Urban and Community Forestry program through mandatory accreditation for all municipalities and boards of education.
5. Provide additional incentives and technical tools to assist communities in forestry management and climate friendly agricultural practices.
6. Monitor sequestration results of current pilot blue carbon projects and utilize data to inform future project selection criteria.

## AGENCY STAKEHOLDERS

- New Jersey Department of Environmental Protection
- New Jersey Department of Agriculture
- State Agricultural Development Committee
- United States Department of Agriculture Natural Resources Conservation Service
- Rutgers Cooperative Extension

## OVERVIEW

New Jersey's forests, wetlands and preserved open spaces are important in satisfying the Global Warming Response Act 80x50 goal. These lands act as natural sinks[1] that work to remove greenhouse gases (GHGs) from the atmosphere (IPCC, 2014). If New Jersey implements the pathways proposed in this report, GHG emissions will be reduced to 29.8 MMT $CO_2$e by 2050, still falling short of the 80x50 goal of 24.1 MMT $CO_2$e. Natural sinks will be needed to offset gross emissions.

Fortunately, New Jersey's natural lands currently sequester over 8 MMT $CO_2$e, therefore protecting and maintaining these carbon sinks are vital to the state's long term GHG reduction strategy. New Jersey has large areas of permanently preserved lands that could be restored and managed to better protect existing carbon stocks[2] from wildfire, insects, disease, inundation, and erosion (NJCAA, 2014; Lathrop & Bognar, 2014; Crocker, et al., 2013). Initial efforts should focus on developing a statewide carbon sequestration plan that establishes a target for both blue carbon[3] and terrestrial carbon sequestration.[4]

[1] The Intergovernmental Panel on Climate Change (IPCC) defines a sink as any process, activity or mechanism that removes a GHG, an aerosol or a precursor of a GHG or aerosol from the atmosphere (IPCC, 2014).
[2] Carbon stock is the amount of carbon that has been sequestered from the atmosphere and is now stored within the ecosystem, mainly within living biomass and soil.
[3] Blue Carbon refers to organic carbon that is captured and stored by the oceans and coastal ecosystems, particularly by vegetated coastal ecosystems: seagrass meadows, tidal marshes, and mangrove forests (Macreadie, 2017).
[4] Terrestrial carbon sequestration is a process that involves the capture of carbon dioxide from the air by plants through photosynthesis, and storage of that carbon in woody biomass and in plant-derived soil organic carbon (USDOE, 2010).

## WHERE WE STAND

New Jersey's GHG Inventory report for 2018 estimates that the state's land sector (forests, woodlands, agricultural lands and wetlands) sequestered the equivalent of 8.1 MMT $CO_2e$. This estimate is based on the quantity of carbon stored in both biomass and soil for forests, grasslands, agricultural lands, and wetlands. Sequestration of atmospheric carbon offset some of the state's GHG emissions described in the previous chapters, achieving net emissions of 97.0 MMT $CO_2e$ in 2018.

Carbon sequestration estimates are developed using state-specific data when available or by applying working assumptions (Table 7.1). The New Jersey Department of Environmental Protection (DEP) supported a study by Rutgers University (Lathrop R. , 2011) to more accurately quantify the capacity of New Jersey forests to sequester carbon. Updated biomass carbon density factors derived from that study are used to estimate forest sequestration in the New Jersey GHG Inventory. New Jersey needs to continue to generate data on the sequestration capabilities of New Jersey's state lands through improved monitoring and measurement.

*Table 7.1. New Jersey Specific Biomass and Soil Carbon Density Factors.*

| Land Use/Natural Resources | Biomass Carbon Density (Metric Tons/Acre) | Soil Carbon Density (Metric Tons/Acre) |
|---|---|---|
| Urban/Developed | No data available* | No data available* |
| Upland Forest | 49.0 | 32.7 |
| Wetland | Limited data available** | Limited data available** |
| Agricultural Land | 1.2 | No data available |
| Barren Land | 2.0 | 8.0 |

For purposes of the *GHG Inventory*, the working assumption for urban/developed land applies the barren land and forest carbon density factors in certain proportions taking into account lot size and building area.

**There is limited New Jersey empirical data for certain wooded wetland types. The *GHG Inventory* currently assumes 50% forest and 50% barren/bare land and the corresponding carbon density factors are applied.

Terrestrial carbon sequestration in New Jersey has incrementally increased over the last decade. Between 2006 and 2018, New Jersey realized an increase of 2.1 MMT $CO_2e$ in carbon sequestration (Table 7.2).

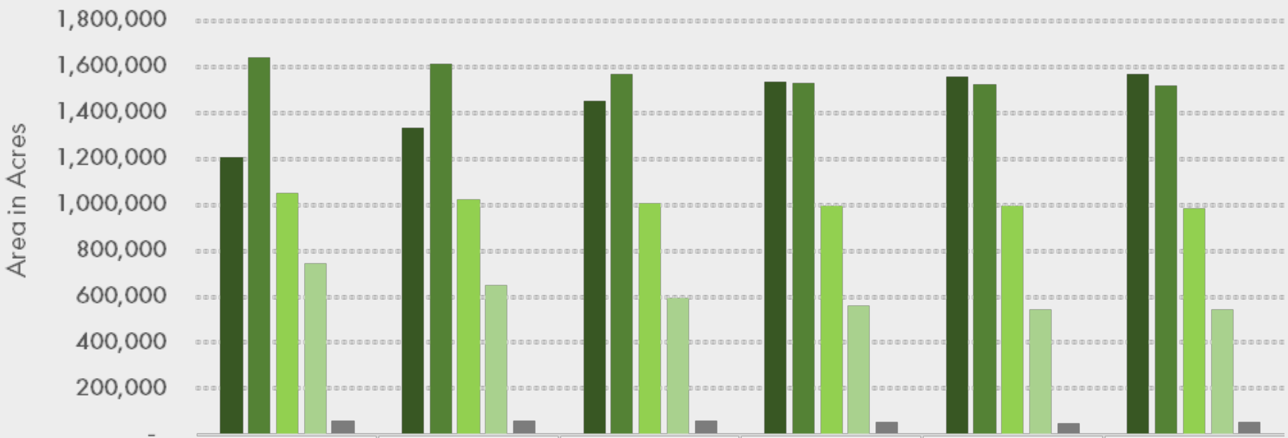
*Table 7.2. Annual GHG Sequestration in New Jersey 2006 – 2018 (MMT $CO_2e$).*

| 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -6.0 | -7.6 | -7.6 | -7.6 | -7.6 | -7.6 | -7.6 | -8.1 | -8.1 | -8.1 | -8.1 | -8.1 | -8.1 |

The slight gains in sequestration totals are attributed to carbon accumulation in biomass and soil due to continued maturation of New Jersey forests and wetlands. While this growth is noteworthy, at the same time the state's land use decisions continue to reduce the acreage of its valuable carbon sinks. The ability of land to sequester carbon is significantly impacted by changes in land use (USDOE, 2010). Between 1986 and 2015, New Jersey saw a 360,000-acre increase in land categorized as urban or developed, and experienced decreases in acreage of upland forests, cropland, grassland and wetlands (Figure 7.1).[5]

[5] Based on land use change calculations completed by the DEP Bureau of GIS, January 2020.

***Figure 7.1. New Jersey Land-Use Trends, 1986 – 2015.***
*Development pressures have led to losses of forest, wetlands and agricultural lands.*




| | 1986 | 1995 | 2002 | 2007 | 2012 | 2015 |
|---|---|---|---|---|---|---|
| Urban/ Developed | 1,208,553 | 1,334,645 | 1,452,077 | 1,534,278 | 1,558,802 | 1,568,570 |
| Forest | 1,641,279 | 1,616,492 | 1,568,807 | 1,531,496 | 1,528,481 | 1,518,737 |
| Wetland | 1,049,195 | 1,022,626 | 1,005,636 | 996,291 | 995,782 | 986,462 |
| Crop/ Grassland/ Agriculture | 744,382 | 652,334 | 594,697 | 559,624 | 545,596 | 543,469 |
| Bare | 57,223 | 57,562 | 59,138 | 52,321 | 49,170 | 52,843 |

Urban/ Developed · Forest · Wetland · Crop/ Grassland/ Agriculture · Bare

While the rate of growth in urban/developed land has slowed in more recent years, due in part to the Great Recession of 2008, changes in housing market preference and New Jersey's strong land preservation policies (Lathrop & Bognar, 2016), the overall percentage of urban/developed land in New Jersey continues to grow each year. Studies suggest that New Jersey is likely to be the first state in the nation to reach build-out (Hasse J. , 2009). Between 2012 and 2015 New Jersey developed almost 10,000 acres of forest, over 9,000 acres of wetland and over 2,000 acres of crop/grassland.[6] A total of 34% of New Jersey's land area is now classified as urban/developed (Table 7.3).

***Table 7.3. Distribution and Trends in New Jersey's Developed and Natural Lands.***

| New Jersey Total Land Use (Acres and Percent of Total) | | |
|---|---|---|
| *Land Use/Natural Resource* | *Area (acres)* | *Percent (%) of Total Land Area* |
| Urban/Developed | 1,568,570 | 34% |
| Upland Forest | 1,518,737 | 33% |
| Wetland | 986,462 | 21% |
| Crop/Grass Land | 543,469 | 12% |
| Bare | 52,843 | 1% |
| **Land Use Change from 2012 to 2015** | | |
| *Land Use/Natural Resource* | *Area Change (acres) per year* | *Type of Change* |
| Urban/Developed | 9,768 | increase |
| Upland Forest | -9,744 | decrease |
| Wetland | -9,320 | decrease |
| Crop/Grass Land | 2,127 | decrease |
| Bare | 3,673 | increase |

[6] Based on land use change calculations completed by the DEP Bureau of GIS, January 2020.

In addition to development trends, the state's carbon stocks are also affected by land management techniques, particularly in agricultural lands, coastal wetlands, and forests. In agricultural lands the frequency of tillage and vegetation changes can have long term soil carbon impacts (Reicosky, 2003). Agricultural practices that disturb the soil such as tilling, planting mono-crops, removing crop residue, excessive use of fertilizers and pesticides and over-grazing remove carbon from the soil (Lal R, 2011). In coastal wetlands, practices that cut off tidal flows reduce salinity and can make wetlands net GHG emitters (Kroeger, 2017).

**In 2018, New Jersey's land sector was estimated to sequester 8.1 million metric tons of $CO_2e$, offsetting GHG emissions.**

Somewhat counter-intuitively, increased density[7] in New Jersey's forests also threatens to reduce their future capacity to sequester carbon, even putting them at risk of eventually becoming net emitters as forest trees die off and release carbon back into the atmosphere. This is a serious threat for New Jersey's pinelands forests, which have experienced a steady increase in Relative Density Index[8] over the last century (NJDEP, 2020). The increased density stresses tree species, leaving them more vulnerable to pest species, such as the southern pine beetle. With the unmitigated invasion of pests, tree mortality and commensurate carbon losses are guaranteed (Coulson & Klepzig, 2011).

## Existing Carbon Sequestration Policies

The state's open space, farmland preservation and wetland protection policies implemented over the last five decades have resulted in the public ownership of development rights for more than a third of New Jersey's land area, protecting over 1.5 million acres (Table 7.4). Several programs have worked in tandem for the public purchase of development rights for large swaths of land throughout the New Jersey. Most notably the Garden State Preservation Trust and Green and Blue Acres programs have received broad public support to preserve open space, farmland wetlands and historic resources.

*Table 7.4. Public Ownership of Development Rights for lands in the State by type and acreage.*

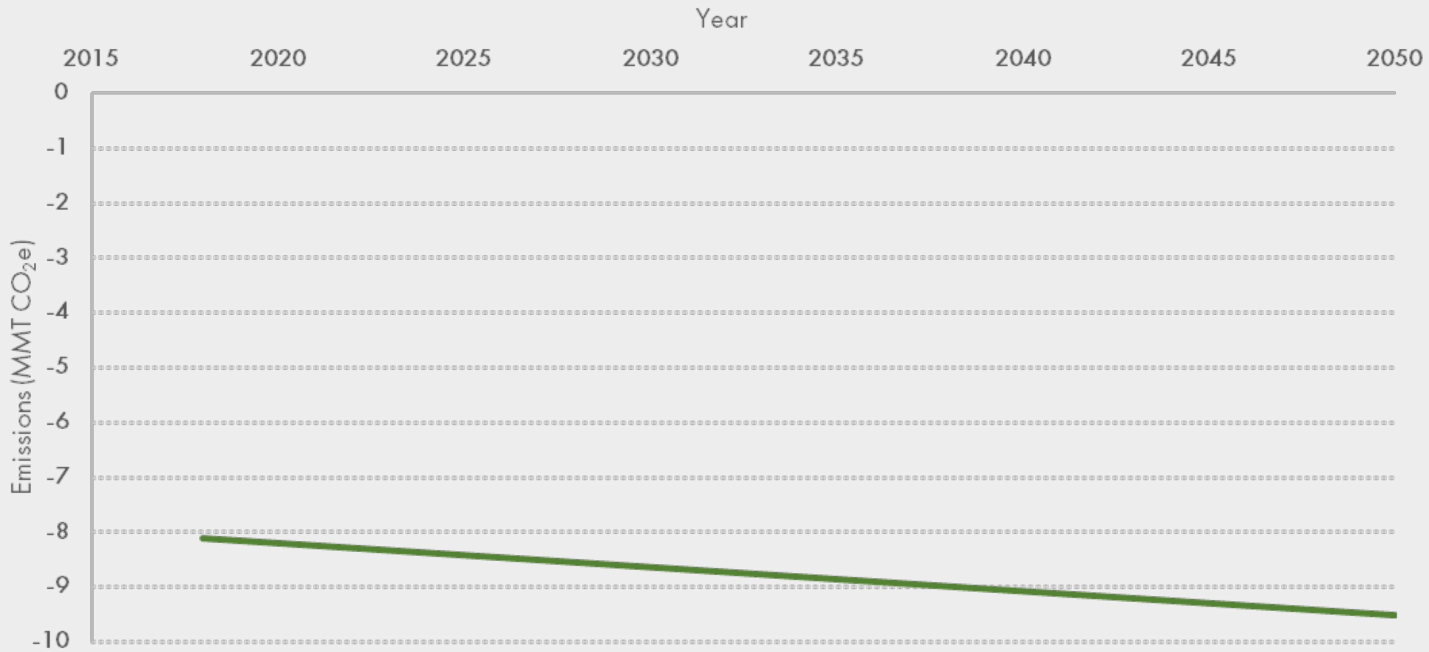
| Type | Acreage |
|---|---|
| Federal Recreation Open Space | 115,100 |
| Inter-State Recreation Areas | 2,452 |
| State Parks & Forests | 449,863 |
| State Wildlife Management Areas | 356,071 |
| NJ Natural Land Trust | 29,257 |
| NJ Water Authority | 2,039 |
| County Parks | 125,413 |
| Municipal Parks | 131,721 |
| Other Local Preserved Lands | 14,229 |
| Nonprofit Preserved Open Space | 68,660 |
| Pineland Development Credits | 52,346 |
| Preserved Farmland | 233,751 |
| Total Preserved Lands | 1,580,902 |

[7] Density can be defined multiple ways in a forested community, but for our purposes it refers to the proportion of 'growing space' occupied on a site. Growing space is a theoretical term to describe the available resources on a site available to a given taxa.
[8] Foresters use the term 'Relative Density Index' (RDI), which is a forest's current proportion of theoretical maximum density, ranging from 0 to 1

## Business-As-Usual (BAU) Projection

Accurate projection of future GHG sequestration levels depends heavily on the future trends in land development and land management. Looking forward to 2030 and 2050, if current trends remain the same, DEP projects a modest increase in total sequestration levels, to 8.6 MMT $CO_2e$ by 2030 and 9.5 MMT $CO_2e$ by 2050 (Figure 7.2) (NJDEP, 2019). This Business-as-Usual projection assumes no signficant changes in recent land use data and a decline in land clearing due to development being concentrated in already developed or built up areas of the state. This projection also does not take into account recent sea-level rise projections, which predict upwards of a 5.1 foot sea-level rise increase by 2100 (Kopp, 2019) under even a moderate emissions scenario. The rising sea-level will critically endanger coastal wetlands that currently serve as key carbon sinks. Modeling suggests the state's tidal salt marsh could decline by between 5 and 9% by 2050 (Lathrop & Bognar, 2014).

***Figure 7.2. New Jersey Terrestrial Carbon Sequestration 2018 – 2050 Business-As-Usual Projection (MMT $CO_2e$).***
*If a decline in land clearing occurs, New Jersey is anticipated to experience a modest increase in sequestration. However, this does not consider recent sea level rise projections or other potential climate change impacts on the state's landscape.*




## THE PATH FORWARD

DEP staff experts and internal studies (Reyes, 2017), as well as preliminary opportunity assessments conducted for the U.S. Climate Alliance states (USCA, 2018), have identified five potential pathways for maintaining and increasing carbon sequestration in the state's natural carbon sinks:

- Pathway 1, Reforestation, evaluates opportunities to reforest portions of the state;
- Pathway 2, Avoided conversion of natural lands, examines benefits of retaining existing forests and grasslands;
- Pathway 3, Salt marsh and seagrass restoration and enhancement, considers state blue carbon resources;
- Pathway 4, Conservation management of agricultural lands, considers opportunities for implementation of best management practices on farmlands; and
- Pathway 5, Proactive forest management, examines ways to preserve and strengthen New Jersey's existing state forests.

### CARBON GAIN ACTIVITES

- Forest Management
- Open Space Preservation
- Cover Cropping
- Restoring Tidal Flows

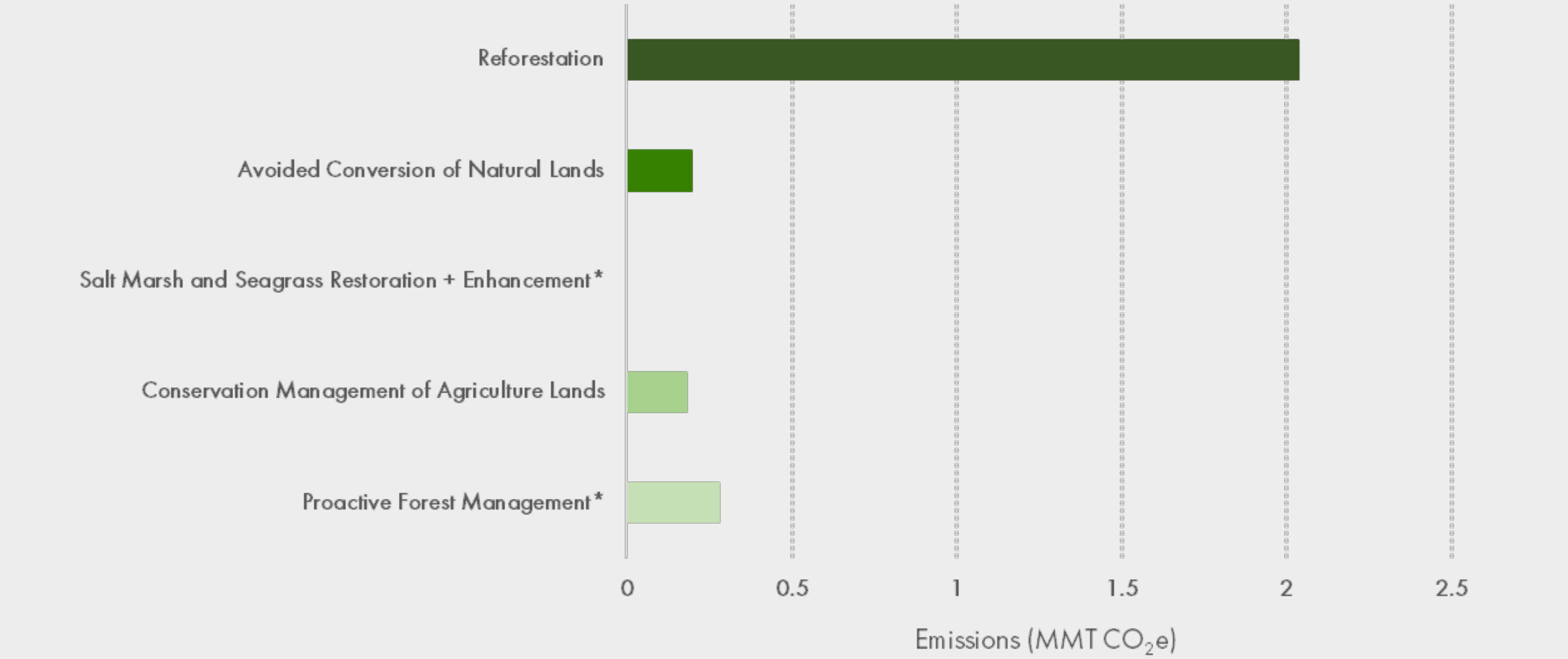
### SEQUESTRATION PATHWAYS

1. Reforestation
2. Avoided conversion of natural lands
3. Salt marsh and seagrass restoration and enhancement
4. Conservation management of agricultural lands
5. Proactive forest management

DEP does not currently have final estimates of the full sequestration potential of these pathways, but preliminary evaluations indicate that these pathways could provide somewhere between 2 to 3 MMT $CO_2e$ per year in additional carbon sequestration (estimates are pending for Salt Marsh and Seagrass Restoration and Proactive Forest Management pathways) (Figure 7.3). Reforestation represents by far the largest opportunity for carbon gains in New Jersey. Ultimately, adopting this suite of natural climate solutions can deliver significant reductions in New Jersey's net carbon emissions cost-effectively. The U.S. Climate Alliance estimates that the majority of New Jersey's carbon gain may be achieved at a cost well under $60/Metric Tons $CO_2e$ (USCA, 2018).

***Figure 7.3. Carbon Gain Pathways.***

*Preliminary opportunity analysis indicates New Jersey could gain between 2 to 3 MMT $CO_2e$ per year in additional carbon sequestration. Pathways with an asterisk (*) are pending a full carbon gain analysis.*




## **Sequestration Pathway 1:** Reforestation

Reforestation can sequester significant amounts of carbon in both soil and woody biomass (Nave L, 2018). Studies of the reforestation of former cultivated land have found increases in topsoil carbon storage, along with immediate to multi-decadal carbon sequestration benefits due to the establishment of woody vegetation (Nave, et al., 2019). The expansion of urban forestry also can provide carbon sequestration benefits. Generally, sequestration within cities increases with urban tree cover[9] and large, healthy trees (Nowak & Crane, 2002).

The U.S. Climate Alliance (2018) preliminary calculation found that reforestation has the potential to sequester 2.0 MMT $CO_2e$ additional carbon each year, through four approaches:

1. <u>Reforestation of Pasture and Cropland</u>

Reforestation of pasture lands and croplands that were historically forested, but currently have less than 25% tree cover, could sequester up to 0.83 MMT $CO_2e$ per year. Most of this gain could be achieved at an estimated cost of less than $40/Metric Tons $CO_2e$.

2. <u>Reforestation of Wetland and "Other" Lands</u>

Reforestation via active planting and maintenance on wetlands and other lands that were historically forested but currently have less than 25% tree cover, such as abandoned mines, burned forest area, roadsides, powerline rights of way, parks, golf courses and other areas, has a carbon sequestration potential of up to 0.98 MMT $CO_2e$ per year. It is estimated that the majority of this potential can be achieved at less than $30/Metric Tons $CO_2e$ and all of it can be achieved at less than $50/ Metric Tons $CO_2e$.

3. <u>Urban Reforestation</u>

Planting trees along streets and in parks and yards could sequester up to 0.11 MMT $CO_2e$ per year. While this reforestation method can be more costly (estimates exceed $100/Metric Tons $CO_2e$), important ancillary benefits

---

[9] City area multiplied by percent of tree cover.

include reducing urban heat island effects, reducing energy costs for cooling, and reducing urban and suburban stormwater runoff. Shaded surfaces may be 20-45F cooler than the peak temperatures of unshaded materials (Akbari, 1997). Evapotranspiration, alone or in combination with shading, can help reduce peak summer temperatures by 2-9F (Huang, 1990) (Kurn, 1994).

4. Agroforestry

Silvopasture (planting trees in pastureland while still maintaining productive agricultural land) and reforesting riparian buffers along streams have the potential to sequester an additional 0.10 MMT $CO_2e$ per year (assuming tree planting in 30-foot buffers along all streams in the state). Riparian areas immediately adjacent to lakes, reservoirs and some coastal areas were not included in this estimate and offer additional opportunities. The U.S. Climate Alliance estimates that more than half of the silvopasture potential is achievable at $50/Metric Tons $CO_2e$ and the remainder at $60/Metric Tons $CO_2e$, and that the planting of riparian buffers is achievable at $60/Metric Tons $CO_2e$.

## **Sequestration Pathway 2:** Avoided conversion of natural lands

The U.S. Climate Alliance (2018) preliminary calculations found that retaining existing forests and grasslands that would otherwise be converted to other land uses (e.g., development, pasture, cropland) has a carbon sequestration potential of 197,000 Metric Tons $CO_2e$ per year. The cost of avoiding grassland conversion is estimated at less than $30/Metric Tons $CO_2e$ and avoided forestland conversion is estimated at $10/Metric Tons $CO_2e$. Avoiding conversion of forest by foregoing development, however, is associated with much higher opportunity costs, estimated by U.S. Climate Alliance at over $100/Metric Tons $CO_2e$.

## **Sequestration Pathway 3:** Salt marsh and seagrass restoration and enhancement

Salt marshes and seagrass play a key role in storing carbon. These ecosystems store carbon at a rapid rate and can sequester carbon in the soil for thousands of years. Wetlands are excellent at storing carbon because their wet soils are low in oxygen, which slows down decomposition and allows organic material to build up (Mcleod, 2011). Globally, within the first meter of soil, salt marshes sequester 917 Mg $CO_2e$/ha and seagrasses sequester 512 Mg $CO_2e$/ha (Restore America's Estuaries, 2020). Average carbon sequestration rates are several times greater than for forests, storing large quantities of "blue carbon" in both plants and sediments (Restore America's Estuaries, 2020).[10]

It is estimated that New Jersey currently has 191,178 acres of blue carbon resources,[11] but modeling based on NOAA's sea-level rise predictions of 1 and 2.5 feet by 2050, suggests the state's tidal salt marsh could decline between 5 and 9% by 2050 due to sea level rise (Lathrop & Bognar, 2014).[12] Rising seas can, however, create new salt marshes where "marsh migration"[13] pathways are protected and left open. Tidal salt marsh surface can rise in relation to sea-level through the process of vertical accretion of sediment and organic matter. Ecological solutions that restore tidal flows to salt marshes that have been disconnected from the ocean enable vertical accretion, reduce methane emissions and should be prioritized (Macreadie, 2017).

[10] Seagrasses 138 ± 38 gC/m2/yr equal to 5.1 $tCO_2$/ha/yr and salt marshes 218 ± 24 gC/m2/yr equal to 8.0 $tCO_2$/ha/yr
[11] Based on land cover calculations completed by the NJDEP Bureau of GIS, January 2020.
[12] Assuming a sea level rise between 1 and 2.5 feet.
[13] Marsh migration is the ability for new wetlands to form inland in undeveloped areas.

## **Sequestration Pathway 4:** Conservation management of agricultural lands

New Jersey has over 411,000 acres of harvested cropland which could benefit from better land management practices (USDA, 2017a). Improved land management practices could help reduce carbon losses from the lands. Practices that improve carbon sequestration in agricultural lands focus on increasing the organic carbon content of soil (Richards K, 2006). Best management practices such as conservation tillage[14], cover crops and improved nutrient management can serve to enhance carbon sinks and reduce GHG emissions (Fargione J, 2018).

The U.S. Climate Alliance's preliminary evaluation of the carbon gain potential of increased cover cropping and improved cropland nutrient management (specifically nitrogen fertilizers) in New Jersey calculates that adopting these farming practices has a carbon gain potential of 181,000 Metric Tons $CO_2$e per year (USCA, 2018). The use of cover crops can boost yields, control weeds and reduce herbicide costs, saving farmers money (USDA, 2017b). Additionally, cropland nutrient management is low-cost due to savings from reduced use of fertilizers. The U.S. Climate Alliance estimates that the vast majority of this pathway would be possible at net zero cost.

Between 2012 and 2017 New Jersey did realize an increase in acreage of cover crops by 25%, with over 63,000 acres of planted cover crops in 2017 (USDA, 2017c). New Jersey should continue to build on this momentum and work to institutionalize best management practices within its farming community. New Jersey also needs to evaluate the carbon benefits of conservation tillage. In 2017, New Jersey farmers employed no-till practices on 104,499 acres of cropland (USDA, 2017c).

## **Sequestration Pathway 5:** Proactive forest management

The critical carbon pools[15] in New Jersey's existing forests are at risk from several effects of climate change, including increased risk from wildfire, invasive species, pests, disease, and inundation (Mylecraine & Zimmerman, 2000; Crocker, et al., 2013). This pathway focuses on some of the practices identified in the New Jersey State Forest Action Plan that allow forests to maintain their role in the carbon cycle, by defending the existing carbon pool and restoring the function of these ecosystems.

Forestlands with excessive density are at risk of increasing tree loss, with the resulting potential to become net emitters of carbon as dead trees decompose. The risks posed by threats to forests such as severe wildfires and bark beetle attacks must be considered alongside forest carbon stores and potential net gains. Actions that provide increased crown separation and consumption of surface fuels (such as a combination of tree thinning and prescribed burning) have been shown to reduce wildfire severity within and adjacent to treated areas. Likewise, actions that target stand composition and density can reduce the extent and severity of bark beetle attack and can also reduce stand susceptibility to bark beetle attack and thereby potential carbon emissions (Moghaddas, 2018). The New Jersey Forest Service estimates that approximately 178,000 acres of forest in the state would benefit from thinning (NJDEP, 2020). The pinelands forests have experienced a steady increase in Relative Density Index over the last century, leaving them more vulnerable to pest species, such as the southern pine beetle (Coulson & Klepzig, 2011; NJDEP, 2020). With the unmitigated invasion of pests, tree mortality and commensurate carbon losses will occur. Additional analysis is needed, however, to fully understand the carbon gain potential (or avoided emissions) from carbon defense strategies such as active forest management through thinning and selective burning. In addition to risk mitigation through thinning, several studies have shown that there are carbon gains that can occur as a result of thinning and/or burning treatments on the aboveground carbon uptake in certain forest types (Chiang, 2008; Kashian, Romme, Tinker, M.G, & Ryan, 2006).

An additional opportunity to increase sequestration within New Jersey's forests is by planting new trees in forest areas that are currently understocked. The U.S. Climate Alliance preliminary estimates found that restocking understocked forests in New Jersey could provide up to 281,000 $MTCO_2$e per year (USCA, 2018). This analysis is based on estimates

---

[14] Conservation tillage decreases soil disturbance and decomposition, leaving surface residue cover that can increase water retention, carbon and nitrogen in the soil, and crop yield (Johnson, et al., 2017).

[15] Carbon pools are reservoirs of carbon that have capacity to store and release carbon (Food and Agriculture Organization of the United Nations, 2003).

by the United States Forest Service Forest Inventory and analysis of existing public and private forestland that is currently understocked.[16] The U.S. Climate Alliance found that restocking forests can be achieved at less than $20/ $MTCO_2e$. Stewarding both new and existing forests across the state is an important part of ensuring that trees and forests remain viable carbon sinks.

## 2050 RECOMMENDATIONS

To achieve New Jersey's ambitious 2050 GHG reduction target, the state must maintain and strengthen its commitment to protecting and enhancing the carbon pools of its natural lands. DEP recommends developing a statewide carbon sequestration plan, which establishes both a 2030 and 2050 sequestration target. The plan should refine the preliminary analysis of the carbon gain pathways discussed above and align with the state's Climate Change Resilience Plan, the Forest Action Plan, the Wetland Program Plan and the State Agricultural Development Committee Farmland Preservation Plans. Additionally, through this effort, estimates of New Jersey's sequestration capability should be enhanced through improved monitoring and measurement. Research is needed to develop New Jersey specific carbon density factors for various land use types.

State government operations should lead by example by expanding the scope of its land preservation efforts. Executive Order 215 (1989) requires departments, agencies, and authorities of the state to submit environmental assessments or environmental impact statements to the DEP for state-funded or state-initiated construction projects greater than $1 million. This Executive Order should be updated to include consideration of climate change and impacts to natural carbon sinks. Currently, state-funded projects must also comply with the no net loss goal of forested area and tree replacement provisions of the "No Net Loss Act "(N.J.S.A. 13:1L-14.1 et. seq). However, New Jersey state entities are only required to replant trees when trees are removed during development projects involving one-half acre or more. This threshold could be lowered or eliminated to ensure greater protection of natural resources. Additionally, the DEP should develop guidelines and best management practices for maximizing sequestration on state owned and maintained properties. This should include specifications for plantings and management that state projects and properties are required to use. Finally, the state should evaluate adopting climate considerations in state lease agreements and easements to ensure carbon pools are protected.

Further, a slate of incentives should be made available to private and public landowners to ensure continued protection of natural lands. An estimated 29% of forestland in New Jersey is owned by families, individuals, trusts and estates, with 93% of the owners over the age of 45 (Crocker & Butler, 2016). It will be imperative to work closely with these individuals and the next generation of owners to protect and manage these natural resources for climate considerations. The NJDA and DEP should explore creating a new conservation program for privately held woodlands and forests. The program could purchase easements or offer other incentives for property owners to maintain woodlands and forests and reforest their properties, while staying in private ownership. This addresses a critical gap in the current land preservation programs, which only incentivizes easements on active farmland or easements that require public access to lands.

Simultaneously, development efforts in the state must reduce impacts to natural lands. New Jersey should adopt legislation modeled after Maryland's Forest Conservation Act (Natural Resources Article 5-1601-5-1613). The Forest Conservation Act calls for a minimum amount of forest cover on development sites, requiring developers to perform forest stand delineation and forest conservation plans. DEP could also better integrate tree, woodland and forest protection in existing land use permits and the CAFRA regulations.

New Jersey should scale up its Urban and Community Forestry program. This voluntary program allows municipalities to earn accreditation and receive liability protection from hazardous tree situations by working with the DEP to develop an approved Community Forestry Management Plan, completing special training and submitting annual reports. As of 2018, only 150 municipalities had achieved full accreditation in New Jersey. The New Jersey Shade Tree and Community Forest Assistance Act could be amended to require accreditation by municipalities and boards of education. By developing and implementing a management plan for a town's shade trees, the town can better manage its existing

[16] Forests with stocking levels below 25% were excluded from this analysis to avoid double counting with the reforestation pathway.

carbon sinks. The state should also purchase a municipal tree inventory and assessment tool to collect better data on trees throughout New Jersey. The tool would be offered for free to municipalities and counties to collect data on trees and assist in their management and maintenance. Pennsylvania recently launched PA Tree Map, an asset management software program for its municipalities which could serve as a model.

Blue Carbon systems are particularly vital tools in reducing GHGs. Tidal marshes, seagrasses and mangroves have the ability to store carbon in sediments over millennial timescales and can store carbon continuously without reaching saturation (Mcleod, 2011). New Jersey must take action to protect these systems and restore carbon sequestration function to its tidal lands. Initial efforts should focus on developing a Blue Carbon Action Plan that includes goals, a comprehensive list of blue carbon projects within the state, project prioritization criteria and monitoring policies. This plan would, as an example, identify salt marshes that are especially vulnerable to being converted into mudflat or open water and implement projects (such as thin-layer placement of sediments and living shorelines) to protect carbon sequestered in the soil by vegetated marsh from erosion and re-emission. It could also identify areas where salt marshes are expected to move or form inland as sea level rises and evaluate policies to protect these areas from development and impediments to tidal flow. The state should pilot a series of blue carbon projects to demonstrate the carbon sequestration and other ecological benefits of living shorelines, beneficial use of dredged material, seagrass restoration, and other tidal wetland restoration techniques. These projects would help inform the GHG inventory estimation of carbon sequestration benefits. The state should also consider policies that outright protect these systems, such as extending the protections afforded to the Marine Conservation Zones to environmentally sensitive areas with seagrass and adopting a Coastal Blue Carbon program.

Implementing climate-friendly technologies and practices into agricultural activities can increase the sequestration potential of New Jersey's agricultural lands and assist in meeting the 80x50 goal. Expanded educational and outreach efforts to the agricultural community about climate friendly agricultural practices is necessary. New Jersey has over 9,000 farms under 179 acres (USDA, 2017a). The state should explore incentivizing the use of advanced technologies at small and mid-size farms that assist with precise application of fertilizer, water and pesticides. A Climate Friendly Farming Certification Program could be created to promote this effort. The program can work in tandem with New Jersey Fresh and the New Jersey Sustainable Business Registry. Early adopters should be featured and promoted to encourage participation. Further, the state should amplify outreach efforts to enroll farmers in the Conservation Reserve Enhancement Program (CREP), providing technical assistance directly to farmers to assist in the application process and implementation. The program offers financial incentives to encourage farmers to create stream buffers on existing farmland and will cover 100% of the cost to establish the conservation practices and annual rental and incentive payments to the landowner.

*Table 7.5. Carbon Sequestration Programmatic Recommendations.*

| Actions | Entity | Timeframe [17] | Reference |
|---|---|---|---|
| Set a statewide carbon sequestration target for 2030 and 2050. | DEP, NJDA | Near-term | |
| Develop a New Jersey Carbon Sequestration Plan. | DEP, NJDA | Near-term | |
| Update Executive Order 215 (1989) to include consideration of climate change and carbon sequestration. | Governor's Office | Near-term | EO 215 (1989) |
| Sign onto the U.S. Climate Alliance Natural and Working Lands Challenge. | Legislature | Near-term | |
| Refine sequestration estimates in the Greenhouse Gas Inventory. | DEP | Throughout | |

*Table 7.6. Reforestation, Forest Management, and Urban Forestry Recommendations.*

[17] Near-term: now through 2030. Mid-term: 2030-2040. Long-term: 2040-2050. Throughout: Ongoing now through 2050.

| Actions | Entity | Timeframe | Reference |
| --- | --- | --- | --- |
| Set reforestation, wetland revegetation and urban reforestation goals for the state. Explore the potential to reforest less agriculturally productive lands (agricultural modified wetlands) on preserved farms. | DEP | Near-term | |
| Offer a Private Woodland Conservation Program. | Legislature, DEP, NJDA | Throughout | |
| Create an incentive program to encourage reforestation of 5+ acre parcels. | Legislature, DEP, NJDA | Near-term | |
| Develop and adopt minimum forest cover objectives for land development, including performance of requirements for forest stand delineations and implementation of forest conservation. | DEP | Near-term | Maryland's Forest Conservation Act (Natural Resources Article 5-1601-5-1613). |
| Integrate tree, woodland and forest protection in existing land use permits and the CAFRA regulations. | DEP | Throughout | |
| Expand the No Net Loss Program to projects under one half acre. | Legislature | Near-term | |
| Develop guidelines and best management practices for maximizing sequestration on state owned and maintained properties. | DEP | Near-term | |
| Expand the "NJ Fresh" and "Jersey Grown" marketing program to better promote forestry products from the Garden State. | NJDA | Near-term | |
| Update the Municipal Land Use Law to encourage and facilitate green infrastructure including green streets. Prioritization should be given to infrastructure that accommodates trees. | DCA | Near-term | |
| Enhance education and outreach around the Conservation Reserve Enhancement Program. | NJDA | Throughout | |
| Evaluate establishing forest carbon markets in New Jersey. | DEP | Mid-term | |
| Evaluate adopting climate considerations in state lease agreements and easements. | DEP | Mid-term | |
| Create a clearinghouse for information on sources of funding, and regulatory processes for carbon sequestration/forestry restoration projects and management applications. | DEP | Near-term | |
| Expand deer population management, including by allowing depredation permits for forestry management on private lands. Adopt Carbon Sequestration criteria as part of the Community Based Deer Management Plans. | DEP | Near-term | |
| Implement selective thinning in the Pine Barrens to prevent carbon loss from southern pine beetle infestation. | DEP | Near-term | |

| | | | |
|---|---|---|---|
| Consider requiring municipal and board of education accreditation through the New Jersey Shade Tree and Community Forest Assistance Act. | Legislature | Near-term | |
| Provide Municipal Tree Inventory and Assessment Tools. | DEP | Near-term | |

*Table 7.7. Blue Carbon Recommendations.*

| Actions | Entity | Timeframe | Reference |
|---|---|---|---|
| Develop a Blue Carbon Action Plan. | DEP | Near-term | |
| Identify areas where salt marshes are expected to move/form inland as sea-level rises and evaluate policies to protect these areas from development and impediments to tidal flow. | DEP | Near-term | |
| Pilot projects to demonstrate the carbon sequestration and other ecological benefits of living shorelines, beneficial use of dredged material, seagrass restoration, and other tidal wetland restoration techniques. | DEP | Near-term | |
| Develop blue carbon best management Practices based on pilot projects and lessons learned from projects in other states. | DEP | Near-term | |
| Create a voluntary wetland stewardship program, similar to federal programs that incentivize restoration and stewardship on private lands such as the Natural Resources Conservation Service's Wetlands Reserve Program. | DEP | Near-term | |
| Evaluate adopting a blue carbon market to provide funding for wetland conservation and restoration in the state. | DEP | Near-term | California and Louisiana Studies |
| Extend Marine Conservation Zone to seagrass beds. | DEP | Near-term | |

*Table 7.8. Climate Friendly Agriculture Recommendations.*

| Actions | Entity | Timeframe | Reference |
|---|---|---|---|
| Incentivize precision agricultural at small and mid-size farms. | NJDA | Near-term | |
| Create a Climate Friendly Farming Certification Program. | NJDA, DEP | Near-term | |
| Explore tax credits for the voluntary implementation of climate friendly practices, such as cover crops, organic certification, limited fertilizer application, and no-till/conservation tillage. | Legislature | Throughout | |
| Amplify promotion of the Conservation Reserve Enhancement Program. | NJDA, DEP | Throughout | |

## WORKS CITED

Akbari, H. K. (1997). Peak power and cooling energy savings of share trees. *Energy and Buildings*, 25:139-148.

Chiang, J. R. (2008). The effects of prescribed fire and silvicultural thinning on the aboveground carbon stocks and net primary production of overstory trees in an oak-hickory ecosystem in southern ohi. *Forest Ecololgy and Management*, 225: 1584-1594.

Coulson, R., & Klepzig, K. (2011). *Southern Pine Beetle II.* Asheville, NC: U.S. Forest Service.

Crocker, S. J., & Butler, B. J. (2016). *Forests of New Jersey, 2015.* Northern Research Station: U.S. Department of Agriculture, Forest Service.

Crocker, S., Barnett, C., Butler, B., Hatfield, M., Kurtz, C., Lister, T., . . . Zipse, W. (2013). *New Jersey Forests 2013.* Newtown Square, PA: U.S Forest Service. Retrieved from https://www.fs.fed.us/nrs/pubs/rb/rb_nrs109.pdf

Fargione, J. (2018). Natural climate solutions for the United States. *Sci Adv.* Retrieved from https://advances.sciencemag.org/content/4/11/eaat1869

Food and Agriculture Organization of the United Nations. (2003). *Forests and Climate Change.* Retrieved from http://www.fao.org/3/ac836e/AC836E03.htm

Hasse, J. (2009). Final Harvest in the Garden State: New Jersey's Struggle with Suburban Sprawl. In D. C. Most, *Earthcare: An Anthology in Environmental Ethic.* Lanham: Rowman & Littlefield Publishers.

Huang, J. H. (1990). The Wind-Shielding and Shading Effects of Trees on Residential Heating and Cooling Requirements. *ASHRAE Winter Meeting, American Society of Heating, Refrigerating and Air Conditioning Engineers.* Atlanta, Georgia.

IPCC. (2014). *Annex II: Glossary [Mach, K.J., S. Planton and C. von Stechow (eds.)]. In: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* Retrieved from https://www.ipcc.ch/site/assets/uploads/2018/02/AR5_SYR_FINAL_Annexes.pdf

Johnson, J., Jin, V., Colnenne-David, C., Stewart, C., Pozzi Jantalia, C., & Xiong, Z. X. (2017). Row-Crop Production Practices Effects on Greenhouse Gas Emissions. In M. M. Al-Kaisi, *Soil Health and Intensification of Agroecosystems* (pp. 257-275). Academic Press.

Kashian, D. M., Romme, W., Tinker, D., M.G, T., & Ryan, M. (2006). Carbon storage on landscapes with stand-replacing fires. *BioScience*, 56(7): 598-606.

Kopp, R. (2019). *New Jersey's Rising Seas and Changing Coastal Storms: Report of the 2019 Science and Technical Advisory Panel.* Trenton, New Jersey: Rutgers, The State University of New Jersey. Prepared for the New Jersey Department of Environmental Protection. Retrieved from www.nj.gov/dep/climatechange/pdf/njdep-stap-summary-report.pdf

Kroeger, K. (2017). Restoring tides to reduce methane emissions in impounded wetlands: A new and potent Blue Carbon climate change intervention. *Scientific Reports*, 7(1), pp.1-12.

Kurn, D. (1994). *The Potential for Reducing Urban Air Temperatures and Energy Consumptions through Vegetative Cooling.* ACEEE Summer Study on Energy Efficiency in Buildings, American Council for an Energy Efficient Economy.

Lal R, D. (2011). Management to mitigate and adapt to climate change. *Journal Soil and Water Conservation*, 66(4):276–85. Retrieved from http://www.jswconline.org/content/66/4/276.abstract

Lathrop, R. (2011). *Assessing the Potential for New Jersey Forests to Sequestration Carbon and Contribute to Greenhouse Gas Emissions Avoidance.* Retrieved from https://crssa.rutgers.edu/projects/carbon/RU_Forest_Carbon_final.pdf

Lathrop, R., & Bognar, J. (2014). *Modeling the Fate of New Jersey's Salt Marshes Under Future Sea Level Rise.* Retrieved from http://njadapt.rutgers.edu/docman-lister/resource-pdfs/83-projecting-nj-salt-marshes/file (2014).

Lathrop, R., & Bognar, J. (2016). *Changing Landscapes in the Garden State. Land Use Change in NJ 1986 thru 2012.* Center for Remote Sensing and Spatial Analysis, Rutgers University.

Macreadie, P. (2017). Can we manage coastal ecosystems to sequester more blue carbon? *Frontiers in Ecology and the Environment*, 15(4), pp.206-213.

Mcleod, E. (2011). A blueprint for blue carbon: toward an improved understanding of the role of vegetated coastal habitats in sequestering CO2. *Frontiers in Ecology and the Environment*, 9: 552–60.

Moghaddas, J. (2018). *Fuel Treatment for Forest Resilience: A Critical Review for Coniferous Forests of California, a report for California's Fourth Climate Change Assessment.* California Natural Resources Agency.

Mylecraine, K., & Zimmerman, G. (2000). *Atlantic white-cedar Ecology and Best Management Practices Manual.* Department of Environmental Protection. Retrieved from http://atlantic-white-cedar.org/pubs/Mylecraine&Zimmermann_2000-BMP-for-AWC-symposium-2006.pdf

Nave L,. (2018). Reforestation can sequester two petagrams of carbon in U.S. topsoils in a century. *Proceedings of the National Academy of Sciences of the United States*.

Nave, L., Walters, B., Hofmeister, K., Perry, C., Mishra, U., Domke, G., & Swanston, C. (2019). The role of reforestation in carbon sequestration. *New Forests*, 50(1): 115-137. doi:https://doi.org/10.1007/s11056-018-9655-3.

NJCAA. (2014). *A Summary of Climate Change Impacts and Preparedness Opportunities for the Agricultural Sector of New Jersey.* Retrieved from https://njadapt.rutgers.edu/docman-lister/resource-pdfs/96-njcaa-agriculture/file

NJDEP. (2019). *Terrestrial Carbon Sequestration Business as Usual Projection: Unpublished Analysis.* Trenton, New Jersey.

NJDEP. (2020, February 7). Unpublished data from the Bureau of Forest Management.

Nowak, D., & Crane, D. (2002). Carbon storage and sequestration by urban trees in the USA. *Environmental Pollution.*, 116(3): 381-389. doi:https://doi.org/10.1016/S0269-7491(01)00214-7.

Reicosky, D. (2003). Tillage-induced CO2 emissions and carbon sequestration: effect of secondary tillage and compaction. In *Conservation agriculture.* (pp. pp.291-300). Berlin: Springer: Springer.

Restore America's Estuaries. (2020, February 2). *Blue Carbon Science & Projects*. Retrieved from Restore America's Estuaries: https://estuaries.org/bluecarbon/blue-carbon-science-projects/

Reyes, J. (2017). *Quantitative Analysis of New Jersey's Land-Use Potential for Enhanced Carbon Sequestration.* New Jersey Department of Environmental Protection. Bureau of Climate Change and Clean Energy/Division of Climate, Clean Energy, and Radiation Protection.

Richards K. (2006). *Agricultural & Forestlands: US Carbon Policy Strategies.* Arlington, VA: Pew Center for Global Climate Change,. Retrieved from https://www.c2es.org/site/assets/uploads/2006/09/agricultural-and-forestlands-us-carbon-policy.pdf

USCA. (2018). *Natural Working Lands Learning Lab Opportunity Assessment for New Jersey.*

USDA. (2017a). Census of Agrilcultural - New Jersey State Data. Retrieved from https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_1_State_Level/New_Jersey/st34_1_0007_0008.pdf

USDA. (2017b, February 21). *Cover Crops Provide Multiple Benefits, Higher Yields*. Retrieved from https://www.usda.gov/media/blog/2015/01/21/cover-crops-provide-multiple-benefits-higher-yields

USDA. (2017c). *Census of Agricultural State Data.* Retrieved from https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_1_State_Level/New_Jersey/st34_1_0047_0047.pdf

USDOE. (2010). *Best Practices for Terrestrial Sequestration of Carbon.* Retrieved from https://www.netl.doe.gov/sites/default/files/2018-10/BPM_Terrestrial.pdf

# CONCLUSION

# CONCLUSION

Over the last fifteen years, New Jersey reduced its greenhouse gas (GHG) emissions by approximately 20%, primarily as a result of market forces that motivated energy generating units to transition from coal to cleaner burning natural gas. By comparison to this single-sector transition, meeting the ambitious GWRA goal of reducing emissions 80% by 2050 will require an economy-wide transformation over the next 30 years that demands all levels of government, economic sectors, communities and individuals to accept and adopt changes that will reduce the adverse effects of climate change.

While the positive climate policy developments of the last two years have begun moving New Jersey in this direction, existing initiatives are by themselves insufficient to meet this goal, underscoring the urgent need to aggressively pursue legislative, regulatory and policy initiatives that implement the recommendations of this report, which incorporates the strategies of the 2019 Energy Master Plan. These initiatives should include, among other efforts, steadily and steeply reducing the state's reliance on fossil fuels, expediting the deployment of wind and solar energy generation, amending building codes to promote electrification while phasing out natural gas-powered utilities and appliances, and facilitating the development of statewide electric vehicle charging infrastructure while further incentivizing electric vehicle use, hastening the eventual retirement of gasoline-powered vehicles.

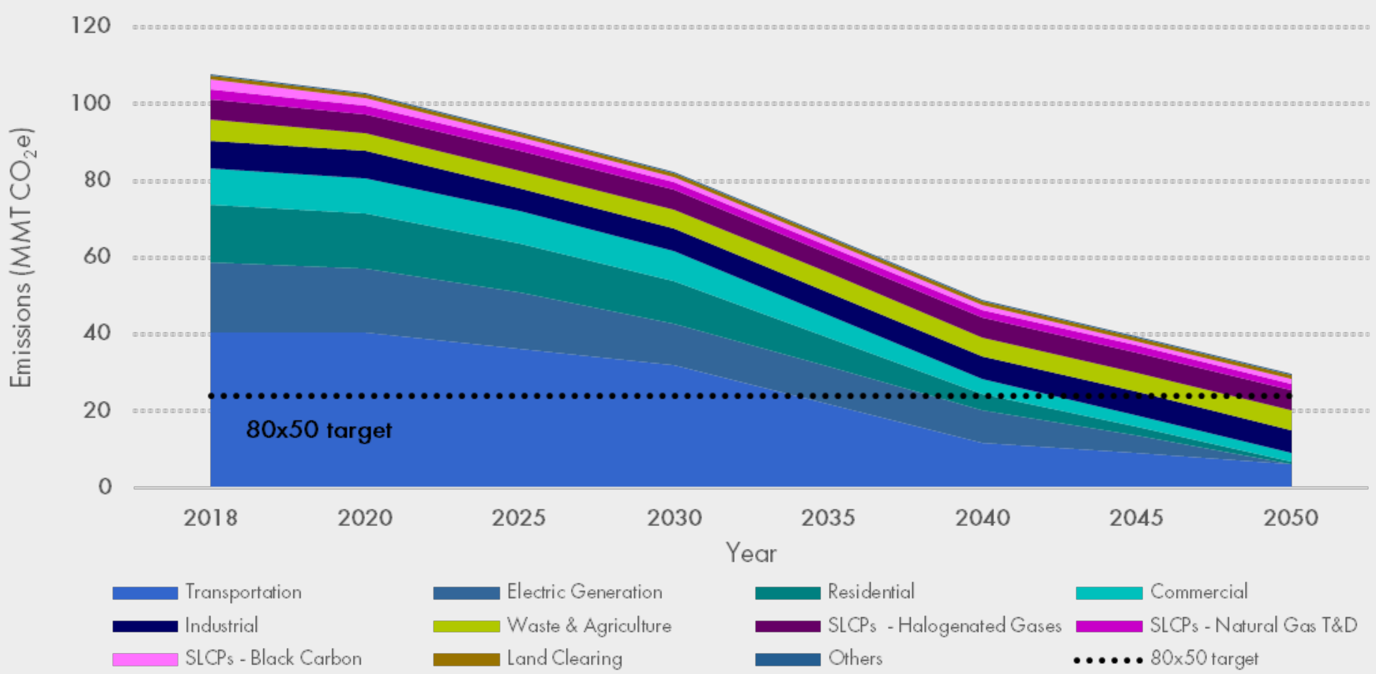
Without a steadfast commitment to successive legislative, regulatory and policy actions that facilitate deep emissions reductions over the next 30 years, New Jersey's business-as-usual emissions are projected to be higher in 2050 than they are today—only 12% below 2006 levels, erasing progress over the last fifteen years and missing the 80x50 goal.

New Jersey's swift and successful implementation of these recommendations, however, can reduce emissions from the 2018 level of 97.0 MMT $CO_2e$ to 29.8 MMT $CO_2e$ by 2050. When combined with efforts to protect and expand the ability of New Jersey's natural lands to absorb and sequester carbon, achieving a projected 10.8 MMT $CO_2e$ reduction by 2050, the state would attain the GWRA 80x50 goal with total emissions of 19 MMT $CO_2e$ (Figure 1).

As one component of New Jersey's comprehensive approach to reducing and responding to climate change, the Department of Environmental Protection is committed to revisiting this report every three years to assess the state's progress in achieving the 80x50 goal and to update the recommendations herein as both policy and technology mature.

***Figure 1. New Jersey GHG Emission Pathway to 2050 (MMT $CO_2e$).***

*The 2019 EMP least cost pathway combined with non-energy sector strategies, and carbon sequestration (not shown) have the potential to reduce net emissions below the 80x50 target prior to 2050.*



# GLOSSARY & ACRONYMS

# GLOSSARY (A-Z)

## A

**Advanced Metering Infrastructure:** An integrated system of smart meters, communication networks, and data management systems that enables two-way communications between utilities and customers.

**Aerobic Digestion:** The process in which microorganisms break down biodegradable material in the presence of oxygen.

**Agricultural Sources:** GHG emissions from enteric fermentation or digestion of food in ruminant animals such as cattle, animal wastes, nitrogen fertilization of soils and the burning of crop residues.

**Agroforestry:** The intentional integration of trees and shrubs into crop and animal farming systems to create environmental, economic, and social benefits.

**Anaerobic Digestion:** The process in which microorganisms break down biodegradable material in the absence of oxygen.

**Appliance Standards:** Minimum efficiency requirements for appliances. Depending on the appliance, these standards are set at the state or federal levels.

## B

**Benchmark:** A measurable variable used as a baseline or reference in evaluating the performance of a technology, a system or an organization. Benchmarks may be drawn from internal experience, from external correspondences or from legal requirements and are often used to gauge changes in performance over time.

**Biodiesel:** Biodiesel can be made from renewable or non-renewable feedstocks.

**Biofuel:** Biomass converted into liquid. Most common types are ethanol and biodiesel. As referenced in this report, biofuels are assumed to be low-carbon or carbon neutral fuels.

**Biogas:** Mixture of gases, comprising mainly of methane and carbon dioxide, produced from biomass through the process of anaerobic decomposition. Used as a generic term for landfill gas and digester gas.

**Biomass:** Organic non-fossil material of biological origin constituting a renewable energy source.

**Black Carbon (BC):** Operationally defined aerosol species based on measurement of light absorption and chemical reactivity and/or thermal stability; consists of soot, charcoal and/or light-absorbing refractory organic matter.

**Blowdowns:** The release of gas from a pipeline to the atmosphere in order to relieve pressure in the pipe so that maintenance, testing or other activities can take place.

**Blue Carbon:** The carbon stored in coastal and marine ecosystems.

**British Thermal Unit (Btu):** One British thermal unit is the amount of energy that will raise the temperature of one pound (mass) of water at 68 degrees F by 1degree F.  It is equal to 1,054 Joules.

**Building Codes:** Set of minimum standards for construction and renovation of residential, commercial and industrial structures that ensure health, safety and welfare of the occupants.

**Business-as-Usual (BAU):** A reference case scenario that represents hypothetical circumstances chosen to highlight the alternatives being examined. There is no one single "business-as-usual" set of conditions, with assumptions varying by sector. Reference cases do not necessarily represent what would take place if there were no intervention.

# C

**Carbon Dioxide Equivalent ($CO_2e$):** A metric measure used to compare the emissions from various greenhouse gases based upon their global warming potential (GWP). Carbon dioxide ($CO_2$) is the reference gas against which other greenhouse gases are measured and therefore has a Global Warming Potential (GWP) of 1. The carbon dioxide equivalent for a gas is derived by multiplying the tons of the gas by the associated GWP.

**Capacity:** The maximum amount of electricity a generator can produce, measured in megawatts (MW).

**Capacity Factor:** Capacity factor is the ratio between what a generation unit is capable of generating at maximum output versus the unit's actual generation output over a period of time

**Cap-and-Trade:** A system to reduce emissions across a region through the application of a regional cap. Allowances are used to allocate emissions under the cap, and can be distributed either directly or through auction markets. Auction proceeds can provide funding to programs such as, investments in clean and renewable energy, and direct bill assistance.

**Chlorofluorocarbons (CFCs):** An ozone depleting substance used in manufacture of aerosol sprays, blowing agents for foam, as solvents, and as refrigerants.

**Class I Renewable Energy:** Class I renewables in New Jersey include solar, wind, biomass, tidal, wave, fuel cell, and geothermal technologies, and hydropower facilities less than 3 MW in accordance with N.J.S.A 48:3-51.

**Class II Renewable Energy:** Class II renewables in New Jersey include recovery (i.e., waste-to-energy plants) and hydropower facilities greater than 3MW in accordance with N.J.S.A 48:3-51.

**Clean Energy:** The term 100% clean energy is considered to be "100% carbon-neutral electricity generation and maximum electrification of the transportation and building sectors . . . to meet or exceed the GWRA emissions reductions by 2050" in accordance with Executive Order 28 and the EMP.

**Clean Energy Act:** A New Jersey law passed in 2018 mandated several changes to the state's energy system, including the Renewable Portfolio Standard, renewable energy procurements and programs, and energy efficiency.

**Clean Firm:** Dispatchable electricity generation with zero greenhouse gas emissions. Clean firm resources can include long-duration energy storage, turbines fueled using biogas and/or synthetic gas, and hydrogen-powered generators.

**Climate Change:** Any significant change in the measures of climate lasting for an extended period. In other words, climate change includes major changes in temperature, precipitation, or wind patterns, among other effects, that occur over several decades or longer. Current references to climate change are focused on those changes that are attributed to human activities and might be mitigated through reduced production of $CO_2$ emissions.

**Coal:** A readily combustible black or brownish-black rock whose composition, including inherent moisture, consists of more than 50 percent by weight and more than 70 percent by volume of carbonaceous material. It is formed from plant remains that have been compacted, hardened, chemically altered, and metamorphosed by heat and pressure over geologic time.

**Combined Heat and Power (CHP):** CHP plants, also referred to as cogeneration, provide electric and thermal energy, thus obtaining overall efficiency from the fuel.

**Commercial Buildings:** Sector includes retail space, hospitals, senior care facilities, schools, local, state and federal government buildings, religious buildings, universities, and sewage treatment facilities.

**Compression Stations:** Maintain transmission pipeline pressure when natural gas is transferred into the system from a storage facility.

**Complete Streets:** Streets designed and operated to enable safe use and support for all users. Those include people of all ages and abilities, regardless of whether they are traveling as drivers, pedestrians, bicyclists or public transportation riders.

**Community Solar:** A program promoting solar arrays where output is virtually divided among multiple participants, known as subscribers. Participants receive credit on their utility bills in return for their participation in the community solar project.

**Commercial Property Assessed Clean Energy (CPACE):** Commercial property-assessed clean energy (CPACE) is a financing structure in which building owners borrow money for energy efficiency, renewable energy, or other projects and make repayments via an assessment on their property tax bill. The financing arrangement then remains with the property even if it is sold, facilitating long-term investments in building performance.

# D

**Direct Current Fast Charger (DCFC):** A charging station for electric vehicles that converts alternating current power to direct current power within the electric vehicle charging station and deliver direct current power directly to the vehicle's battery. These chargers are faster than level 1 or level 2 chargers and are predominantly utilized for quick charging sessions on long trips.

**Digester Gas:** Mixture of gases, mainly methane and carbon dioxide, generated due to anerobic digestion in an engineered system.

**Decarbonization:** The process of reducing and eliminating carbon emissions from the economy.

**Deforestation:** Those practices or processes that result in the conversion of forested lands for non-forest uses, such as agriculture or logging. Deforestation contributes to increasing carbon dioxide concentrations for two reasons: 1) the burning or decomposition of the wood releases carbon dioxide; and 2) trees that once removed carbon dioxide from the atmosphere in the process of photosynthesis are no longer present.

**Demand Response:** Measures that consumers take to minimize their demand for energy. It includes curtailment of energy or the use of on-site generation of electricity at critical times.

**Direct Emissions:** Produced onsite at the facilities. Emissions come from the consumption of fossil fuels for space and water heating, clothes drying and cooking needs, management of waste and wastewater and leaks from refrigerants in homes and businesses.

**Distillate Fuel:** A petroleum distillate that can be used as either a diesel fuel or fuel oil.

**Distributed Energy Resources (DERs):** Small-scale electricity production that is on-site or close to the primary user and is interconnected to the utility distribution system.

**Distribution Pipelines:** Used to supply natural gas to the consumer. A distribution line is located in a network of piping located downstream of a natural gas transmission line. As defined in natural gas pipeline safety regulations, a distribution line is a pipeline other than a gathering or transmission line.

**Driving Range Anxiety:** Fear of being stranded in an electric vehicle if its battery runs out.

# E

**E-85:** Motor fuel containing 85% ethanol and 15% gasoline

**Electrification:** The action or process of transitioning from a machine or system traditionally powered with a fuel such as natural gas, oil, propane, or gasoline to one powered with electricity. An example is replacing or converting a building heating system that uses natural gas to one that uses a system powered by electricity.

**Electric Generation:** The amount of gross generation less the electrical energy consumed at the generating station(s) for station service or auxiliaries.

**Electric Vehicle (EV):** A vehicle that uses one or more electric motors for propulsion. Typically, these vehicles, such as battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs), are charged through an external source of electric power and are typically referred to as EVs. Fuel cell electric vehicles (FCEVs) also use electric motors but are fueled with electricity produced internally with hydrogen instead of a battery and refuel at a hydrogen station (similar to today's gas stations) instead of plugging into an outlet or an EV charging station.

**EV Charging Infrastructure:** Electric vehicle service equipment used to supply electric energy to recharge electric vehicles. Types of EV charging are Level 1 and Level 2 Charging, and Direct Current Fast Charging (DCFC). DCFC is faster than Level 1 or Level 2 and is useful for quick charging sessions on long trips.

**Electric Vehicle Law (P.L. 2019 c.362):** This New Jersey bill, P.L 2019 c.362, promotes use of electric vehicles and establishes a Statewide public plug-in electric vehicle charging program. This law sets targets for EV adoption, with objectives of having 85% of all new passenger vehicle sales be EV by 2040, and promotes the installation of EV charging infrastructure. The bill directs a working group of the Board of Public Utilities, the Department of Environmental Protection, the Department of Transportation, the New Jersey Transit Corporation, the New Jersey Turnpike Authority, the South Jersey Transportation Authority, and the Department of Community Affairs to develop a Statewide plan for installing at least 600 public DC fast chargers and Level 2 public community chargers at 300 locations or more in the State by December 31, 2020.

**Emission Factor:** An emission factor is the rate of emission per unit of activity, output or input.

**Energy Codes**: Set of minimum efficiency requirements for new and existing buildings that ensure reduction in energy use and emissions over the life of the building. Energy codes are a subset of building codes.

**Energy Efficiency (EE):** Reducing wasted energy, or using less electricity, to perform the same task. For example, a high-efficiency appliance will use less energy than a low-efficiency appliance. Alternatively, adding insulation to exterior walls will reduce building heat loss.

**Enteric Fermentation:** Normal digestive process in ruminant animals such as cattle, sheep and goats that causes fermentation of the feed consumed and releases methane as a by-product.

**Energy Storage:** The capturing and storing of energy for future use. Energy can be stored through electrochemical (batteries), thermal, and mechanical means, as well as through pumped hydropower and hydrogen. Depending on the technology used, energy storage can be used for a long or short duration.

# F

**Facility:** The combination of all structures, buildings, equipment, control apparatus, storage tanks, source operations, and other operations located on a single site or on contiguous or adjacent sites and that are under common control of the same person or persons.

**Flaring:** Controlled combustion of biogas at landfills or wastewater treatment facilities.

**Fossil Fuels:** An energy source formed in the Earth's crust from decayed organic material. The common fossil fuels are petroleum, coal, and natural gas.

**Fuel Cell:** A fuel cell is an electrochemical cell that converts the chemical energy of a fuel into electricity.

**Fugitive Emissions:** Unintended leaks of gas during routine processing, transmission, and/or transportation.

## G

**Gas Public Utility:** Elizabethtown Gas (ETG), New Jersey Natural Gas (NJNG), Public Service Electric and Gas (PSE&G), and South Jersey Gas (SJG).

**Gigawatt:** A Gigawatt (GW) is a unit of electrical capacity equal to 1,000,000,000 watts.

**Global Warming Potential (GWP):** A measure of the total energy that a gas absorbs over a particular period of time (for example 100 years), compared to carbon dioxide.

**Global Warming Response Act (GWRA):** The Global Warming Response Act of 2007 requires New Jersey to reduce its greenhouse gas emissions 80% below 2006 levels by 2050 (80x50).

**Green Bank:** A public or non-profit bank designed to increase the amount of public and private capital flowing to important clean energy projects and innovations.

**Greenhouse Gas (GHG):** Any gas that absorbs infrared radiation in the atmosphere, including carbon dioxide, methane, nitrous oxide, hydrochlorofluorocarbons, perfluorocarbons, sulfur hexafluoride, and other halogenated species that are listed in the IPCC.

**Greenhouse Gas Reporting Program (GHGRP):** A federal program administered by the USEPA for reporting greenhouse gas (GHG) data and other relevant information from large GHG emission sources, fuel and industrial gas suppliers, and CO2 injection sites in the United States.

## H

**Halogenated Gas:** Organic compounds onto which a halogen (e.g., fluorine, chlorine, bromine or iodine) has been attached.

**Heavy-Duty Vehicle:** See Medium or Heavy-Duty Vehicle

**Hydrochlorofluorocarbons (HCFCs):** An ozone depleting substance used as a replacement for CFCs in refrigeration and air-conditioning, aerosol propellants, and foam manufacture.

**Hydrofluorocarbons (HFCs):** A group of halogenated gases that are primarily used for cooling and refrigeration; and as a replacement for ozone depleting substances.

## I

**Indirect Emissions:** Emissions from an activity that are not emitted at the point of use. For example, emissions associated with electric lighting may be released at an electric generating station located elsewhere.

**Integrated Energy Plan (IEP):** A study commissioned by NJBPU in 2019 that models several energy future scenarios for New Jersey to determine the least-cost pathway to accomplish the state’s goals of reaching 100% clean energy by 2050.

# K

**Kigali Amendment:** An amendment adopted by 197 countries to phase down HFCs under the Montreal Protocol. Countries are committed to cut the production and consumption of HFCs by more than 80 percent over the next 30 years from the year 2016.

**Kilowatt-hour (kWh):** A kWh is a unit of electrical energy equal to 1,000 watt-hours or 3,600,000 Joules. According to the US Department of Energy, the average New Jersey residential home consumes almost 700kWh/month.

# L

**Landfill Gas:** Gas that is generated by anaerobic decomposition of organic material at a landfill disposal site.

**Light-duty Vehicle:** A passenger vehicle that weighs less than 8,500 lbs., including but not limited to, hatchbacks, sedans, crossovers, sport utility vehicles, pick-up trucks, coupes, and convertibles, which has four wheels.

**Liquid Natural Gas (LNG):** Natural gas (primarily methane) that has been liquefied by reducing its temperature to -260 degrees Fahrenheit at atmospheric pressure.

**Liquefied Petroleum Gas:** A group of hydrocarbon gases, primarily propane, normal butane, and isobutane, derived from crude oil refining or natural gas processing.

**Local Distribution Company (LDC):** A company in the retail sale and/or delivery of natural gas through a distribution system that includes main lines (that is, pipelines designed to carry large volumes of gas, usually located under roads or other major right-of-way's) and laterals (that is, pipelines of smaller diameter that connect the end user to the mainline).

# M

**Medium or Heavy-Duty Vehicle:** A medium- or heavy-duty vehicle weighs more than 8501 lbs. Medium duty vehicles are lighter than heavy-duty vehicles. These vehicles are typically commercial in nature and perform duties related to the movement of goods and people.

**Megawatt (MW):** A MW is a unit of electrical capacity equal to 1,000 kilowatts or 1,000,000 watts.

**Megawatt-hour (MWh):** A MWh is a unit of electrical energy equal to 1,000 kWh.

**Methane ($CH_4$):** A colorless, odorless, flammable gas at standard conditions, having a molecular composition of one carbon atom and four hydrogen atoms.

**Microgrid:** A microgrid is a group of interconnected loads and distributed energy resources (DERs) within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. A microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island-mode

**MMBtu:** A MMBtu is a standard measure of energy unit equal to 1,000,000 Btu.

**Mitigation:** Measures to reduce the amount and speed of future climate change by reducing emissions of heat trapping gases or removing carbon dioxide from the atmosphere.

**Montreal Protocol:** A global agreement to protect the stratospheric ozone layer by phasing out the production and consumption of ozone-depleting substances (ODS).

**Motor Vehicle Emissions Simulator (MOVES):** An emission modeling system created by the USEPA to estimate emissions for mobile sources at the national, county, and project level for criteria air pollutants, greenhouse gases, and air toxics.

**Municipal Solid Waste (MSW):** Residential solid waste and some nonhazardous commercial, institutional, and industrial wastes.

## N

**Natural Gas:** A fossil energy source that formed deep beneath the earth's surface. Natural gas contains many different compounds. The largest component of natural gas is methane, a compound with one carbon atom and four hydrogen atoms (CH4). Natural gas also contains smaller amounts of natural gas liquids (NGL, which are also hydrocarbon gas liquids), and nonhydrocarbon gases, such as carbon dioxide and water vapor.

**Natural Gas Transmission & Distribution:** An integrated pipeline network that links natural gas production areas and storage facilities with consumers.

**Net Zero Carbon:** The World Green Building Council defines “net zero carbon” as when the amount of carbon dioxide emissions released on an annual basis is zero or negative.

**Nitrogen Oxides ($NO_X$):** $NO_X$ is the term used to describe the sum of nitric oxide (NO), nitrogen dioxide ($NO_2$), and other oxides of nitrogen. Most airborne $NO_X$ comes from combustion-related emissions sources of human origin, primarily fossil fuel combustion in electric utilities, high-temperature operations at other industrial sources, and operation of motor vehicles. However, natural sources, like biological decay processes and lightning, also contribute to airborne $NO_X$. Fuel-burning appliances, like home heaters and gas stoves, produce substantial amounts of $NO_X$ in indoor settings.

**Nitrogen Trifluoride ($NF_3$):** A colorless gas used as a cleaning gas in semi-conductor manufacturing as well as etchant for certain materials.

**Non-Road Equipment:** Equipment with combustion engines that operate off public roadways or highways. This includes gasoline-powered lawn equipment, backhoes, cranes, and materials handling equipment such as forklifts.

**Non-Road Transportation:** Vehicles that operate off public roadways or highways. This includes commercial marine vessels, locomotives, and aircraft.

**Non-Wires Solutions (NWS):** An umbrella term for projects or investments that may defer or replace electric distribution or trans-mission upgrades by reducing load.

## O

**Off-road equipment:** See Non-Road Equipment

**Off-road transportation:** See Non-Road Transportation

**On-road transportation:** Mobile sources used on roads and highways for transportation of passengers or freight. On-road sources include: passenger cars and trucks; commercial trucks and buses; and motorcycles.

**Organic Carbon (OC) (particulate emission type):** A short-lived particle which has cooling impacts on the atmosphere and can also be emitted from sources of black carbon.

**Ozone Depleting Substances (ODS):** Chemical compounds that damage the ozone layer such as Chlorofluorocarbons (CFCs) and Hydrochlorofluorocarbons (HCFCs).

# P

**Particulate Matter (emission type):** A mixture of solid particles and liquid droplets found in the air. These droplets are so small that they can be inhaled and cause serious health problems.

**Passenger Miles Travelled (PMT):** The sum of the miles travelled by individual passengers on public transit.

**Peak Demand:** The highest electrical power demand that has occurred over a specified time period.

**Perfluorocarbons (PFCs):** A byproduct of aluminum smelting and semiconductor manufacturing. PFCs have very high, 100-year Global Warming Potentials and are very long-lived in the atmosphere.

**Petroleum:** A broadly defined class of liquid hydrocarbon mixtures. Included are crude oil, lease condensate, unfinished oils, refined products obtained from the processing of crude oil, and natural gas plant liquids.

**PJM Interconnection, L.L.C. (PJM):** PJM is the regional transmission organization responsible for planning and operating the electric transmission grid across thirteen Mid-Atlantic and Midwestern states and the District of Columbia. PJM is also the independent system operator that administers the wholesale power markets in its territory to assure bulk system reliability.

# R

**Reforestation:** Replanting of forests on lands that have recently been harvested or otherwise cleared of trees.

**Regional Greenhouse Gas Initiative (RGGI):** The Regional Greenhouse Gas Initiative (RGGI) is the first mandatory market-based program in the United States to reduce greenhouse gas emissions. RGGI is a cooperative effort among several states in the Northeast and Mid-Atlantic regions to cap and reduce $CO_2$ emissions from the power sector.

**Regional Transmission Organization (RTO):** A Regional Transmission Organization, e.g. PJM, is an entity responsible for planning and operating regional electric transmission grids.

**Renewable Energy:** Energy resources that are naturally replenishing but flow limited. They are virtually inexhaustible in duration but limited in the amount of energy that is available per unit of time. Renewable energy resources include biomass, hydro, geothermal, solar, wind, ocean thermal, wave action, and tidal action.

**Renewable Portfolio Standard (RPS):** An RPS is a state requirement that mandates the increased production of energy from renewable energy sources, such as wind, solar, biomass, and geothermal, to meet a specified goal. Twenty-nine states and the District of Columbia have RPS requirements.

**Residential Buildings:** Sector consists of private households, multi-family and apartment buildings.

**Residual Fuel:** Consists of the heavy petroleum products left over after distillation.

**Retrofit:** Modifications to any existing building that may improve energy efficiency or decrease energy demand.

**Ridesharing (Ridesourcing):** This one of the most common types of shared mobility. A user requests a ride through an online platform, typically a phone app, which then pairs the user with a driver; payments and feedback also occur through the online platform. Companies providing these services are sometimes called transportation network companies (TNCs).

**Rooftop Solar:** Type of solar generating facility that is sited on the roof of a building or structure.

**Ruminant:** A ruminant is an even-toed, hoofed, four-legged mammal that eats grass and other plants and has a stomach with four compartments. Ruminants include domestic cattle (cows), sheep, goats, bison, buffalo, deer, antelopes, giraffes, and camels.

# S

**Safer Affordable Fuel Efficient (SAFE):** Vehicle Rule that sets fuel economy and carbon dioxide standards that increase 1.5% in stringency each year from model years 2021 through 2026.

**Service Line:** A pipe for transport of natural gas from a common source of supply to a customer's meter, or the line connecting to a customer's piping.

**Short-Lived Climate Pollutants (SLCPs):** Potent climate forcers that have a greater impact on climate change in the near term, compared to longer-lived greenhouse gases like carbon dioxide.

**Significant New Alternative Policy (SNAP):** A program within the Clean Air Act (CAA) legislation passed by Congress which identifies and evaluates substitutes in end-uses that have historically used ozone-depleting substances (ODS).

**Sink:** In the context of global warming any process, activity or mechanism that removes a greenhouse gas or aerosol, or a precursor of a greenhouse gas or aerosol, from the atmosphere.

**Solar Photovoltaic (PV):** Technology that utilizes solar radiation to generate electricity by means of solar photovoltaic panels.

**Solar Renewable Energy Certificate (SREC):** An SREC is a tradable certificate that represents the clean energy benefits of electricity generated from a solar energy system.

**Solar Thermal:** Technology that utilizes rooftop solar panels to provide water heating for residential, commercial and industrial buildings.

**Space Heating:** The use of energy to generate heat for warmth in buildings using space-heating equipment. Space heating does not include the energy used by furnace fans or blowers, nor does it include the use of energy to operate appliances, such as lights, televisions, and refrigerators, that give off heat as a byproduct.

**Sulfur Dioxide ($SO_2$):** An air pollutant associated with respiratory harm, sulfur dioxide is a member of a group of reactive gases known as sulfur oxides ($SO_x$) that are regulated under the USEPA's national ambient air quality standards.

**Sulfur Hexafluoride ($SF_6$):** A halogenated gas which is utilized in very small portions as an insulating fluid in high voltage electrical equipment. It possesses the highest 100-year Global Warming Potential of any gas (23,900).

# T

**Transit Village:** Program that promotes centralized development in neighborhoods surrounding transit hubs.

**Transmission Pipelines:** Large diameter, high-pressure lines that transport gas from production fields, processing plants, storage facilities, and other sources of supply over long distances to local distribution companies or to large volume customers.

**Transportation:** Sector includes on-road motor vehicles as well as off-road modes of transportation such as trains, boats, and airplanes.

**Trip Chaining:** Replacing multiple trips into a single tour through the use of public transit. For example, a commuter may pick up groceries or dry cleaning on the way home from a transit station.

# V

**Value Stack:** The practice of enabling a single energy resource to receive multiple different streams of revenue corresponding to different services, or “use cases,” provided by the resource.

**Vehicle Miles Travelled (VMT):** One vehicle traveling one mile equals one vehicle mile traveled (VMT).

**Venting:** Natural gas that is disposed of by releasing to the atmosphere.

# W

**Waste Management:** Consists of two separate subsectors; municipal solid waste (MSW) management and wastewater treatment (WWT), both of which can be sources of methane and carbon dioxide (CO2).

**Wastewater Treatment (WWT):** Process that removes contaminants from wastewater from residential, commercial establishments and industrial processes and converting it into an effluent that can be discharged back into the water cycle without any environmental impacts.

**Water Heating:** The use of energy to heat water for hot running water. This category does not include energy used to heat water for cooking, hot drinks, or swimming pools.

**Wind Energy:** Kinetic energy present in wind motion that can be converted to mechanical energy for driving pumps, mills, and electric power generators.

# Z

**Zero Emission Vehicle (ZEV):** A vehicle that emits no tailpipe pollutants from the onboard source of power, such as particulates, hydrocarbons, carbon monoxide, ozone, lead, and various oxides of nitrogen. According to the Multi-State ZEV Memorandum of Understanding to which New Jersey is a signatory, ZEVs include battery-electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), and hydrogen fuel cell electric vehicles (FCEVs).

**Zero Emission Vehicle Action Plan:** A plan created in 2014 and revised in 2018 to accelerate market growth and development clean passenger cars, including battery-electric, plug-in hybrid electric, and fuel cell electric vehicles.

**Zero Emission Vehicle Programs Memorandum of Understanding:** Established in 2013 and signed by New Jersey in 2018, the State Zero-Emission Vehicle Programs Memorandum of Understanding formally commits New Jersey and nine other states (now ten) to place a combined 3.3 million zero-emission vehicles on the road by the year 2025.

# ACRONYMS

| | |
|---|---|
| ACEEE | American Council for an Energy-Efficient Economy |
| AMI | Advanced Metering Infrastructure |
| APCA | Air Pollution Control Act |
| APTA | American Public Transportation Association |
| BAU | Business-as-Usual |
| BHP | Brake horsepower |
| BOEM | Bureau of Ocean Energy Management |
| BPU | Board of Public Utilities |
| BTU | British thermal unit |
| CAFRA | Coastal Area Facility Review Act |
| CAFE Standards | Corporate Average Fuel Economy Standards |
| CARB | California Air Resources Board |
| CAT | Corporation for Advanced Technology |
| CEA | Clean Energy Act |
| CFCs | Chlorofluorocarbons |
| $CH_4$ | Methane |
| CHP-FC | Combined Heat and Power and Fuel Cell |
| $CO_2$ | Carbon Dioxide |
| $CO_2e$ | Carbon Dioxide Equivalent |
| CNG | Compressed Natural Gas |
| CREP | Conservation Reserve Enhancement Program |
| DCA | Department of Community Affairs |
| DCFC | Direct Current Fast Chargers |
| DEP | Department of Environmental Protection |
| DER | Distributed Energy Resource |
| DOBI | Department of Bank and Insurance |
| DOE | Department of Energy |
| DOT | Department of Transportation |
| DSHW | Division of Solid and Hazardous Waste |
| EDA | Economic Development Authority |
| EMP | Energy Master Plan |
| EO | Executive Order |
| EQIP | Environmental Quality Incentives Program |
| EV | Electric Vehicle |
| MW | Megawatt |
| MWh | Megawatt-hour |
| NAAQS | National Ambient Air Quality Standard |
| NAICS | North American Industry Classification System |
| NEI | National Emissions Inventory |
| NESCAUM | Northeast States for Coordinated Air Use Management |
| $NF_3$ | Nitrogen Trifluoride |
| NHTSA | National Highway Traffic and Safety Administration |
| NJAPCA | New Jersey Air Pollution Control Act |
| NJCAC | New Jersey Clean Air Council |
| NJCEP | New Jersey Clean Energy Program |
| NJDA | New Jersey Department of Agriculture |
| NJDT | New Jersey Department of Treasury |
| NJHMFA | New Jersey Housing and Mortgage Finance Agency |
| NJNG | New Jersey Natural Gas |
| NJ PACT | New Jersey Protecting Against Climate Threats |
| NJ TRANSIT | New Jersey Transit |
| NJSBR | New Jersey Sustainable Business Registry |
| $NO_X$ | Nitrogen Oxides |
| NWS | Non-Wires Solutions |
| ODS | Ozone Depleting Substances |
| OREC | Offshore Wind Energy Certificate |
| OSW | Offshore Wind |
| OWEDA | Offshore Wind Economic Development Act |
| PFCs | Perfluorocarbons |
| PHMSA | Pipeline and Hazardous Materials Safety Administration |
| PJM | Pennsylvania, New Jersey, Massachusetts |
| PL | Public Law |
| PM | Particulate Matter |
| PM 2.5 | Particulate Matter 2.5: fine inhalable particles, with diameters that are generally 2.5 micrometers and smaller. |
| PMT | Passenger Miles Traveled |
| PSE&G | Public Service Enterprise Group |
| PV | Photovoltaic |
| RDI | Relative Density Index |

| | |
|---|---|
| g | Gram |
| GHG | Greenhouse Gas |
| GHGRP | Greenhouse Gas Reporting Program |
| GIS | Geographic Information System |
| GW | Gigawatt |
| GWP | Global Warming Potential |
| GWRA | Global Warming Response Act |
| $H_2S$ | Hydrogen Sulfide |
| Ha | Hectare |
| HCFCs | Hydrochlorofluorocarbons |
| HFCs | Hydrofluorocarbons |
| hr | Hour |
| HVAC | Heating, Ventilation and Air Conditioning |
| HWG | Highly Warming Gases |
| IECC | International Energy Conservation Code |
| IEP | Integrated Energy Plan |
| IPCC | Intergovernmental Panel on Climate Change |
| kWh | Kilowatt-hour |
| LDAR | Leak Detection and Repair |
| LDC | Local Distribution Company |
| LEV | Low Emission Vehicle |
| LGEA | Local Government Energy Audit |
| LNG | Liquid Natural Gas |
| Mg | Megagram |
| MMT | Million Metric Tons |
| MSW | Municipal Solid Waste |
| MVC | Motor Vehicle Commission |
| RGGI | Regional Greenhouse Gas Initiative |
| RMP | Refrigerant Management Program |
| RPS | Renewable Portfolio Standards |
| RTO | Regional Transmission Organization |
| SAFE | Safer Affordable Fuel-Efficient |
| SEDS | State Energy Data System |
| SEIA | Solar Energy Industries Association |
| $SF_6$ | Sulfur Hexafluoride |
| SIT | State Inventory Tool |
| SLCP | Short-Lived Climate Pollutant |
| SNAP | Significant New Alternative Policy |
| $SO_2$ | Sulfur Dioxide |
| SREC | Solar Renewable Energy Certificate |
| SUV | Sports Utility Vehicle |
| TCM | Transportation Control Measures |
| TOU | Time-of-use |
| TWh | Terawatt-hour |
| UCC | Uniform Construction Code |
| $ug/m^3$ | Micrograms per Cubic Meter of Air |
| USCA | United States Climate Alliance |
| USDA | United States Department of Agriculture |
| USEIA | United States Energy Information Agency |
| USEPA | United States Environmental Protection Agency |
| USEPA MOVES | USEPA Motor Vehicle Emission Simulator |
| VMT | Vehicle Miles Travelled |
| WWT | Wastewater Treatment |
| ZEV | Zero Emission Vehicle |