NJTPA

Regional Greenhouse Gas

Emissions Inventory and Forecast

Final Report

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The North Jersey Transportation Planning Authority (NJTPA) is the federally authorized Metropolitan Planning Organization (MPO) for the 13-county northern New Jersey region. Each urbanized region of the country is required to establish an MPO in order to qualify for the receipt of federal transportation funding. The NJTPA serves a region of 6.5 million people, one of the largest MPO regions in the country. The NJTPA evaluates and approves proposed transportation improvement projects. It also provides a forum for cooperative transportation planning efforts, sponsors transportation and planning studies, assists county and city planning agencies and monitors the region's compliance with national air quality goals.

The 20-member NJTPA Board of Trustees is composed of local elected officials from each of the region's 13 counties and from the region's two largest cities, Newark and Jersey City. It also includes representatives of state agencies and the Governor's office. NJTPA's host agency is the New Jersey Institute of Technology. More information about the NJTPA is available at www.njtpa.org.

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EXECUTIVE SUMMARY

There is consensus within the global scientific community that the earth's climate is changing due in large part to the abundance of greenhouse gases (GHG) in the atmosphere. The global concentrations of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) have increased markedly as a result of human activity, mainly due to fossil fuel use. If steps are not taken to reverse these trends, the increased levels of greenhouse gases in the atmosphere are expected to have severe adverse effects on natural and human systems, including the transportation system.

The North Jersey Transportation Authority (NJTPA) has taken a leadership role in developing a region-wide GHG Inventory and Forecast (I&F) project. The purpose of conducting this project was to measure the amount of GHG emissions occurring in the NJTPA region and determine which sources emit the greatest amount of GHG emissions. This is a substantial first step in a multi-year climate change initiatives program and provides a baseline for comparison and quantification of proposed emissions mitigation actions.

The GHG inventory and forecast covers all greenhouse gas sources, including the use of electricity, the consumption of fuel use, the combustion of gasoline and diesel fuel in transportation, emissions from the industrial and fossil fuel industries, agricultural activities, and changes in land use. This project provides GHG emission estimates for the six primary GHG gases; Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), Sulfur Hexafluoride (SF_6), Hydroflourocarbons (HFCs), and Perflourocarbons (PFCs). This inventory estimated GHG for the 2006 base year and projected GHG emissions through the year 2050. The GHG I&F project also estimates GHG emissions for the counties and municipalities within the NJTPA region, allowing local governments the ability to conduct their own GHG inventory and mitigation planning. Furthermore, a GHG Management web-based tool was developed by NJTPA to facilitate the sharing of GHG emissions data with county and municipal planners.

The NJTPA GHG inventory was developed utilizing two accounting methods: direct emissions and consumption-based emissions. Direct emissions are defined as those emissions that take place within the NJTPA region. GHG gases emitted from landfills and from the combustion of motor fuels in automobiles are examples of direct emissions. Consumption-based emissions are those emissions associated with a product or process, such as the generation of electricity. Since a significant amount of the electricity consumed within the NJTPA region is generated outside of New Jersey, the consumption-based method estimated the emissions associated with that electricity even though it was generated elsewhere. The NJPTA also estimated the greenhouse gases associated with the upstream production of a product or process, called energy-cycle emissions, which include emissions associated with material extraction, processing, and transport. For example, the extraction, distribution, and refining of gasoline is often not considered in the direct emissions accounting, but is included in a consumption/energy cycle accounting method. Measuring greenhouse gas emissions by using both methods provide a more nuanced and complete picture of where greenhouse gas are being emitted and provides additional guidance on what GHG mitigation measures may be pursued.

Greenhouse Gas emissions in the NJTPA region were estimated at 86 million metric tons CO_2 equivalent ($MMtCO_2e$) in 2006. The emissions are forecasted to increase by 14% to approximately 98 $MMtCO_2e$ by 2050. These emissions were estimated by measuring direct GHG emissions for all sectors except for the electricity sector, which are consumption-based emissions. This method of calculating GHG emissions is a commonly accepted practice in many State, regional, and local GHG emission inventories, and is consistent with the methodology of other Metropolitan Planning Organizations. . The consumption of electricity by homes, businesses, and industry contributed to 36% (30MMTCO2e) of all GHG emissions in the region. The use of natural gas, oil, and other fossil fuels for homes, businesses and industry contributed to 28% (24 MMTCO2e) of all greenhouse gases emitted in the region. The combustion of gasoline and diesel fuel in the transportation sector also contributed to 28% (24 MMTCO2e) of the region's greenhouse gas emissions. These three sectors amount to 92% of all greenhouse emissions in the region. Other sectors contributed relatively small amounts to the region's GHG emissions.

Estimating GHG emissions on a consumption basis and considering the upstream greenhouse gas emissions in the energy-cycle, emissions in the NJTPA region exceeded 107 $MMtCO_2e$ in 2006. The consumption of electricity by homes, businesses, and industry still contributes the largest amount of GHG emissions at 31% (33MMTCO2e) by sector in the NJTPA region. The use of natural gas, oil, and other fossil fuels for homes, businesses and industry contributed to 26% (28 MMTCO2e) and the combustion of gasoline and diesel fuel in the transportation sector contributed to 19% (20 MMTCO2e) of the region's greenhouse gas emissions. While these three sectors still account for the majority (76%) of the emissions within the NJTPA region, emissions from other sectors became more prevalent. For example, GHG emissions from the solid waste sector contributed 11% (12MMTCO2e) as compared with 2% in the Direct Emissions inventory. Industrial Processes related to the production of steel and cement contributed to 12% (13MMTCO2e) of the region's emissions. Region-wide GHG emissions are anticipated to increase by approximately 46% to about 156 $MMtCO_2e$ by 2050, with solid waste constituting the greatest increase in GHG emissions over the time period.

By providing the GHG emissions using both methods of accounting, governments are better informed of the potential GHG benefits of mitigation options aimed at reducing GHG emissions at the local, county, and regional level. These options might include electrical and fossil fuel energy efficiency measures, solid waste source reduction and recycling, building materials substitution, and reduction of transportation-related emissions.

1. INTRODUCTION AND GENERAL APPROACH

1.1 Background

The 2007 report of the United Nations Intergovernmental Panel on Climate Change crystallized the overwhelming consensus within the global scientific community that the earth's climate is changing due in large part to the abundance of greenhouse gases (GHG) in the atmosphere. The global concentrations of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) have increased markedly as a result of human activity, mainly due to fossil fuel use and land use changes. CO_2 is the predominant anthropogenic GHG (emitted as a result of human activity), with concentrations increasing from a pre-industrial value of about 280 parts-per-million (ppm) to current atmospheric concentrations of 390 ppm.

The increased levels of GHGs in the atmosphere are seriously detrimental to the ecosystems and environment of the world, and are expected to have severe adverse effects on natural and human systems. Ultimately, if steps are not taken to reverse these trends, the effects on humans, other animals, and plant life on Earth may be catastrophic.

The heavy reliance on and rapid consumption of fossil fuels, is the largest contributor to the increase in GHG concentrations. In recent years, transportation has been the fastest growing source of GHG emissions in the nation and its dependence on fossil fuels raises concern among scientists, policy-makers, and citizens that this energy supply not sustainable. Recent reports from the International Energy Administration predict a peaking of conventional oil resources within the next 20 years, with a greater reliance on more expensive and non-traditional sources of fossil fuels, which are associated with increased environmental impacts. This profound transformation will create mobility problems in the region's transportation sector resulting from increasing uncertainty in the availability and cost of fossil fuels.

In response to these concerns, the *New Jersey Global Warming Response Act* (GWRA), enacted in 2007, mandates the reduction of GHG emissions to 1990 levels by 2020, and to 80 percent below 2006 levels by 2050. The *Global Warming Response Act Recommendation Report* (December 2009), provides an outline of actions to be taken toward achieving these goals, including actions in the transportation and planning sectors. The *Regional Greenhouse Gas Initiative (RGGI)*, a mandatory market-based effort by ten Northeastern and Mid-Atlantic States, seeks to reduce CO_2 emissions from the power sector by 10 percent by 2018.

The North Jersey Transportation Planning Authority, Inc. (NJTPA) has a role in coordinating, evaluating, and advancing such efforts in northern New Jersey. As the first step in this process, NJTPA retained a consultant team led by E.H. Pechan and Associates, Inc. (Pechan) and AKRF, Inc. (AKRF) to prepare a GHG inventory and forecast (I&F) for the NJTPA region.

1.2 Objective

A GHG inventory is an accounting of GHGs emitted (sources) or removed from (sinks) the atmosphere over a period of time. Developing a region-wide I&F represents a substantial first step in NJTPA's multi-year climate change initiatives program, which also includes mitigation and adaptation research and planning, conducting an inventory of climate vulnerable facilities within the region, and the creation of a framework for incorporating climate impacts into evaluation criteria for programs and project selection and prioritization. This GHG I&F will form the foundation for such activities in the NJTPA region, by providing a baseline for comparison and quantification of any proposed emissions mitigation actions.

The NJTPA I&F includes both sources and sinks of GHGs and provides emission estimates for all six Kyoto Protocol gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6) at the regional, county, and municipal levels. Emissions were analyzed for a 2006 baseline year—the year used to define GWRA's long-term emissions reduction goal, and also the base year used for the *Plan 2035* analysis, which is central to this effort. Emissions were allocated to the NJTPA subregions (counties) and municipalities to the extent practicable, and forecast for the years 2020, 2035, and 2050. The I&F presents GHG emissions from fuel consumption in the residential, commercial, industrial sectors; electricity production; the transportation sector, including on-road, non-road, aviation, marine, and rail (including freight); industrial processes; agricultural sources, including soils, manure and livestock; solid waste management; wastewater treatment and land use, land use change, and forestry.

The NJTPA I&F is designed to support the future analysis of mitigation efforts in the 13 counties and 385 municipalities within the NJTPA region, presented in Figure 1-1. The I&F will help state, regional, and local policy makers and citizens understand the sources of GHG emissions and facilitate well-informed policy decisions to reduce those emissions.

1.3 Approach and Accounting Methods

To inform the approach to the regional GHG I&F for NJTPA, a review of other GHG inventory and forecast (I&F) projects was conducted. The project team reviewed inventories prepared at the municipal, regional, state, and national levels,[1] including the Delaware Valley Regional Planning Commission (DVRPC) GHG inventory,[2] a GHG inventory project developed for the Washington, DC Council of Governments (WashCOG),[3] the state of New Jersey's inventory and forecast,[4] and work

[1] E.H. Pechan & Associates, Inc., AKRF, Inc., *"NJTPA Regional Greenhouse Gas Emissions Inventory and Forecast: Final Protocol"*, prepared for the North Jersey Transportation Planning Authority, Newark, JJ, 2010, http://www.njtpa.org/Plan/Element/Climate/documents/NJTPAIFProtocolFinal.pdf.

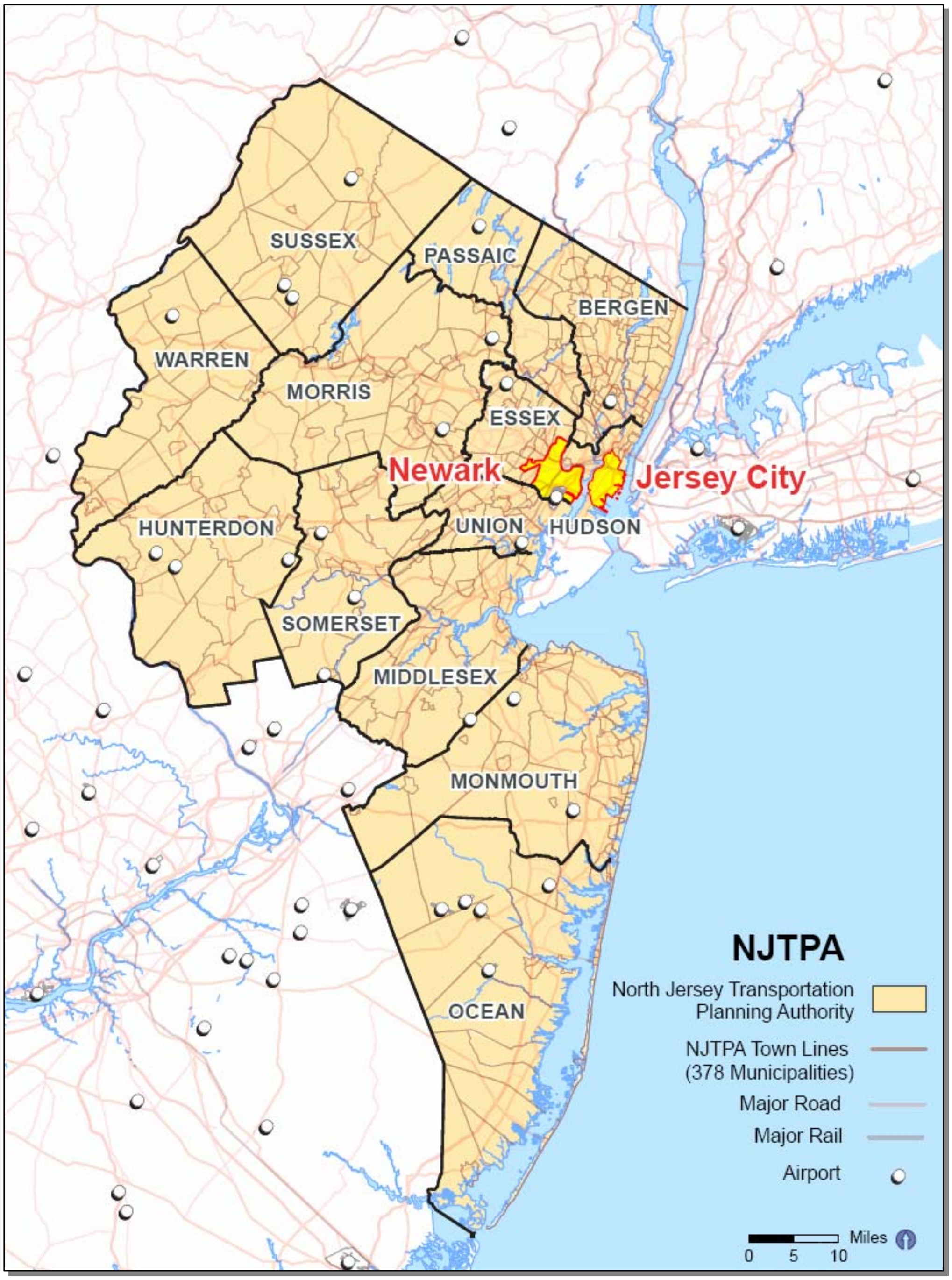
[2] DVRPC *Regional Greenhouse Gas Emissions Inventory*, March 2009, revised December 2010 http://www.dvrpc.org/energyclimate/Inventory.htm.

[3] *National Capital Region, Climate Change Report,* prepared by the Climate Change Steering Committee for the MWCOG Board of Directors, adopted November 12, 2008, downloaded from: http://www.mwcog.org/uploads/pub-documents/zldXXg20081203113034.pdf. A draft I&F memo is located here: http://www.mwcog.org/uploads/committee-documents/tVZXWls20071126113742.pdf.

[4] *New Jersey GHG I&F*, http://www.nj.gov/globalwarming/home/documents/pdf/20081031inventory-report.pdf. Note that these estimates do not include CO_2 emissions from the applications of limestone/dolomite and urea.

related to regional GHG inventories at the federal level by the US Environmental Protection Agency (EPA).[5]

Figure 1-1. Map of NJTPA Subregions and MCDs



[5] U.S. Environmental Protection Agency, Draft Regional Greenhouse Gas Inventory Guidance, January 2009.

The GHG Inventory and Forecast (I&F) for the NJTPA region is intended to provide clear information to help planners determine where to focus mitigation actions that will reduce GHG emissions both directly and indirectly, through reductions in consumption of some GHG-emitting product or process. The Project Team developed an approach, based on currently accepted practices, to facilitate future mitigation and adaptation efforts by presenting the emissions in two accounting methods:

1. **Direct emissions**. Direct emissions occur at the source of emissions (e.g., exhaust stack, tailpipe, landfill). This accounting method enables clear identification of sources, is well suited for estimating total emissions, and avoids double-counting, and is therefore often used in regulatory settings and for emissions trading purposes. In some instances, mitigation is focused on the source and therefore this accounting method can also be used for source-mitigation estimates.

2. **Consumption-based emissions and full energy-cycle emissions**. Consumption-based emissions represent emissions associated with the consumption of a product or process. For example, the use of electricity in any household or business will be associated with consumption-based emissions even if the power is produced outside of the NJTPA region. Another example is transportation; the consumption-based emissions associated with any trip are allocated to the origin and destination of the trip (half of the emissions to each location)—the 'consumption' in this example is the generation of the trip. Consumption-based and energy-cycle analysis are important components of mitigation analysis, enabling the comparison of the full emissions benefits associated with potential mitigation programs focused on consumption or activity (particularly in the electricity, transportation, and waste management sectors).

   Energy-cycle emissions are the emissions associated with upstream activity, including fuel extraction or production, processing and transport. The energy cycle emissions are important for accounting for the differences between various fuels, including biofuels and standard fuels. Since the energy-cycle emissions were prepared for the consumption-based method only, these emissions should not be added to the direct emissions results.

The consumption-based inventory captures indirect emissions occurring as a result of consumption but not occurring at the point of consumption. For example, lowered consumption of electricity indirectly reduces power plant emissions by reducing electricity demand. In the waste management sector, waste reduction/re-use/recycling programs reduce the need to landfill waste and also reduce emissions from extraction and production of virgin materials. For another example, vehicular consumption-based emissions are associated with the trip origin and destination, rather than along the entire trip route (roadway).

A consumption-based approach plus energy-cycle emissions may best fit the needs of planners by providing clear information to help them identify where they should focus efforts to reduce GHG emissions both directly and indirectly. However, many existing inventories, including the New Jersey I&F and the U.S. Environmental Protection Agency (EPA) national inventory, have been developed primarily on the basis of direct emissions, and some mitigation benefits goals may be better measured on that basis. Furthermore, direct emissions are the only way to prepare inventories that can be added together cumulatively without double-counting emissions, providing the more precise accounting needed for regulatory applications such as emissions trading. The NJTPA approach is consistent with these other efforts, yet adds the benefits of providing additional information using the consumption-based accounting method and its associated energy-cycle emissions.

Therefore, when future emissions mitigation options are considered, both direct and indirect reductions can be evaluated using the two accounting formats in this I&F:

- *Direct GHG reductions:* the result of **reducing emissions at the source**. For example, landfill methane collection and combustion, power plant upgrades, and addressing industrial process emissions at the source.

- *Indirect GHG reductions:* the result of **reducing consumption** of some GHG-emitting product or process. For example, lowered consumption of electricity indirectly reduces power plant emissions by reducing electricity demand. Similarly, telecommuting reduces vehicular GHG emissions by reducing the need to take a trip to work. Another important example comes from the waste management sector where composting or reduction/re-use/recycling programs reduce the need to landfill waste that would produce methane.

1.4 Guiding Principles

The Inventory and Forecast will facilitate NJTPA's multi-year climate change initiatives program. Since the baseline and forecast emissions will be the basis for making decisions regarding potential mitigation actions, the I&F was designed to anticipate and meet the needs of NJTPA, its subregions (i.e. county governments), and municipal governments, based on the following guiding principles. The transportation sector was given high priority, as were other sectors influenced by planning, such as fuel and electricity consumption and waste management.

Boundaries:

Boundaries for the I&F were the geographic boundaries of the MPO/subregion/MCD. The level of effort was focused on achieving a higher level of detail for sectors directly under the influence of NJTPA as well as sectors that could be addressed by subregions, and municipalities.

- ***Direct emissions*** are allocated to the MCD where the emissions occurred and within the year in which they emitted.

- ***Consumption-based emissions*** are allocated to the location where the consumption-based activity occurred (e.g., trip origin/destination, point of waste generation) and the full set of emissions, including energy-cycle and other upstream emissions, are assumed to occur within the same year. Note that the emissions themselves may occur in other geographic regions and may be prior to the activity itself.

Sectors:

The approach was comprehensive in terms of sector coverage, but not all encompassing. The level of detail for each sector was tailored to meet municipal-scale GHG planning needs. Emissions were inventoried for the following sectors:

- **Electrical Power Production and Use**—emissions associated with the use of fuels for electricity production.
- **Residential, Commercial and Industrial Fuel Use**—emissions from fuel used for building heat and hot water, as well as fuel for industrial processes, including natural gas, fuel oil, kerosene, liquefied petroleum gas, wood, coal, landfill gas, solid waste, and digester gas.
- **Transportation**—emissions from motor vehicles that typically travel on public roads, such as passenger cars and trucks, motorcycles, commercial trucks, heavy-duty vehicles, and buses. Also included are emissions from aircraft, rail, and marine vessels. These sources may be fueled by gasoline, diesel, or other alternative fuels.
- **Industrial Processes**— emissions from industrial activities, excluding combustion of fuels and electricity use; emissions include CO_2, CH_4, SF_6, HFCs, PFCs, and N_2O released as by-products, and from the direct use of refrigerants, CO_2, and SF_6.
- **Fossil Fuel Industry**—direct emissions associated with the processing and distribution of crude oil and natural gas. As with the Industrial Processes sector above, these cover non-combustion sources (fuel combustion is captured in the RCI sector).
- **Agriculture**—emissions associated with production of crops and livestock management, excluding fuel combustion, plus emissions from agricultural non-road engines.
- **Land Use, Land Use Change, and Forestry (LULUCF)**—include net CO_2 flux from forested lands and urban forests, plus emissions of N_2O from non-agricultural fertilizer application. The CO_2 flux in any given area could represent a net source or a net sink.
- **Solid Waste Management**—direct emission sources include solid waste landfills, waste combustion, and composting operations. Emissions include: CH_4 from solid waste landfills; CO_2, CH_4, and N_2O from waste combustion;[6] and CH_4 and N_2O from composting operations. Composting operations also represent a carbon sink. Consumption-based sources would include the waste management processes mentioned above and also capture emissions from waste recycling.

[6] Emissions from waste combustion for energy purposes (e.g., waste to energy plants) will be captured in the applicable fuel use sector (e.g., electricity production). Where energy from waste combustion is not captured for use, those emissions would be addressed here (e.g., backyard burn barrels). Note: according to the New Jersey I&F, there is no waste combustion occurring in the state other than waste to energy plants.

- **Wastewater Treatment**—direct emissions include CH_4 and N_2O process emissions from municipal and industrial wastewater treatment facilities. Consumption-based emissions capture these process emissions as well as the electricity consumed by wastewater treatment processes.

Base Year:

The Team used 2006 as a base year, the year used to define GWRA's long-term emissions reduction goal, and also the base year used for the *Plan 2035* analysis, which is central to this effort. Although future year emissions were estimated using growth assumptions relative to the base year, in cases where more recent data (some as recent as 2009) were available and where it was practicable, more recent data were included as well. In cases where 2006 data were not available, base year emissions were calculated by back-casting using the available growth assumptions.

Gases Included:

CO_2 and all other Kyoto gases were included to the extent practicable. Emissions of the various GHGs were added together and presented as carbon dioxide equivalent (CO_2e) emissions—a sum which includes the quantity of each GHG weighted by a factor of its effectiveness as a GHG, using CO_2 as a reference.

Forecast:

Demographic and other information from *Plan 2035 Regional Transportation Plan for Northern New Jersey*, adopted in August 2009, was used to forecast greenhouse gas emissions in several source sectors, including the electricity, direct fuel use, transportation, solid waste, and wastewater sectors. Energy consumption reduction goals of the 2008 New Jersey Energy Master Plan and GHG reduction targets the Regional Greenhouse Gas Initiative were included in forecasts of the electricity sector. It should be noted that forecast assumptions have changed during this project. For example, construction of the ARC (Access to the Region's Core) Tunnel was included in transportation sector emissions forecast. Additional Detailed demographic data used in developing the GHG emissions forecast are included in the Technical Appendix. designed to support the future analysis of mitigation efforts in the 13 counties and 385 municipalities within the NJTPA region, presented in Figure 1-1. The I&F will help state, regional, and local policy makers and citizens understand the sources of GHG emissions and facilitate well-informed policy decisions to reduce those emissions.

General Methods and Data Sources:

The best sources available were identified and used to the extent practicable, by reaching out to all involved and relevant entities. The methods were based on existing international and national guidance, and build on existing work done at the national, state, and municipal levels, including the *Draft Regional GHG Inventory Guidance Report* from EPA ("*Draft EPA Regional Guidance*"). The inventory provides data useful to future analyses of mitigation actions by municipal planning organizations (MPOs), subregions and municipalities. Examples include evaluating vehicle trip reduction, solid waste reduction/re-use/recycling programs, energy used for municipal water and wastewater, and options for freight movement. It presents the total emissions within each sector, so the full benefit of potential mitigation actions can be evaluated and compared by data users.

Level of Detail:

Emissions were allocated to the extent practicable down to the county and MCD level. The MCDs and subregions are presented in Figure 2-4. In general, emissions were either calculated ‘bottom-up’ (based on specific data that were already geographically allocated), or ‘top-down’ (based on national, county, or state data) and then allocated geographically based on other metrics, such as population or consumption. In some cases—where considerable effort would have been required, where detailed data were not readily available, and/or where limited mitigation would be available at the municipal level—allocation was performed only to the county level (e.g., rail, industrial process).

Allocation:

Emissions were allocated to the NJTPA subregions and municipalities to the extent practicable. Note that in some cases it was not practicable to allocate down to the subregion or MCD level (e.g., non-road equipment), and therefore, even within a given sector, some emissions may be allocated only at the county level (e.g., rail, industrial process).

For the consumption-based method only, the emissions associated with energy production and transport, or “energy-cycle emissions”, are included as well.

As it pertains to both spatial and temporal boundaries—

- Direct emissions are allocated to the MCD where the activity (e.g., fuel combustion) occurred and within the year in which it occurred.
- Consumption-based and energy-cycle emissions are allocated to the location where the consumption-based activity occurred (e.g., trip origin/destination, point of waste generation) and the full set of emissions, including energy cycle emissions, are assumed to occur within the same year.

In most cases, the allocation of emissions is different for the direct and the consumption-based approach (the methods are discussed for each sector in the relevant section). Residential, commercial, and industrial fuel consumption emission estimates are the same for both the direct and consumption based approaches, as are non-road emissions in all sectors, since the emissions occur at the same location as the activity. In the following cases, the consumption-based approach includes the allocation of emissions from outside of the region for use within the region:

- Emissions associated with production of steel and cement outside of the NJTPA region for use in the NJTPA region were included in the consumption-based Industrial Process sector emissions (including process and energy emissions).
- The embedded emissions for materials that enter the solid waste stream were included within the consumption-based estimates for the waste management sector. The consumption-based estimates also capture the effects of waste exports/imports in that the emissions are assigned to the point of generation, not waste management. Similarly, wastewater treatment emissions

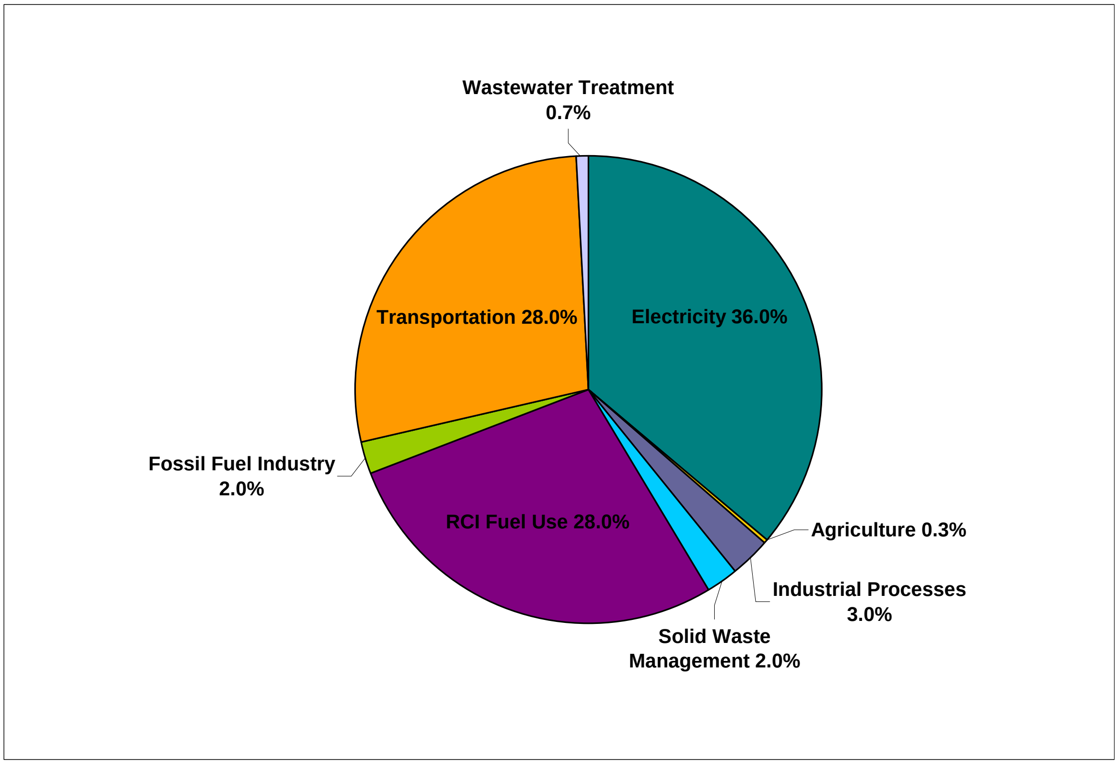
2. NJTPA REGIONAL EMISSIONS

An overview of the region-wide GHG emissions inventory for 2006 and forecast inventory through 2050 are presented in this section. See Section 3 for a description of the accounting methods and detailed results by sector.

2.1 Emissions Inventory

The direct emissions inventory includes all source/sink sectors. For this effort, the consumption-based inventory focused only on those sectors normally identified in GHG inventories and having significant opportunity for reduction through actions aimed at reducing consumption: electricity, fuel use, transportation, industrial processes, and waste. The base year inventory shown in Figure 2.1-1 below is based on direct emissions, except for the electricity sector, which is shown as consumption-based (i.e., emissions associated with the consumption of electricity in the region). This figure shows gross emissions in that the Land Use, Land Use Change & Forestry (LULUCF) sector sink is not included.[8] The total 2006 emissions are nearly 86 $MMtCO_2e$.

Figure 2.1-1. 2006 NJTPA Regional Inventory of Direct GHG Emissions (85,836,959 tCO_2e)

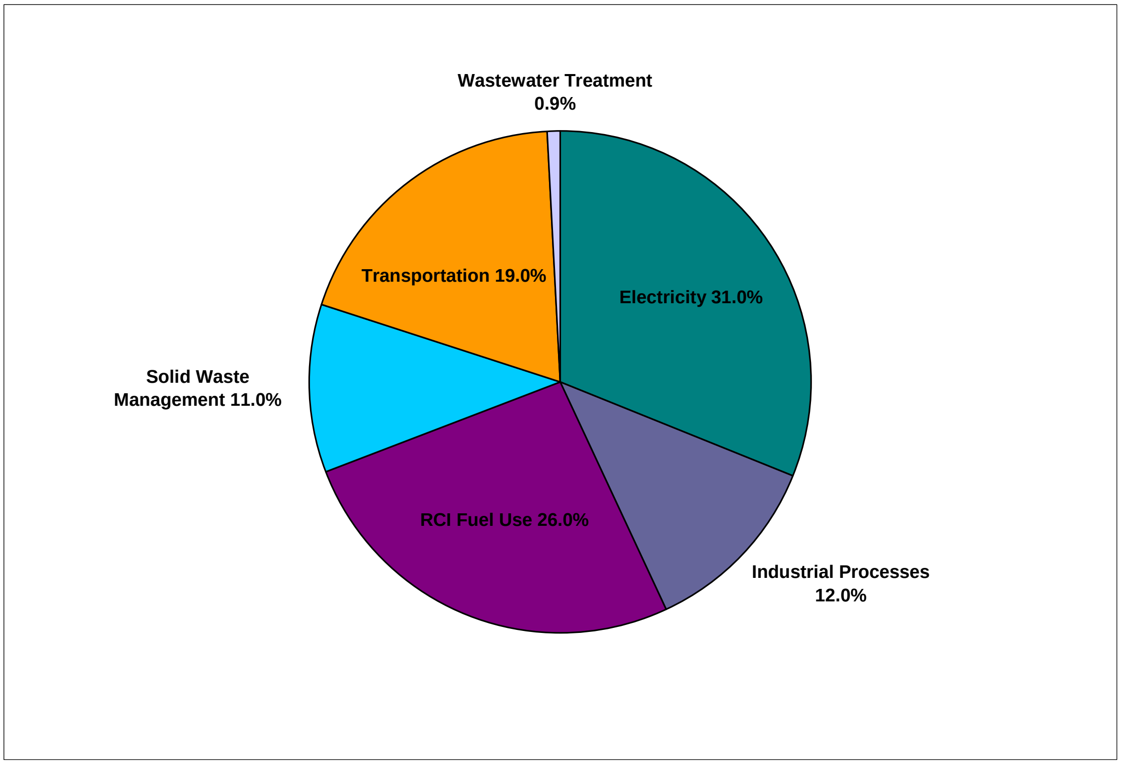


Note: Electricity sector emissions are on a consumption-basis.

[8] As discussed further in Chapter 3 and the Technical Appendix sections for the LULUCF sector, the total regional emissions for the sector are actually positive based on a very high estimate of carbon losses in the forest sector for Sussex County. The Team recommends additional work on the Forestry subsector under LULUCF to determine the validity of these initial estimates.

Figure 2.1-2 shows a comparison pie chart showing sector contributions only using a consumption-basis and adding in the energy-cycle emissions. Base year 2006 emissions are shown to be over 107 $MMtCO_2e$ on this basis.

Figure 2.1-2. 2006 NJTPA Regional Inventory of Consumption-Based + Energy-Cycle GHG Emissions (107,034,556 tCO_2e)



Note: no consumption-based inventories for the agriculture and forestry sectors were prepared for this project.

As expected, on a direct basis (except electricity), the inventory is dominated by three sectors: Transportation (28 percent); Electricity Consumption (36 percent); and Residential, Commercial, and Industrial (RCI) Fuel Use (28 percent). On a consumption-basis (including the energy-cycle emissions), the contributions by sector are quite different. Emissions in the Industrial Processes (12 percent) and Solid Waste Management (11 percent) sectors represent a larger share of the emissions than in the direct emissions inventory. Note that these pie charts could look quite different if they were constructed for a specific county or municipality in the region.

2.2 Emissions Forecast

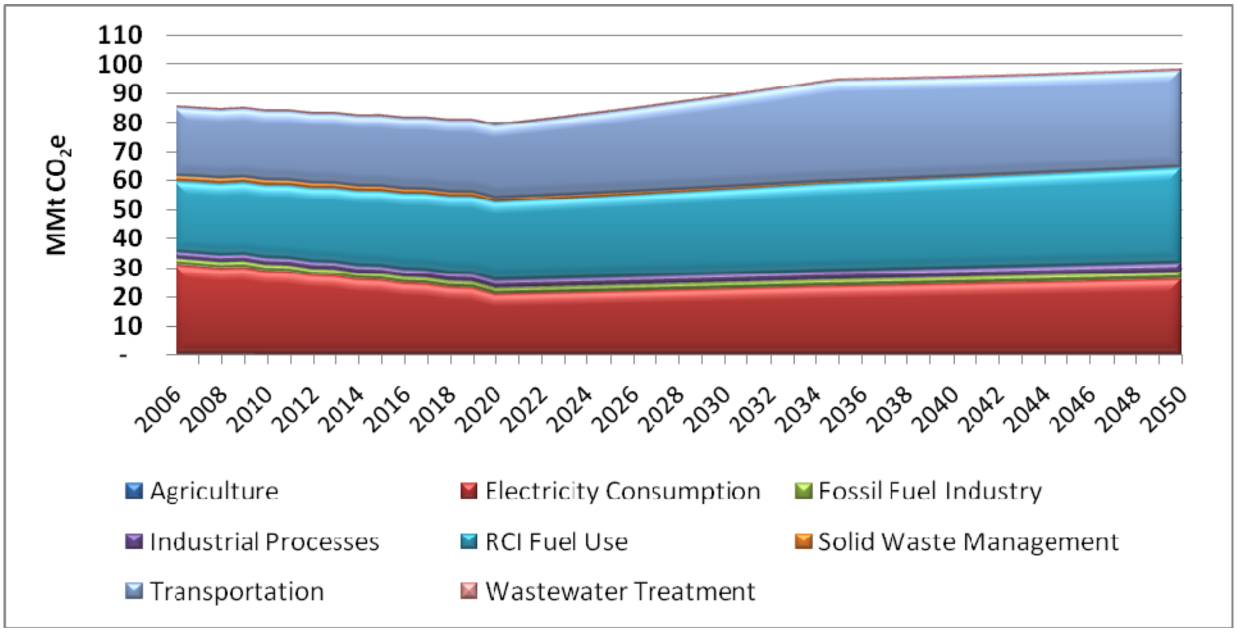
The NJTPA regional GHG forecast is shown in Figure 2.2-1 below. This forecast is shown on a gross basis, which excludes the Land Use, Land Use Change & Forestry (LULUCF) sector and the associated carbon sinks. It captures direct emissions for all sectors, except for electricity, which is included on a consumption-basis (thus including emissions from out-of-region electricity production for consumption in-region). Regional gross direct emissions increase from about 86 MMtCO_2e in 2006 to around 98 MMtCO_2e in 2050. For comparison, the NJ state forecast, prepared by the New Jersey Department of Environmental Protection (NJDEP), is shown in Figure 2.2-2 below. NJDEP's state-level forecast ranges from around 145 MMtCO_2e in 2005 to about 165 MMtCO_2e in 2020. Direct comparisons of emissions estimated for each sector between the two inventories shouldn't be made due to a number of differences in methods and data sources. A comparison of inventory totals would seem to indicate that the NJTPA region contributes about 60% of the state's total. While a comparison of inventory totals is more reasonable, due to the methodological and data source differences just noted, the reader is cautioned against making such comparisons of the regional, county, or municipal level inventories from this project to the NJ state inventory.

Note that the NJTPA electricity sector emissions, presented in Figure 2.2-1, decline significantly prior to 2020, while accounting for growth; this is a result of the renewable portfolio standard (RPS) which requires each supplier/provider serving retail customers in NJ to produce 22.5 percent of electricity it sells in NJ from qualified renewable sources by 2020, and also as a result of the implementation of the Energy Master Plan, which has a goal to reduce to reduce energy consumption by 20 percent by 2020 as compared to the 2020 energy consumption expected without the Plan.

Figure 2.2-3 provides a different view of the regional forecast using a consumption-based approach and including estimates of the upstream energy-cycle emissions for each sector. Regional emissions are about 107 MMtCO_2e in 2006 and are forecast to be around 156 MMtCO_2e by 2050.

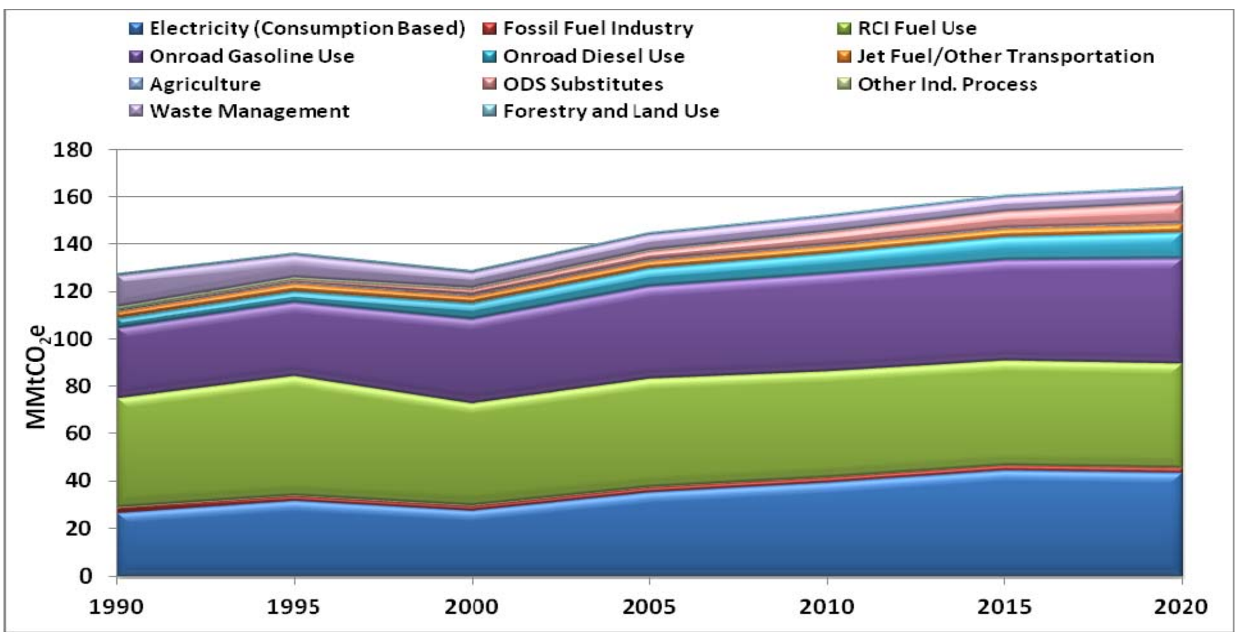
As with the direct emissions forecast, the consumption-based + energy-cycle emissions profile can look much different in specific counties or municipalities based on the mix of sources present. The data developed for this project provide a great deal of flexibility for users to construct carbon footprints that best fit the needs of their planning processes. For example, a user can develop a carbon footprint based strictly on direct emissions, consumption-based emissions, or a hybrid footprint which uses a mix of accounting methods. Standard practice for local to state-level GHG mitigation projects has been to develop a forecast similar to that shown in Figure 2.2-1 below using direct emissions for all sectors, except electricity. However, the users of the NJTPA data now have the ability to better understand the ramifications of selecting one method of inventory development (point of view) over another, and to select the approach (or approaches) that best represent the proposed mitigation efforts. Indeed, some users might elect to develop more than one footprint for use within a mitigation planning project.

Figure 2.2-1. NJTPA Regional Forecast of Direct Gross GHG Emissions



Note: This is a direct emissions forecast (except for the consumption-based electricity sector). Emissions forecasts were determined for 2020, 2035, and 2050. Interim years are straight-line projections between forecast years.

Figure 2.2-2. New Jersey Gross GHG Direct Emissions by Sector, 1990-2020[9]



Note: This is a direct emissions forecast (except for the consumption-based electricity sector). This chart was supplied by NJDEP.

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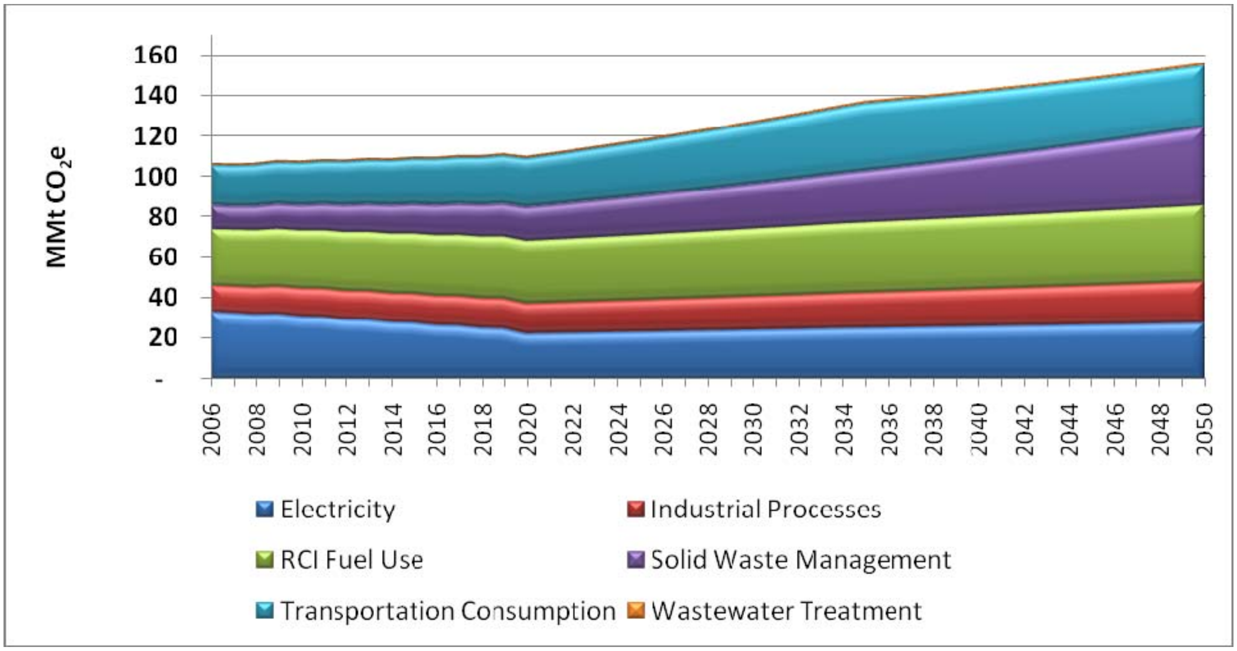
[9] Strait, R., S. Roe, B. Dougherty, and M. Mullen, *Draft New Jersey Greenhouse Gas Inventory and Reference Case Projections 1990-2020,* prepared by the Center for Climate Strategies, prepared for the New Jersey Department of Environmental Protection, October 2007. *This draft contains the same data, including the chart above, from NJDEP's 2008 I&F available at: http://www.nj.gov/dep/oce/gqi.htm.*

Figure 2.2-3. NJTPA Regional Forecast Using a Consumption-Based + Energy-Cycle Approach



Note: Energy-cycle emissions for the Industrial Processes sector are included in these consumption-based estimates.

3. INVENTORY METHODOLOGY AND DETAILED RESULTS

An overview of the methods used to prepare the inventory is presented here, as well as summary results by sector. For more details on the analysis methods and data sources, see Appendix A. The general approach and methods common to all sectors are presented in Section 1, above.

3.1. Electrical Power Production and Use

Source Description

The electricity sector inventory was prepared using both the direct and consumption/energy-cycle accounting methods. Emissions from electricity production and consumption stem mainly from the combustion of fossil fuels used in generating electricity. In New Jersey, the fuels used for most of the electricity generation in 2006 were nuclear (53.7 percent), natural gas (25.8 percent), and coal (17.9 percent).[10] Imported electricity may include electricity produced from other fuel sources. The most significant GHG emitted through electricity generation and consumption is CO_2. CH_4 and N_2O are emitted as well and are included in the inventory.

Analysis Methods

Direct Emissions

Direct electricity emissions are associated with the use of fuels for electricity production occurring at the point of combustion. The NJDEP point source GHG emissions inventory was used in developing the emissions resulting from electricity production in the NJTPA region, by selecting point sources that were engaged in power production located in the NJTPA region. EPA's Clean Air Markets Database (CAMD) and the Emissions & Generation Resource Integrated Database (eGRID) information were used to verify facility locations and to cross check the information reported to NJDEP.[11]

Consumption-Based Emissions

The consumption/energy-cycle based inventory considers the emissions from all electricity used throughout the NJTPA region, regardless of where it is produced and is well suited for estimating the benefits of mitigation efforts targeted at reducing emissions from electricity consumption at the local, county, and regional levels.

Based on the New Jersey I&F for 2005, 26 percent of the electricity consumed in the State is imported. The emissions resulting from electricity consumed in the NJTPA region include the emissions from electricity generated within the region and the emissions imported into it. Four utility companies, one rural cooperative, and several municipal utilities deliver electricity to the NJTPA region. Annual

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[10] 2006 Report, Table 5 for NJ http://www.eia.doe.gov/electricity/st_profiles/e_profiles_sum.html

[11] The Emissions & Generation Resource Integrated Database for 2007 (eGRID2007), http://www.epa.gov/cleanenergy/documents/egridzips/eGRID2007V1_1_year0504_STIE_USGC.xls, prepared for EPA by E.H. Pechan and Associates, Inc, September 2008.

consumption data were requested from the utilities by geographic area (zip code at metered location, or MCD) and by customer type – residential, commercial, industrial, and municipal. Emissions were calculated from the electricity consumption data using eGRID emission factors for the RFCE subregion, the Mid-Atlantic eGRID subregion. Emissions from energy lost through transmission and distribution were included. Based on eGRID, the transmission and distribution loss in the RFCE subregion is 6.41 percent.

The energy-cycle emissions accounted for the emissions associated with fossil fuel production and transport associated with the consumed electricity. The electricity module of the GREET model was used to develop a factor that accounts for the energy cycle emissions. The input to the GREET model was the RFCE subregion energy source mix in 2005, as reported in eGRID2007. (The 2005 mix is the most recent available. A new version of eGRID based on 2007 data is expected soon, but 2006 will not be available.)

Forecast Method

Direct emissions from electricity production were not forecast, since it is uncertain specifically where power will be produced in the future, which fuels would be used, how much power would be generated at specific power plants, and where new power plants would be sited. The forecast of consumption-based and energy-cycle emissions accounted for several factors. The first was the growth projected for the region. Data for the Financially Constrained scenario from *Plan 2035* was used. Household growth was used to forecast BAU consumption in the residential sector, while employment growth was used to forecast BAU consumption in the commercial and industrial subsectors.

The New Jersey Energy Master Plan goal to reduce energy consumption by 20 percent by 2020 as compared with the BAU scenario was included in the consumption-based and energy cycle projections. It was assumed that the energy efficiency improvements would be implemented gradually up to 2020. Therefore, it was assumed that consumption would linearly decrease through 2020 and then remain constant. The emission factors associated with electricity consumption are expected to decrease as a result of the Renewable Portfolio Standard (RPS), RGGI, and the goals of the New Jersey Energy Master Plan. By 2020, the state's goal is to produce 22.5 percent of its electricity from renewable resources.[12] The goal was included in the NJTPA inventory forecast, by adjusting the RFCE source mix for 2005 to account for the increased proportion of renewable energy in the mix, while maintaining the relative proportions of fossil fuels (mainly oil and gas) and nuclear energy. It was assumed that the RFCE source mix would be comparable to the New Jersey source mix in 2020.

[12] State of New Jersey, Draft New Jersey Energy Master Plan, April 17, 2008.

Inventory & Forecast Results

The direct emissions from electricity production in the NJTPA region are estimated at 11.8 MMtCO_2e in the baseline year 2006. Since the inventory was prepared at a local scale, and the distribution of both increases in power production, due to growth in demand, and decreases due to the regional programs such as RGGI and the Energy Plan are not known for each power production facility, future direct emissions are currently presented as unchanged in future years.

Consumption based emissions were projected accounting for growth in demand as well as expected benefits of RPS and the Energy Plan which result in significant emissions reduction until 2020. The analysis does not currently assume any further benefits of these programs since the programs are not currently in place for future years, and projected growth in emissions post-2020 is a result of projected demographic changes. Figure 3.1-1 shows the consumption-based emissions from the electricity sector by year (excluding energy-cycle emissions). Figure 3.1-2 shows the change in projected energy-cycle electricity emissions for the NJTPA area. Figure 3.1-3 shows the consumption-based emissions by subsector (residential, commercial, industrial), excluding energy-cycle emissions.

Figure 3.1-1 Consumption-Based Electricity Sector Emissions

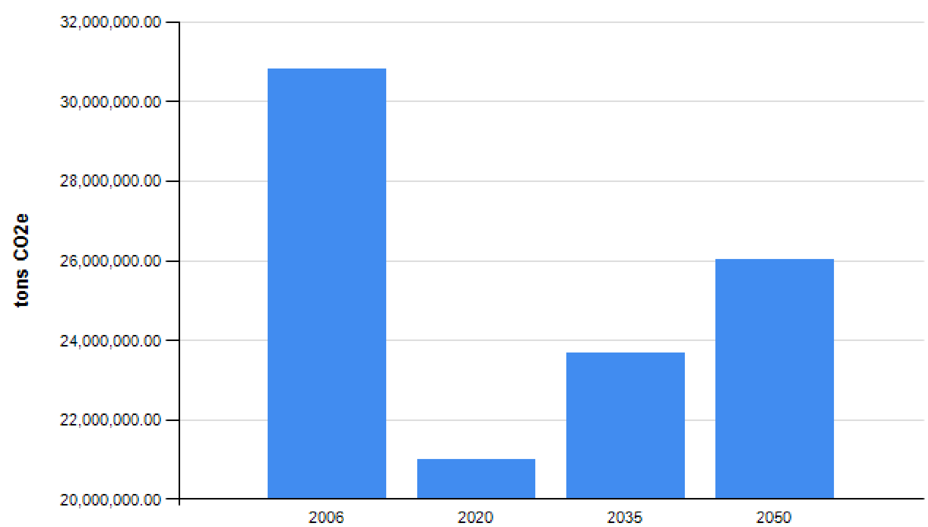


Figure 3.1-2 Electricity Sector Energy-Cycle Emissions

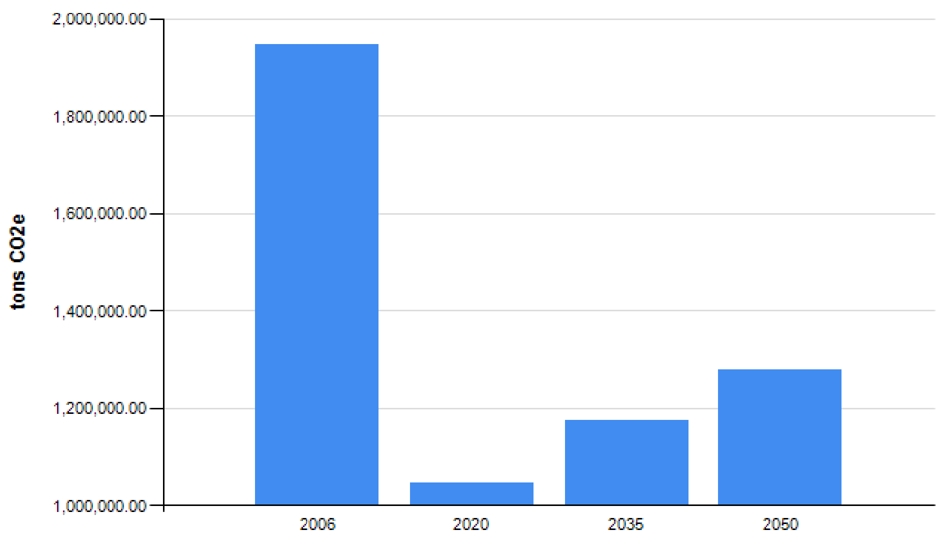
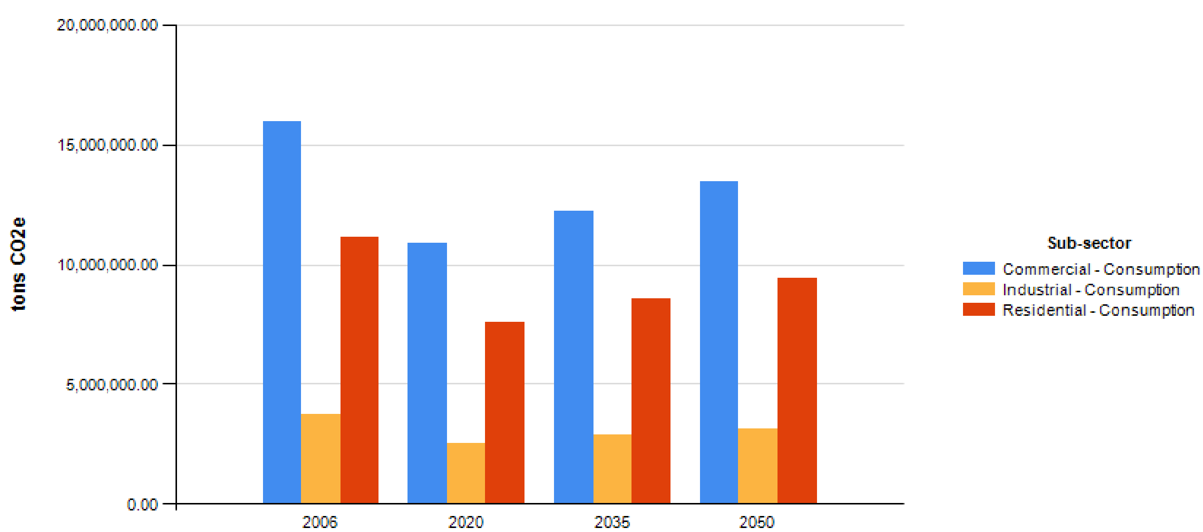


Figure 3.1-3 Consumption Emissions Electricity Sector Emissions by Sub-Sector



3.2. Residential, Commercial and Industrial Fuel Use

Source Description

Direct emissions from fuel use in the residential, commercial, and industrial (RCI) sector include fuel used for building heat and hot water, as well as fuel for industrial processes. The fuel most commonly used in New Jersey by the RCI sector for space and water heating and for industrial processes is pipeline natural gas. Other fuels include fuel oil (residual and distillate), kerosene, liquefied petroleum gas, and wood. Coal, landfill gas, solid waste, and digester gas are used as fuel by some industries. Fuel use for non-road engines in the residential, commercial, and industrial sectors (including construction) are also included here.

Since emissions from direct fuel use occur at the point of consumption, the direct emissions and consumption-based emissions are the same for fuel use in the RCI sector. Note that emissions from electricity production or consumption are not included under the inventory for the fuel use in the RCI sector, as those emissions are accounted for within the electricity sector. Energy-cycle emissions are accounted for and include emissions from fuel extraction, transport, and delivery. The most significant GHG emitted through fuel combustion is CO_2. CH_4 and N_2O are emitted as well and are included in the inventory.

Analysis Methods

Direct Emissions

Three utility companies provide pipeline natural gas to the NJTPA region. Annual consumption of natural gas by zip code of the metered location or by MCD, separated by customer type (RCI), was obtained from the companies. Detailed information on the RCI sector consumption of fuels other than natural gas, most importantly fuel oil, is not easy to obtain. However, for the residential sector, the 2000 Census data and the American Community Survey (2006-2008) include estimates of the number of households in a geographic area using each fuel type (utility gas, fuel oil, coal, wood, solar, etc.).[13] The residential use of fuels other than natural gas was estimated using this information along with the data on natural gas consumption, as reported by the utilities.

Commercial consumption of fuels other than natural gas, and industrial fuel consumption was based on the NJDEP point source inventory, and EIA data for New Jersey, allocated to counties within NJTPA, using data from the NJDEP area source emissions inventory. After estimating the consumption of each fuel by geographic area and subsector, the emission factors from The Climate Registry General Reporting Protocol were used to calculate direct and consumption-based emissions (see Appendix A), with the exception of biogenic sources of CO_2 emissions, which were set to zero.[14]

Emissions from non-road engines associated with each sub-sector were included as well (e.g., lawnmowers in the residential subsector, forklifts in industrial, construction equipment etc.). For methods relating to non-road engines in the residential, commercial, and industrial sectors see the "Recreational Vehicles" section under "Transportation".

[13] U.S. Census Bureau, Census 2000 Summary File 3, House Heating Fuel.

[14] The Climate Registry, General Reporting Protocol (GRP), Default Emission Factors, January 2010, http://www.theclimateregiestry.org/resources/protocols/general-reporting-protocol/#hide.

Consumption-Based Emissions

Since emissions from direct fuel use occur at the point of consumption, the direct emissions and consumption-based emissions are the same for fuel use in the RCI sector.

Energy-Cycle Emissions

Energy-cycle emissions associated with fuel extraction, refining, transport and delivery (upstream emissions) were included for all fuels. Energy-cycle emissions, including upstream emissions for biogenic and fossil fuels, as appropriate, were developed using the GREET model.

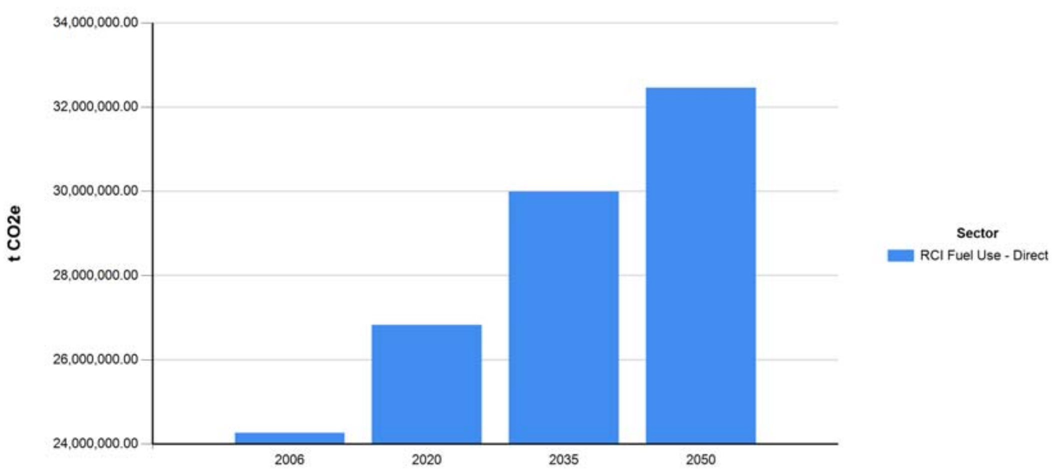
Forecast Method

Plan 2035 demographic data were used to project the change in emissions in future years. Residential consumption was projected to change in direct correlation to the number of households, while commercial and industrial consumption was projected to change in direct correlation to employment.

Inventory & Forecast Results

The total direct/consumption-based emissions from fuel use in the RCI fuel use sector are presented in Figure 3.2-1 (direct and consumption-based emissions are the same in this sector). The contribution by subsector (residential, commercial, industrial) to overall emissions from fuel use in the RCI sector is presented in Figure 3.2-2. The change in projected emissions from direct fuel use for the NJTPA area is shown in Figure 3.2-2. The consumption does not include fuel used to generate electricity, as this consumption was reported as part of the electricity sector inventory.

Figure 3.2-1 NJTPA Region Direct/Consumption-based Emissions from RCI Fuel Use



Note: Since fuel consumption occurs on-site, direct and consumption-based emissions in this sector are the same.

Figure 3.2-2 Energy Cycle Emissions from RCI Fuel Use

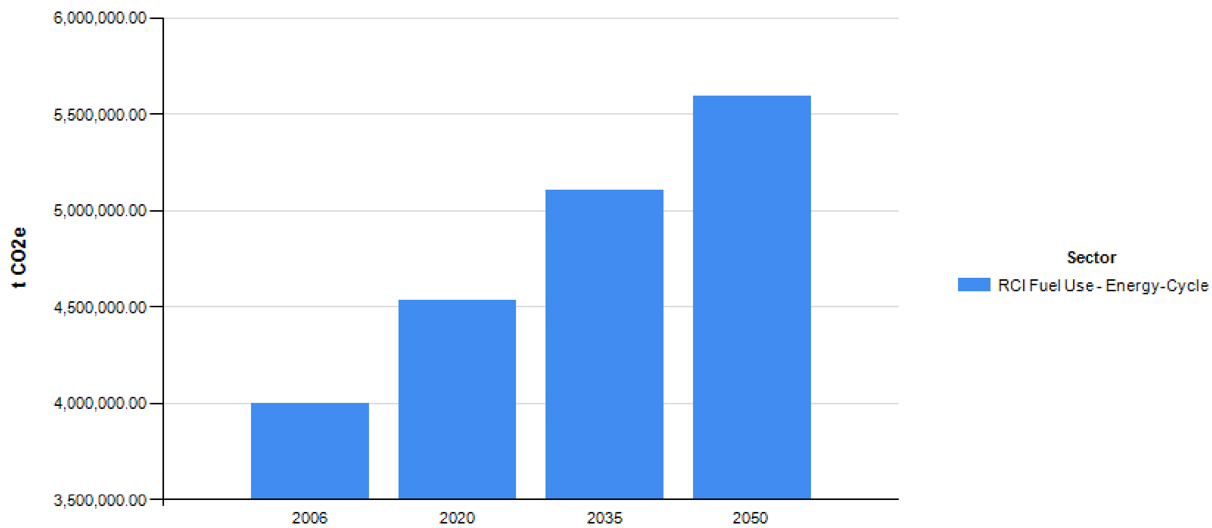
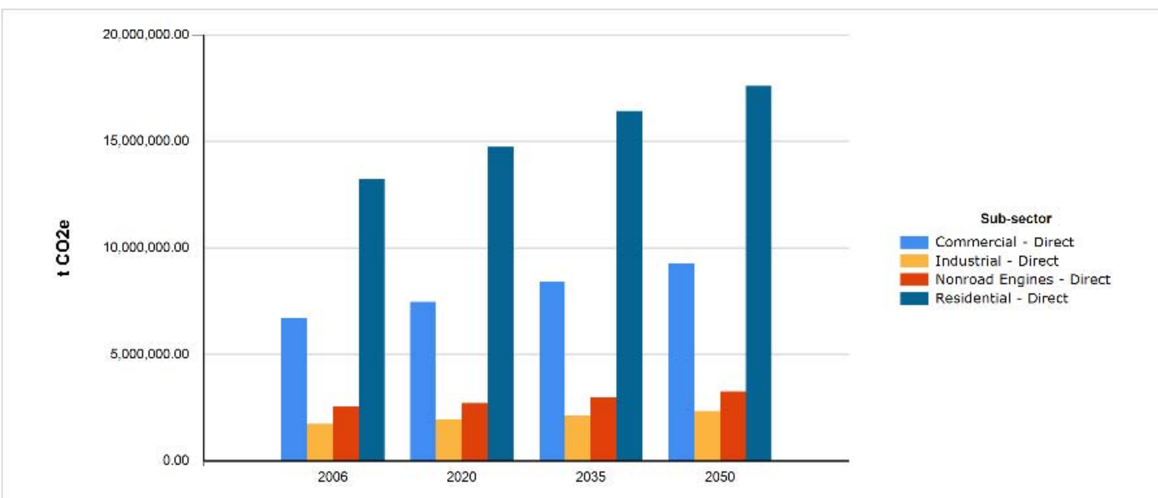


Figure 3.2-3 NJTPA Region Direct/Consumption-based Emissions from RCI Fuel Use



Note: Since fuel consumption occurs on-site, direct and consumption-based emissions in this sector are the same.

3.3. Transportation

On-road Vehicles

Source Description

The on-road (highway vehicles) transportation sector includes motor vehicles that typically travel on public roads. These include passenger cars and trucks, motorcycles, commercial trucks, heavy-duty vehicles, and buses. These vehicles may be fueled by gasoline, diesel, or other alternative fuels. The gasoline used by on-road vehicles in the North Jersey region in all years of the analysis is primarily gasoline with 10 percent ethanol by volume (E10). Although CO_2 is the main GHG emitted from this sector, CH_4 and N_2O are emitted as well. All three pollutants are addressed in the estimation of direct emissions, consumption-based emissions, and energy cycle emissions, which include upstream well-to-pump emissions.

Analysis Methods

Direct Emissions

The on-road vehicle analysis estimates emissions from all privately and publicly-owned vehicles and commercial trucking. All emissions within the NJTPA region were included. Emissions come from fuel combusted in vehicles, including both diesel and gasoline fuels, as well as less common fuels such as ethanol and compressed natural gas. This fuel combustion results in emissions of CO_2, CH_4 and N_2O. Data on direct on-road emissions were provided by NJTPA. The emissions associated with on-road transportation cover all of the GHGs for all highway vehicle travel that occurs within the NJTPA region and exclude the portion of a trip's emissions that might occur outside the region. The direct GHG emission estimates for highway vehicle travel link the location of the vehicle emissions assigned to the county with the associated roadway.

The NJTPA travel demand model [North Jersey Regional Transportation Model – Enhanced (NJRTM-E)] was used as the primary data source for disaggregated activity estimates, and EPA's recently released Motor Vehicle Emission Simulator (MOVES) 2010 model was used as the primary source of GHG emission factors, with most parameters updated to reflect local conditions and programs. NJRTM-E served as the primary data source for disaggregated activity estimates for incorporation into the MOVES model. Post-processing of travel model outputs, and integration with MOVES, was done using Team member AECOM's PPSUITE software which is linked to the NJRTM-E.

There are 119 data tables within the MOVES default database. EPA designed a data importer script to import (overwrite) 13 tables with local data for each county. However, there are many default parameters in MOVES that EPA recommends to use. For the GHG emission estimates for NJTPA, we used the EPA recommended approach, replacing only 13 tables. These data include activity (from the transportation model) and non-activity (meteorology, fuels, I/M, etc.) data. All other inputs were MOVES default parameters (e.g., number of starts, driving cycle, engine size and technology, evaporation coefficients, and other parameters were not replaced with local data).

Consumption-Based Emissions

A separate consumption-based accounting of emissions for on-road was also developed. These emissions were expressed at the MCD level, but unlike the direct estimate, emissions were not broken down by road type or vehicle type. Activity for the consumption-based emission estimates include half of the vehicle miles traveled from every trip either originating or ending in the selected MCD. Thus, these can be considered to be trips that the municipalities or counties have some control over and could apply mitigation measures to reduce these emissions.

Energy-Cycle Emissions

Energy-cycle GHG emissions within the on-road sector are associated with the production, refining and transport of diesel fuel and residual oil. Argonne National Laboratory's GREET model is used to estimate the full energy-cycle emissions of both gasoline and diesel fuels in this analysis. The GREET model allows analysis for any year between 1990 and 2020. The percentage increase from direct to energy cycle emissions is held constant throughout the analysis, because no information is available on any change in energy cycle emissions over the forecast period. On-road data are based on the NJTPA's North Jersey Regional Transportation Model – Enhanced (NJRTM-E) as the primary data source for disaggregated activity estimates, and EPA's recently released MOVES model as the primary source of GHG emission factors. PPSUITE was used for transportation network analysis and to create data for MOVES input.

Forecast Method

Figures 3.3-1 and 3.3-2 show direct and consumption-based emissions output for the base year and forecasted years as they pertain to Highway Vehicles. The emissions forecast is based on *Plan 2035* assumptions about new transportation infrastructure being constructed in the region, such as the ARC Tunnel, which has been terminated. These transportation investments would likely have had an impact on the long-term transportation emissions of the region. Moreover, these assumptions were used as inputs into the MOVES model. The version of MOVES used for this project (MOVES 2010) has since been updated due to flaws in the model. Therefore, the emissions forecast in this sector have a high degree of uncertainty.

Figure 3.3-1 NJTPA Region Direct Emissions from Transportation – Highway Vehicles

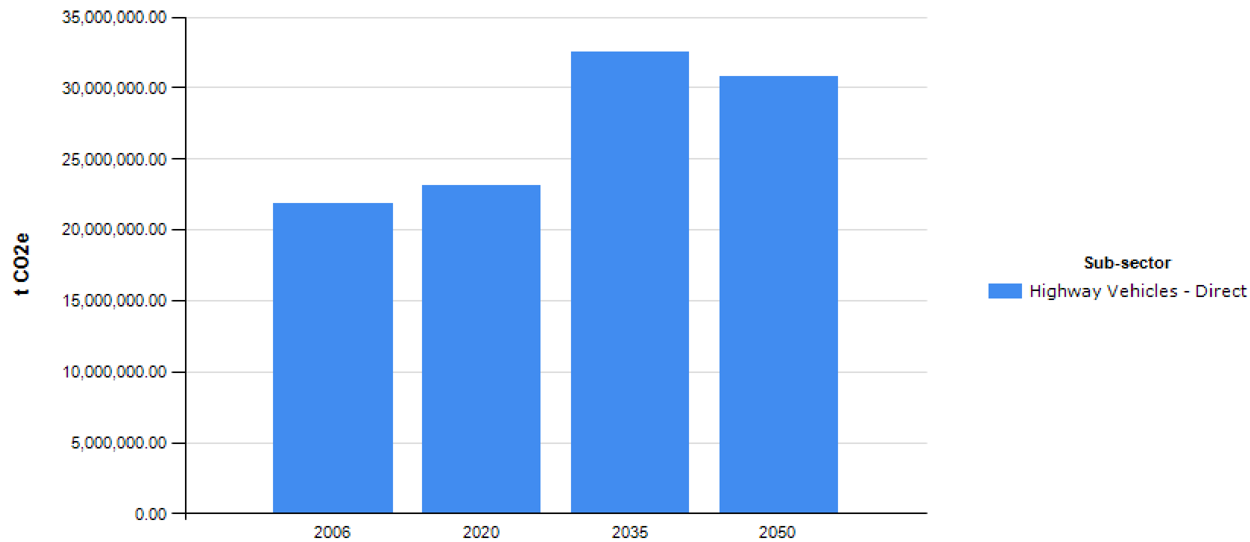
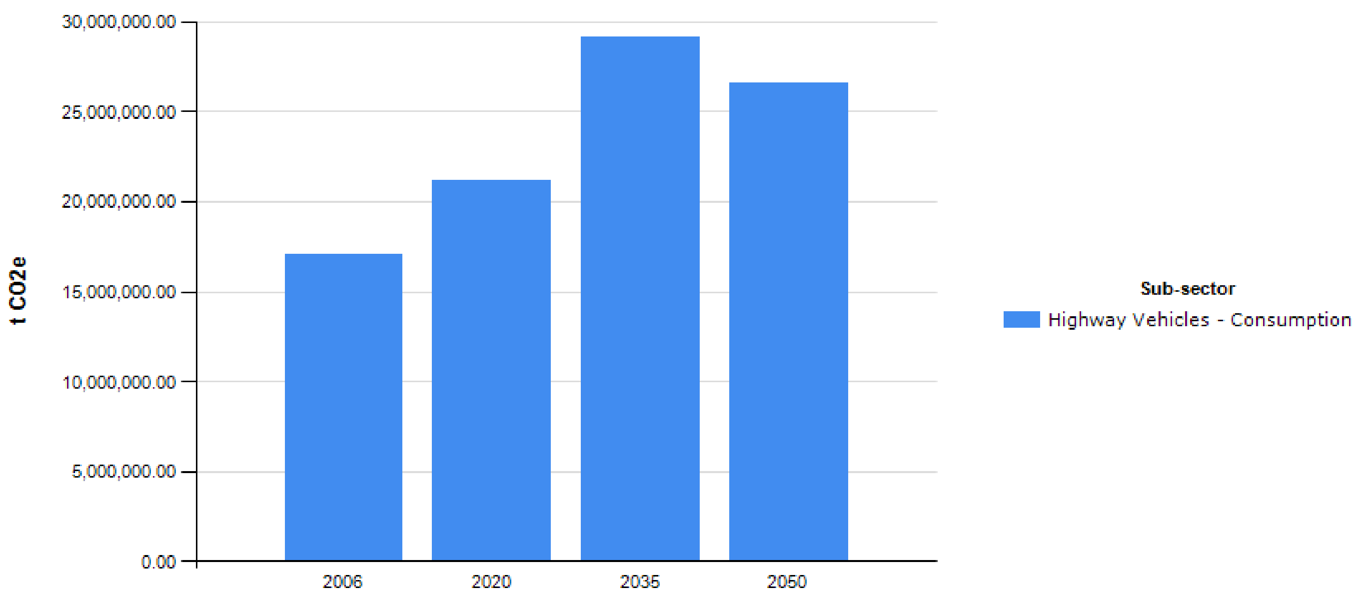


Figure 3.3-2 NJTPA Region Consumption-Based Emissions from Transportation – Highway Vehicles



Aviation

Source Description

Aircraft emission estimates were developed based on estimates from two different sources: the PANYNJ GHG emission inventory for calendar year 2006 (for Newark and Teterboro airports), and EPA 2008 National Emissions Inventory (NEI) landing-takeoff (LTO) data (for all other applicable airports).

Information from PANYNJ was used for Teterboro and Newark airports because it included aircraft type information for all flights taking place. These aircraft types were then assigned emission rates based on their engines, which provides a much more exact method than an estimate based on average emissions from LTOs.

Analysis Methods

Direct Emissions

The geographic boundary for this analysis included all public use airports within the NJTPA area. There is one military airport in the North Jersey area (Naval Air Engineering Station Lakehurst), but it was not included in the GHG inventory because information for military flights was not available. The organizational boundary includes all aircraft operations up to 3000 feet.

Emissions estimates for non-Port Authority airports in North Jersey were estimated based on NEI data. This data source provides 2008 LTO data for all 24 airports in North Jersey. Of these airports, less than one percent has aircraft/engine information reported in the NEI. Where this information was reported, emissions were estimated based on Federal Aviation Administration Emissions and Dispersion Modeling System (EDMS) data. Where no aircraft/engine information is available, emissions were based on a representative aircraft. Emissions were allocated to the county-level. Further allocation to the MCD-level was not deemed important for local GHG mitigation efforts.

Consumption-Based Emissions

A consumption-based accounting of emissions from the aircraft sector was not developed for this project due to available project resources and the limited need for such data in local-scale GHG mitigation planning for airports.

Energy-Cycle Emissions

The GREET model was used to determine the energy-cycle emissions for aviation fuel consumption. Energy-cycle emissions factors from GREET were compared with direct emissions factors from The Climate Registry. The GREET model does not have an energy-cycle emissions estimate specifically for aviation fuels, so diesel fuel was used as a surrogate. This produced a 24.8 percent increase in emissions when energy-cycle emissions are considered.

Forecast Method

Aviation emissions were projected from 2006 through 2030 using general aviation and commercial aircraft operations projections data from the Federal Aviation Administration's Terminal Area Forecast System.[15] Forecast year estimates were adjusted to reflect the projected increase in national aircraft fuel efficiency (indicated by increased number of seat miles per gallon) as reported in the Annual Energy

[15] Federal Aviation Administration, Terminal Area Forecast data, accessed 4/19/10. http://aspm.faa.gov/main/taf.asp.

Outlook (AEO) 2010.[16] . Figures 3.3-3 and 3.3-4 show direct and consumption-based emissions output for the base year and forecasted years as they pertain to Aviation.

Figure 3.3-3 NJTPA Region Direct Emissions from Transportation – Aviation

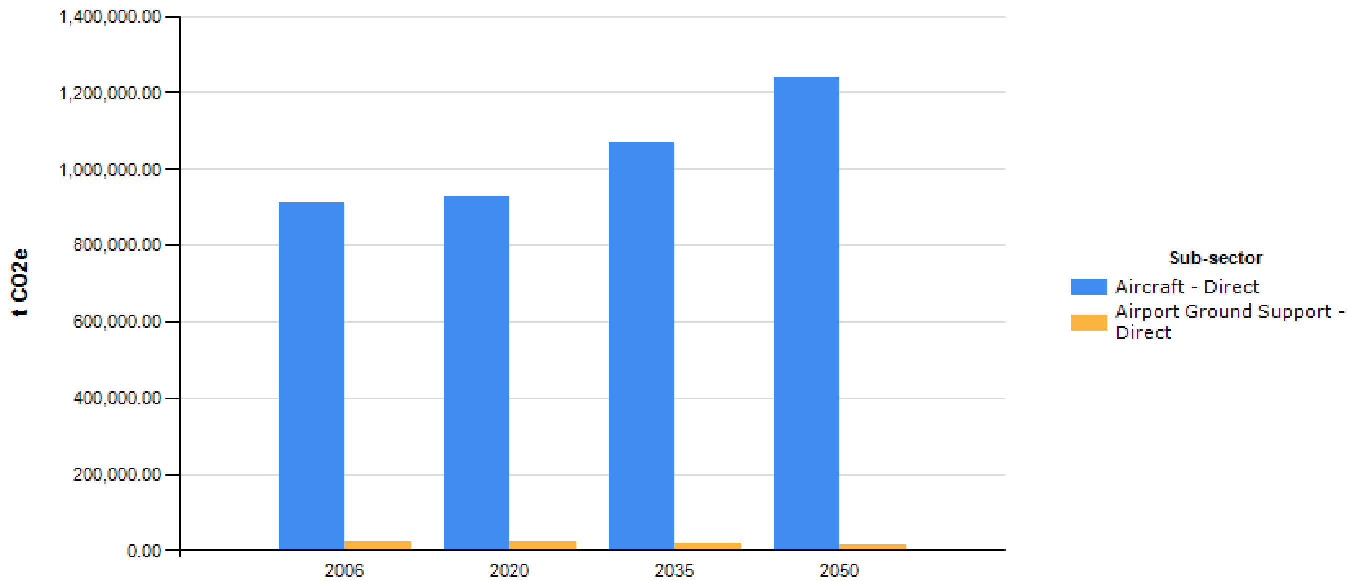
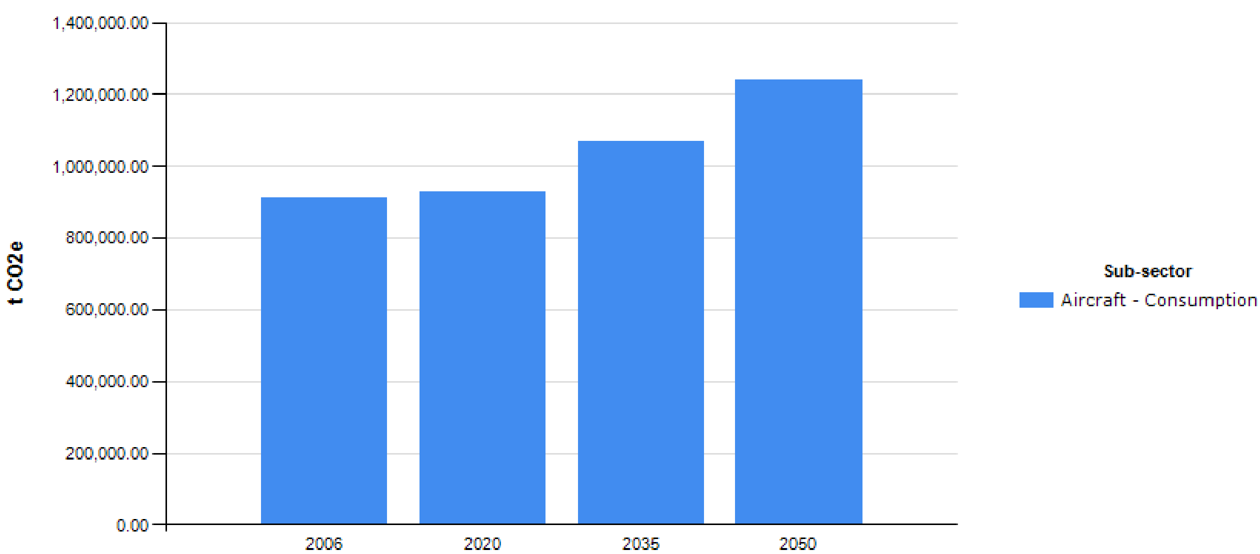


Figure 3.3-4 NJTPA Region Consumption-Based Emissions from Transportation – Aviation



[16] U.S. DOE. Annual Energy Outlook 2010, transportation supplement. http://www.eia.doe.gov/oiaf/aeo/supplement/index.html retrieved 4/19/10.

Marine Vessels

Source Description

The Marine Vessels sub-sector covers all the major marine emissions (commercial marine vessels, CMV), including Ocean Going Vessels (OGVs), harbor boats, towboats, dredging boats, ferry boats, excursion vessels and government boats.

Analysis Methods

Direct Emissions

Only emissions occurring within the three-mile demarcation line of the shore are included in this analysis. This is consistent with the boundary used for the ozone nonattainment area State Implementation Plan (SIP) emission inventory and the PANYNJ GHG inventory. Emissions come from fuel combusted in these vessels, both in the main engines for propulsion and in the secondary engines for electrical power and other onboard services. This fuel combustion results in emissions of CO_2, CH_4, and N_2O, primarily from the combustion of diesel fuel. Other fuels, such as residual oil, are used on occasion in some types of OGVs, but our information indicates that diesel fuel is the primary fuel used at North Jersey terminals.

The majority of CMV activity data were obtained from the appendix of the Port Authority sponsored CMV study that evaluated 2000 calendar year vessel activity in the New York City harbor. This detailed port study provided a more accurate estimate of overall CMV activity and emissions than could be achieved with a top down approach. This report provided activity data for the 2000 calendar year in kilowatt hours (kWh) and horsepower hours (hp-hr) for main and auxiliary engines, and metric tons of fuel for boilers for the entire ozone non-attainment area.

Emissions estimates were made based on estimated total activity of OGVs, harbor boats, towboats and dredging boats. Ferries, excursion vessels and government boats were a much smaller number of vessels, and these were estimated based on their individual activity data and horsepower. All emissions estimates were then grown to 2006 levels based on estimated growth in the Starcrest report for port-wide ship calls by vessel type.

In the case of OGVs, emissions were allocated by county based on the terminal they would eventually use. All other vessels emissions were allocated to counties according to the percentage of time spent in that county. Work to allocate emissions down to the MCD-level was beyond the resources available in this project.

Recreational marine vessel emissions were analyzed using EPA's NONROAD model. For more information, see the 'Recreational Vehicles' section below.

Consumption-Based Emissions

Consumption-based emissions were assumed to be the same as the direct emissions and were allocated in the same fashion. Additional effort was not expended in this project, due to available resources, to allocate these emissions below the county-level.

Energy-Cycle Emissions

Energy-cycle GHG emissions within the CMV sector are associated with the production, refining and transport of diesel fuel and residual oil, which can be estimated using the GREET model. Accurately estimating the upstream GHG emissions associated with fuel extraction, processing and transport can be difficult for the CMV sector, because little information is available on the energy-cycle emissions associated with diesel for marine use. In this analysis, the energy-cycle emissions estimate for on-road diesel fuel is used as a surrogate.

Forecast Method

CMV emissions were forecast through 2050 using estimates of total domestic and international shipping fuel consumption from the AEO 2010. The AEO does not estimate emissions beyond 2035, so the growth factor for 2020-2035 was held constant through 2050. Growth in the recreational emissions was based on EPA's growth projections presented in the NONROAD model. Figures 3.3-5 and 3.3-6 show direct and consumption-based emissions output for the base year and forecasted years as they pertain to Marine Vessels.

Figure 3.3-5 NJTPA Region Direct Emissions from Transportation – Marine

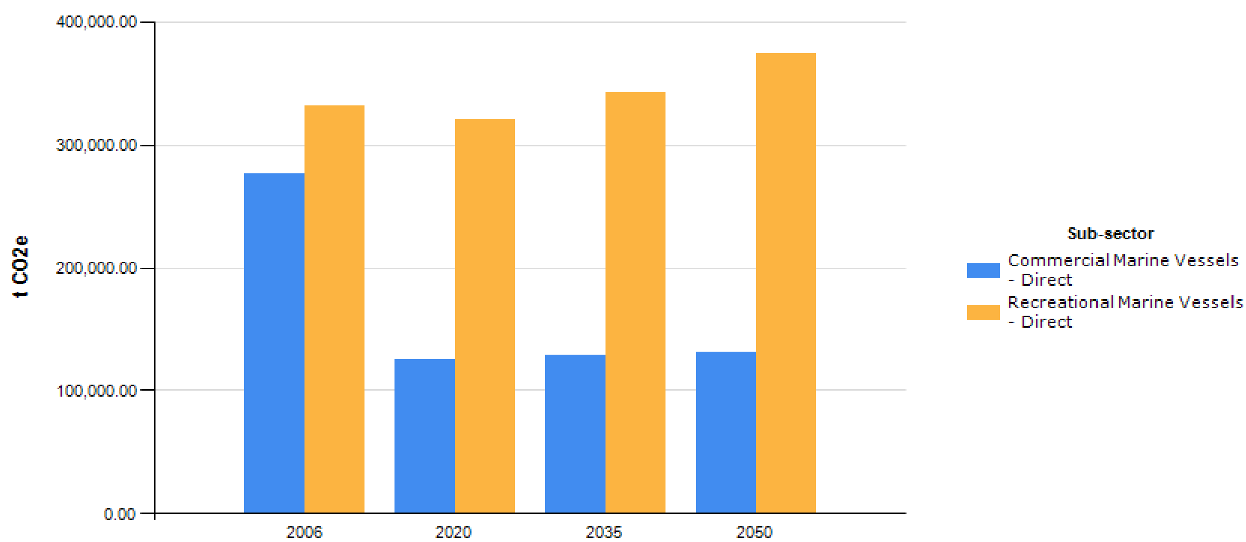
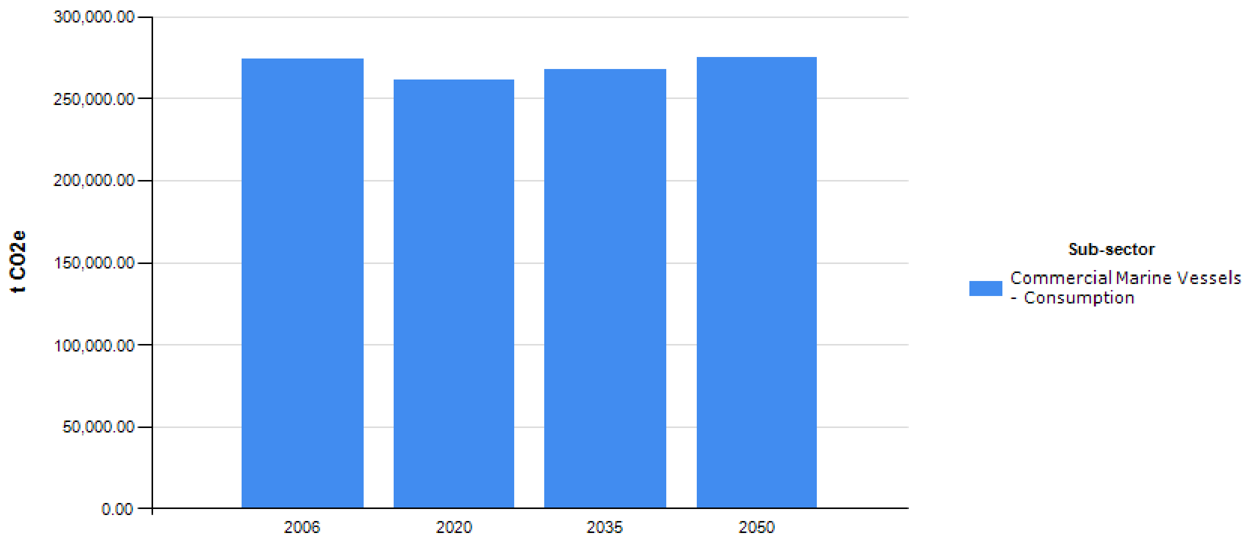


Figure 3.3-6 NJTPA Region Consumption-Based Emissions from Transportation – Marine



Rail

Source Description

The railway sector covers emissions associated with the operation of both passenger rail and freight rail locomotives. The GHGs involved are CO_2, CH_4, and N_2O, primarily from the combustion of diesel fuel and the consumption of electricity.

Direct emissions include only diesel emissions. Consumption based emissions include both diesel and electric. In the NJTPA region, this sector includes the following components:

- NJTransit: electric and diesel rail and electric light rail;
- PATH: electric service only;
- Amtrak: electric service only; and
- Heavy freight rail

Analysis Methods

Direct Emissions

Passenger rail (light rail, heavy rail, commuter rail) include inter-city rail (Amtrak), NJ TRANSIT, and PATH. NJ TRANSIT and PATH annual ridership, energy, and fuel consumption data were obtained from NJ TRANSIT and from the Port Authority of New York and New Jersey. Detailed ridership data for

Amtrak were obtained from the National Association of Railroad Passengers, and energy consumption data for Amtrak were obtained from the Transportation Energy Data Book.[17] GIS estimates of route length of all lines were prepared. Direct emissions were calculated based on train schedules, allocating the emissions based on the location of each line within each municipality and county.

Freight is transported in New Jersey by 14 short line railroads, two regional railroads and three national railroads. Collecting detailed data for all freight rail would require a significant effort and not all detailed data are readily available. Average freight rail traffic densities (ton-miles per mile) for individual lines from the NJ freight plan[18] were used to estimate total ton-miles transported within each county. The emissions for the region were estimated based on the ton-miles originating and culminating in each county, but data at the township level are not available. Due to the complexity of obtaining such data, and since little use of this information could be made at a township level, freight estimates were only analyzed at the county level.

For methods relating to non-road engines in the marine sector, also included here, see the "Recreational Vehicles" section, below.

Consumption-Based Emissions

Consumption-based passenger rail emissions were developed using the same data as direct emissions. Consumption-based emissions, including electric rail, were allocated to the station areas based on ridership origin and destination, allocating half of the emissions associated with each rider's share of the emissions (based on passenger-miles) to the origin and destination stations (50 percent to each).

Consumption based freight rail emissions were developed using the tonnage of freight with an origin or destination in counties in the NJTPA region.[19] Total ton-miles were estimated by multiplying the tonnage by the average distance traveled for freight with an origin or destination of the New York-Newark-Bridgeport, NY-NJ-CT-PA area from the U.S. Census *Commodity Flow Survey*.[20]

Energy-Cycle Emissions

As with other Transportation sub-sectors, energy-cycle emissions were based on results of the GREET model.

Forecast Method

For passenger rail, growth rates for individual lines within the NJ TRANSIT systems were based on estimates obtained from NJ TRANSIT. These growth rates represent various changes in future service and demand, including changes associated with the operation of the Access to the Region's Core (ARC)

[17] Transportation Energy Data Book, Edition 28, Oak Ridge National Laboratory, 2009.

[18] NJDOT, 2007, The New Jersey Comprehensive Statewide Freight Plan, 2000 data, Figure 7-5: Freight Rail System Traffic Density (Estimates) - 2000

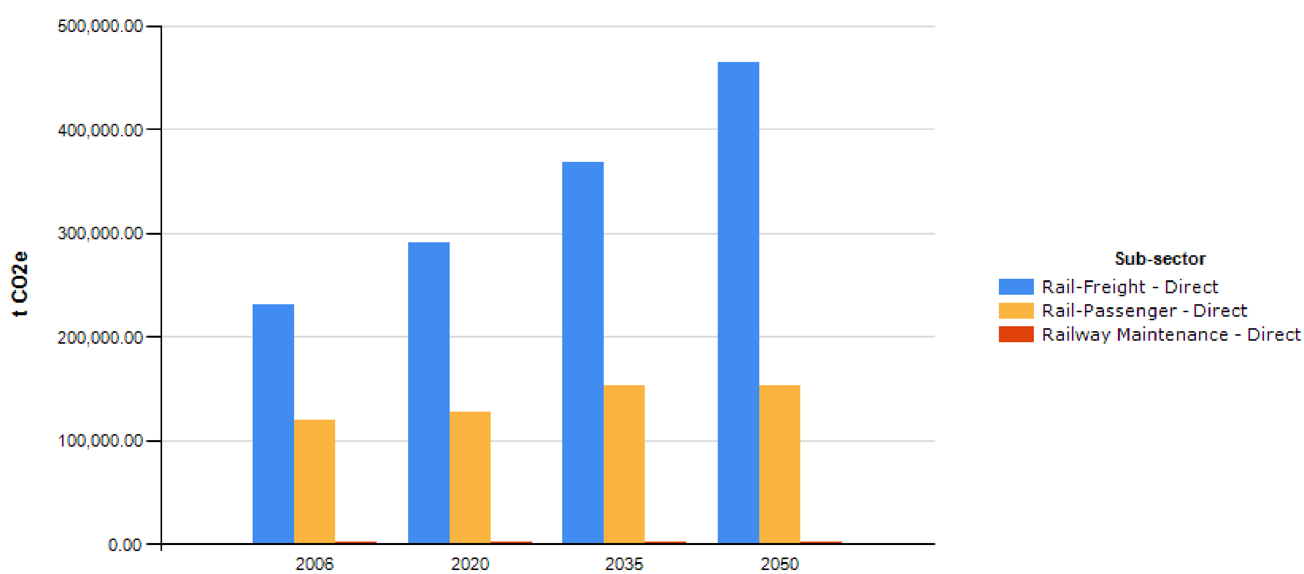
[19] Provided by NJTPA, May 2010.

[20] US Census, 2009, Commodity Flow Survey, US Census, 2007

Tunnel.[21] The passenger-mile distribution is projected to change between 2007 and 2018 because of the differing growth rates between rail lines (reflecting demographic shifts, not changes in the rail system). This resulted in shifts in the projected allocation of consumption-based emissions at the MCD level while the total number of trains (and therefore total emissions) did not grow. Therefore, total emissions were assumed to remain constant until 2018. Emissions were assumed to grow linearly between 2018 and 2030. Additionally, it was assumed that emissions will remain constant past 2030.

For freight Rail, forecasts for direct emissions associated with freight were based on growth in commodity tonnage shipped to and from the NJTPA region projected by FHWA[22] between 2002 and 2035. It was assumed that the growth between 2000 (the base year for the freight data) and 2002 was the same as that projected for 2002-2010. Long-term estimates past 2035 assumed a constant annual growth rate extrapolated from this data. However, the consumption and energy-cycle approaches used growth rates based on growth in shipments to the region as projected in the data provided by NJTPA. Figures 3.3-7 and 3.3-8 show direct and consumption-based emissions output for the base year and forecasted years as they pertain to Rail.

Figure 3.3-7 NJTPA Region Direct Emissions from Transportation – Rail



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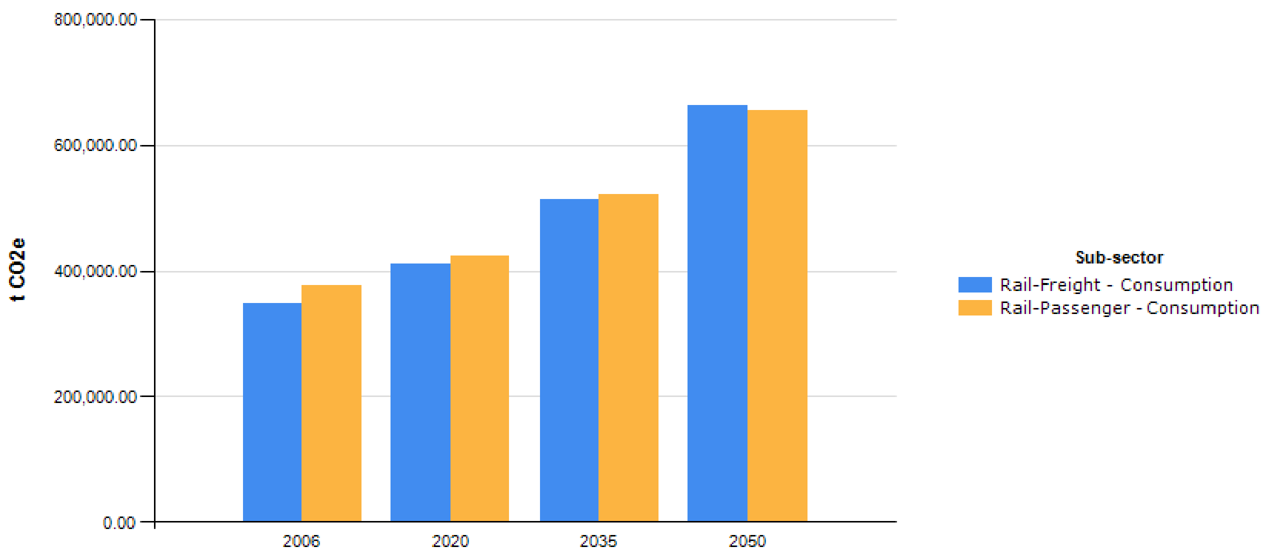
[21] At the time of completion of this inventory, there is some uncertainty about the future of the ARC project. Given this uncertainty and the limited data for other scenarios, all analyses in this inventory include the ARC project in future estimates. Allocation and growth may both differ significantly if ARC is not constructed.

[22] USDOT, 2006, Freight Analysis Framework (FAF) Version 2.2

Figure 3.3-8 NJTPA Region Consumption-Based Emissions from Transportation – Rail



Recreational Vehicles

Source Description

Non-road engines include mobile vehicles and engines (including non-vehicle engines such as movable generators). Non-road engines are used in many sectors for various tasks. Inventory sectors with non-road engines in the NJTPA region include agriculture; forestry; residential, commercial, and industrial; off-road transportation (recreational vehicles); air transportation (ground support equipment); railway transportation; marine transportation (recreational marine); and fossil fuel industry. The general methods described in this section for nonroad engines apply to all sectors, but the emissions are included with each sector as appropriate. Since the emissions are all local, the consumption-based and the direct emissions from these sources is the same.

Analysis Methods

Direct Emissions

The latest version of EPA's NONROAD model (NONROAD2008a) was used to calculate CO_2 emissions and fuel consumption for nonroad engines in all sectors, encompassing non-highway mobile engines. NONROAD provides the best estimate available for emissions down to the county level. Sectors include recreational, construction, industrial, lawn and garden, agricultural, commercial, logging, airport ground support equipment, mining, oil field, railway support equipment, and marine recreational. Emissions were then allocated to the applicable sector (e.g., agriculture, residential, construction, etc.), not included as an aggregate within the transportation sector. The model was run according to the latest procedures and assumptions used by NJDEP.

Consumption-Based Emissions

For all nonroad vehicles, consumption-based emissions are the same as direct emissions.

Energy-Cycle Emissions

As with other transportation sub-sectors, energy-cycle emissions were based on results of the GREET model.

Forecast Method

The EPA NONROAD model forecasts future year emissions based on built-in assumptions regarding engine technologies and fuels (including current Federal regulations regarding future year engine manufacturing and fuel quality), as well as economic and population growth assumptions. The growth assumptions were reviewed and compared with the assumptions in *Plan 2035* and with the growth assumptions for each sector. In cases where specific projections were available, the sector projections for each county were used. For example, growth in the agricultural sector use of non-road engines was assumed to be the same as the projected growth in the sector as a whole for future years.

As described above, all resulting emissions were adjusted to account for effects of the RFS2. Base year and forecast results based on the assumptions described above are provided in their respective sections. Figures 3.3-9 and 3.3-10 show direct and energy-cycle emissions output for the base year and forecasted years as they pertain to Recreational Vehicles.

Figure 3.3-9 NJTPA Region Direct Emissions from Transportation – Recreational Vehicles

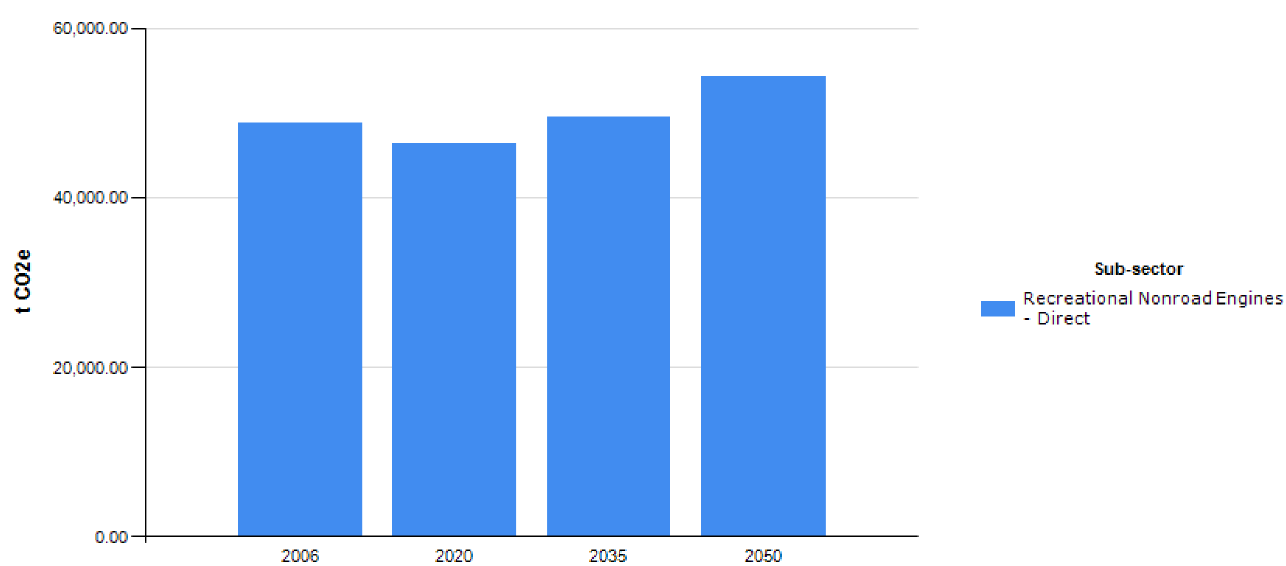
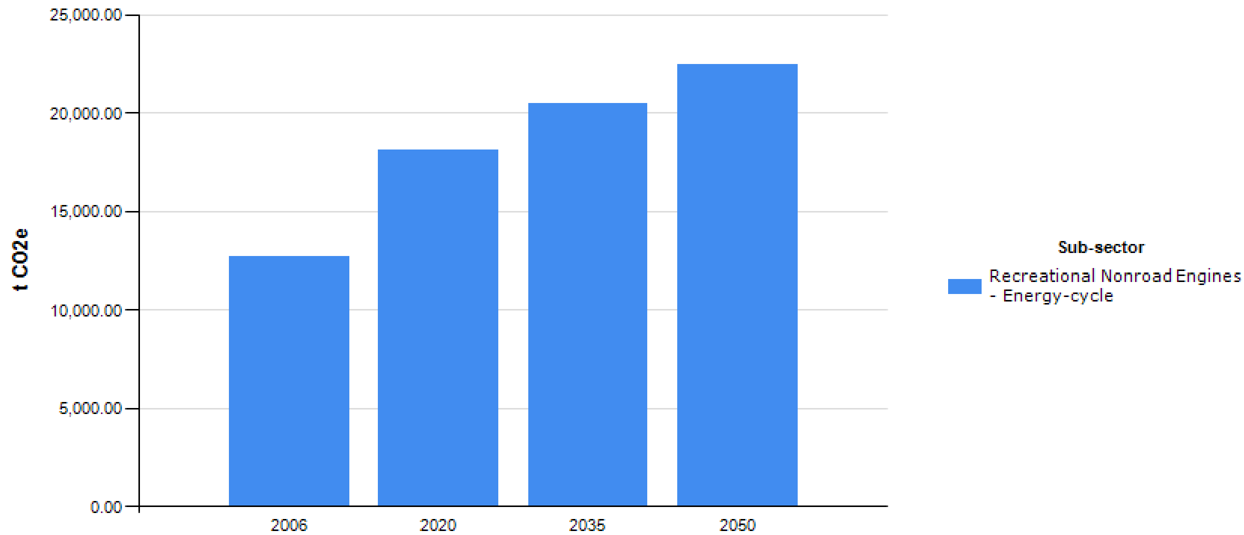


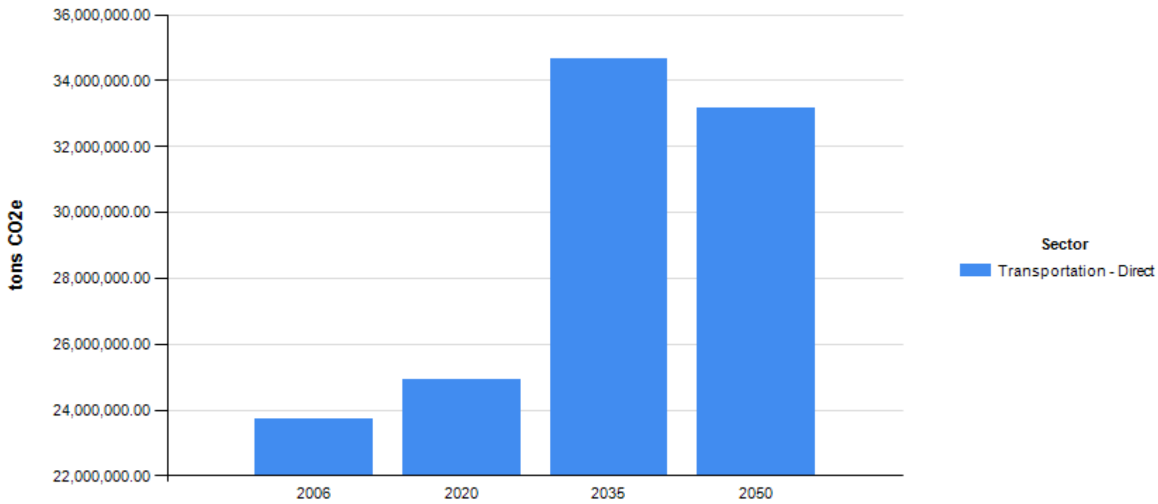
Figure 3.3-10 NJTPA Region Energy-Cycle Emissions from Transportation – Recreational Vehicles



Inventory & Forecast Results

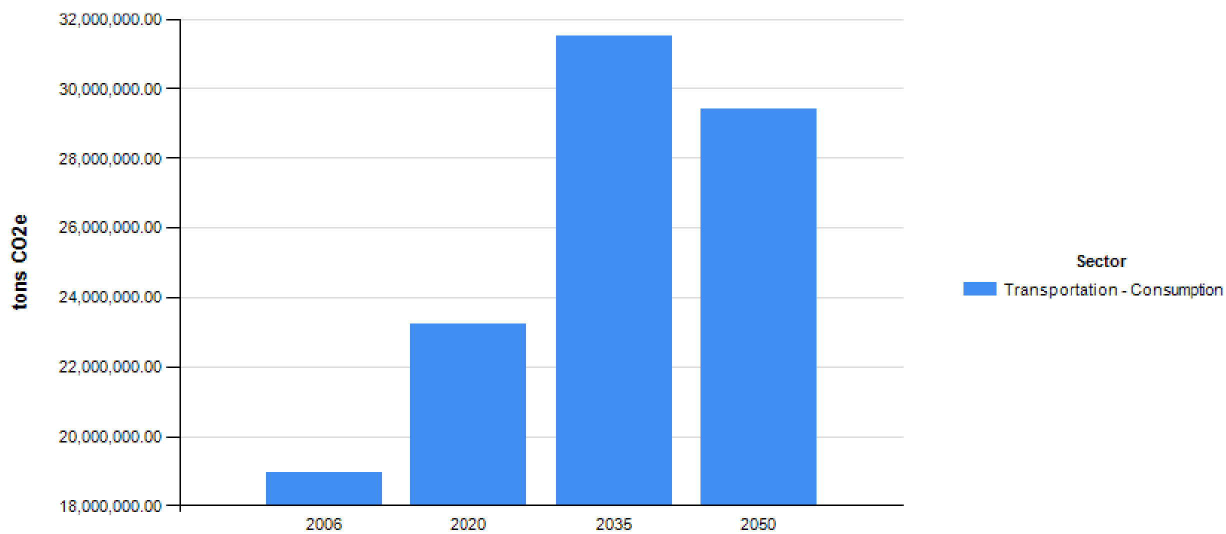
Figures 3.3-11 through 3.3-13 show the regional direct emissions, consumption-based emissions, and consumption-based + energy-cycle estimates for the base year and forecast years. The upstream energy-cycle emissions (Figure 3.3-13) add only small amounts to the overall transportation sector emissions. As seen in Figures 3.3-14 and 3.3-15, regardless of accounting method, the emissions are dominated by on-road vehicles. Additional subsector charts are provided as Figures 3.3-16 and 3.3-17 which exclude on-road (highway) vehicles, so that the contributions from the other subsectors can be seen more clearly. As stated earlier, the version of MOVES used to calculate on-road emissions for this project (MOVES 2010) has since been updated due to flaws in the model. Therefore, the emissions forecast in this sector have a high degree of uncertainty.

Figure 3.3-11 NJTPA Region Direct Emissions from Transportation



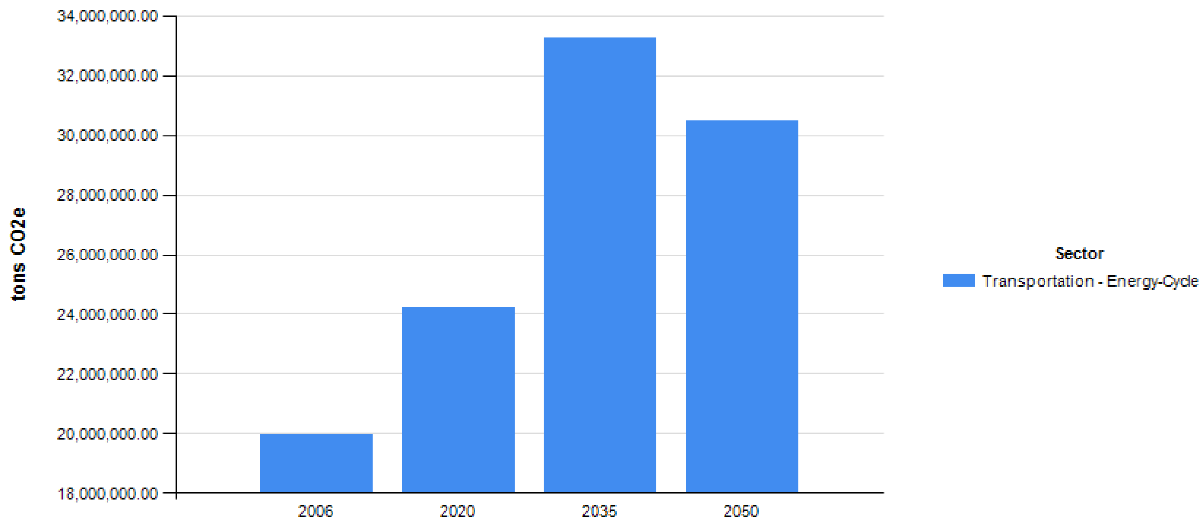
Note: values are in metric tons.

Figure 3.3-12 NJTPA Region Consumption-based Emissions from Transportation



Note: values are in metric tons.

Figure 3.3-13 NJTPA Region Consumption-Based + Energy-Cycle Emissions from Transportation



Note: values are in metric tons.

Figure 3.3-14 NJTPA Region Direct Emissions from Transportation All Sub-sectors

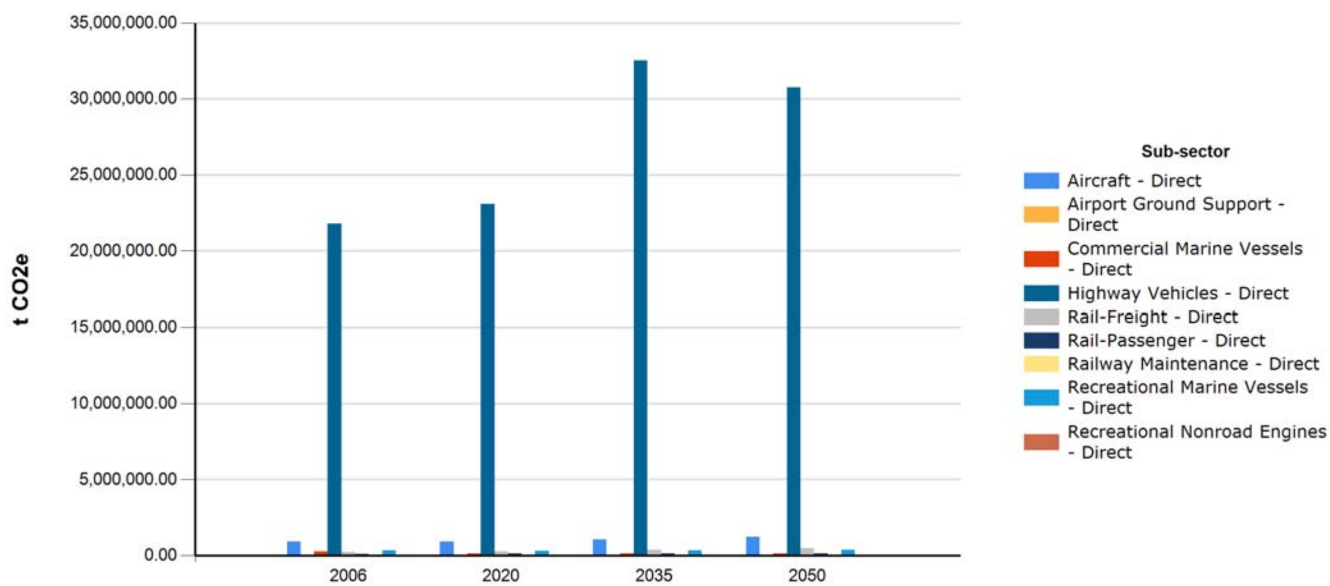


Figure 3.3-15 NJTPA Region Consumption-based Emissions from Transportation All Sub-sectors

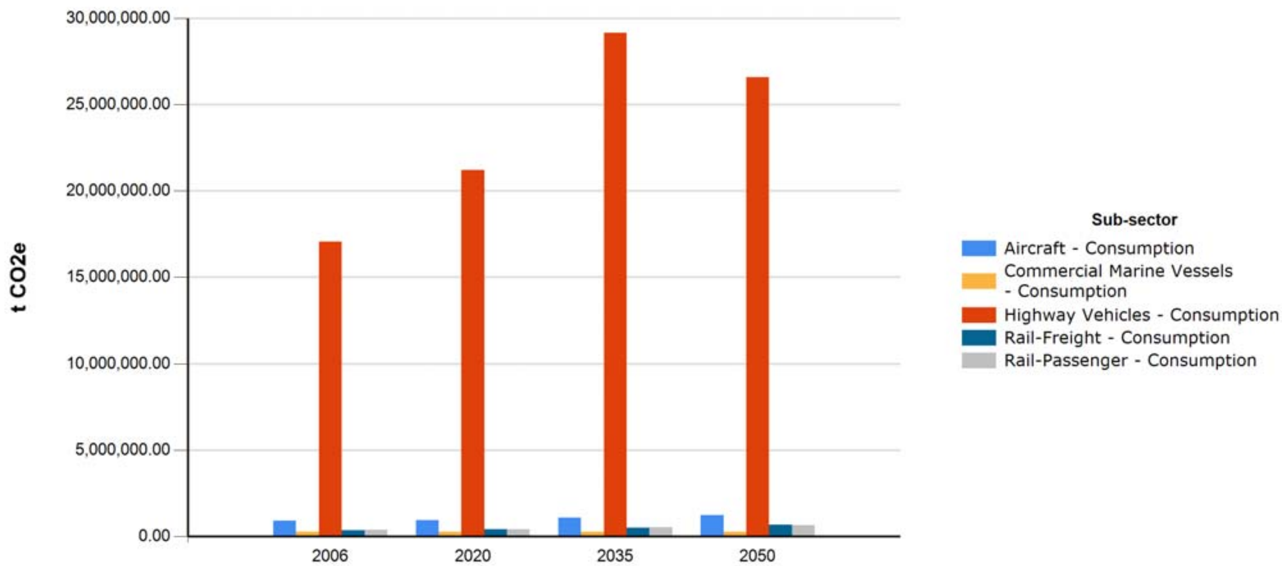


Figure 3.3-16 NJTPA Region Direct Emissions from Transportation Excluding Highway Vehicles

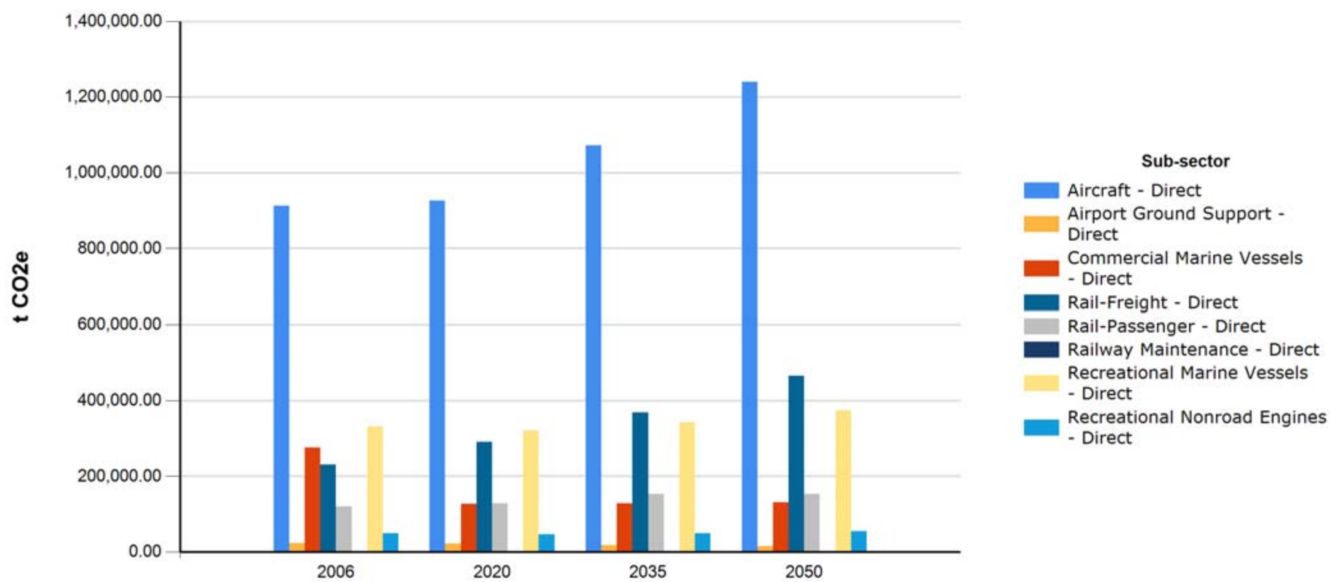
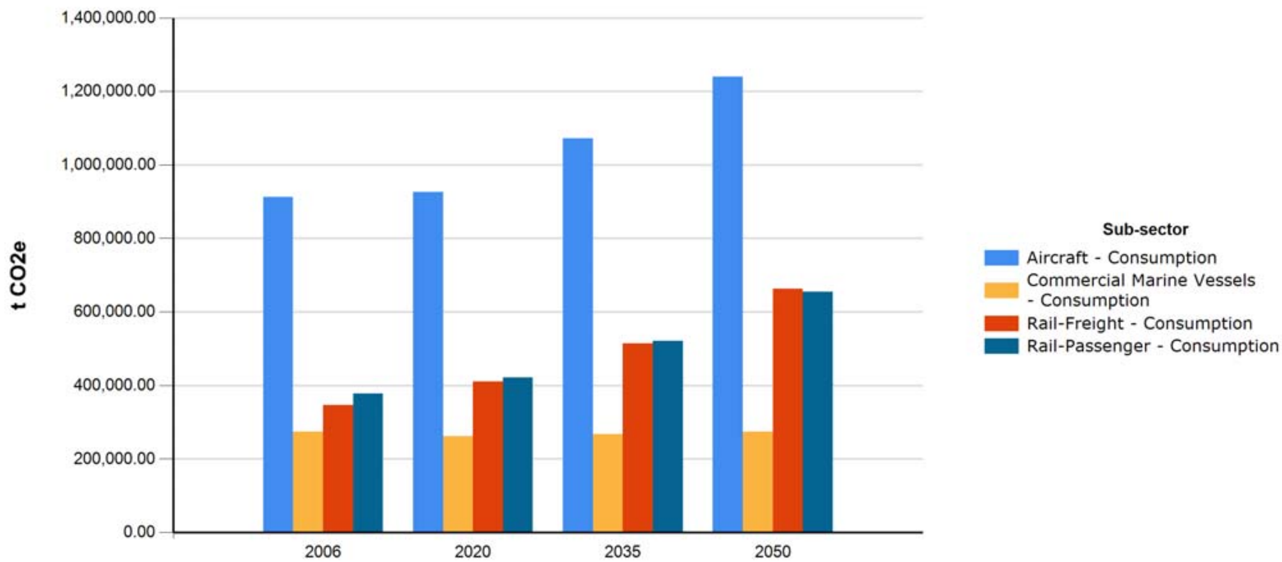


Figure 3.3-17 NJTPA Region Consumption-based Emissions from Transportation Excluding Highway Vehicles



3.4. Industrial Processes

Source Description

Industrial process emissions include CO_2, CH_4, SF_6, HFCs, PFCs, and N_2O released as by-products from industrial activities, excluding combustion of fuels and electricity use (which are included in other sectors), and from the use of refrigerants and SF_6. Many of the traditional IP sources, including some larger ones such as cement, and iron & steel production, are not found in New Jersey. Of the many potential sources, the sources identified as relevant for the NJTPA region are consumption of limestone and soda ash, nitric acid production, the use of ODS substitutes, semiconductor manufacturing, and electric power transmission and distribution. In addition, consumption-based emissions associated with cement and steel production was included since this is a sector that can be addressed locally, and since these emissions are substantial. Reducing the amount of cement and steel used or substituting these materials with low-carbon alternatives can reduce the associated emissions. For other processes, although some of the manufactured products are used locally, considerable effort would be necessary to estimate and allocate those emissions, and since this represents a small fraction of the inventory, these were not included in the current inventory.

Analysis Methods

Direct Emissions

Detailed data regarding the manufacturing output and usage of all of the substances included in this sector within the NJTPA region are not available, and the level of effort required to produce such data were considered to be far beyond the benefit of quantifying the small amount of emissions expected. Furthermore, it is unlikely that actions to mitigate these emissions can be taken at the local level.

Therefore, the approach for the industrial process sector was to allocate the emissions of this sector from the New Jersey I&F and/or the National Inventory, based on the methodology provided by the *Draft Regional Inventory Guidance* (EPA 2009).

For ODS substitutes, the emissions are associated with the use of refrigerants, and therefore their geographic distribution can be estimated to be correlated with population. This method was used to allocate the state-wide emissions down to the region and subregion levels, and to forecast future emission levels.

The release of SF_6 from electric power transmission and distribution was estimated for the NJTPA region and further allocated down to the subregion level based on the proportion of the electric power consumption in each area relative to the State of New Jersey. Similarly, for natural gas distribution losses, allocation was based on the allocation of natural gas consumption emissions (from the RCI sector). Other compounds were allocated based on manufacturing employment levels.

Consumption-Based & Energy-cycle Emissions

For industrial process emissions, in most cases, consumption-based mitigation is not available on a local or regional scale. Given the small portion of the overall inventory these emissions represent, and given the limited utility in providing this data and the high level of effort involved in obtaining specific baseline and consumption data for each product, consumption-based emissions were not calculated for most of the industrial process sector. The analysis focused instead on two central products, cement and metals (iron and steel), which represent a relatively large portion of the national GHG inventory and for which consumption-based mitigation options are available. The analysis was prepared using a top-down approach.

For cement consumption, the analysis was based on the amount of Portland cement shipped to the NJTPA region. This quantity was then multiplied by lifecycle emission factors of 927 kg CO_2 and 0.0395 kg of methane per metric ton of cement produced.[23] For iron and steel consumption, the analysis was based on the amount of base metals shipped to the NJTPA region. This quantity was then multiplied by lifecycle emission factors of 1.83 metric tons per metric ton of metal produced.[24]

Note that the factors used for cement and for iron and steel are lifecycle factors, including both energy and process emissions associated with production and transport of materials (not including delivery), and therefore the consumption-based data include energy components (unlike direct emissions in this sector).

Forecast Method

For ODS substitutes, population projections were used to forecast future emission levels. Other compounds were forecast into the future based on the New Jersey I&F state-wide growth rates.

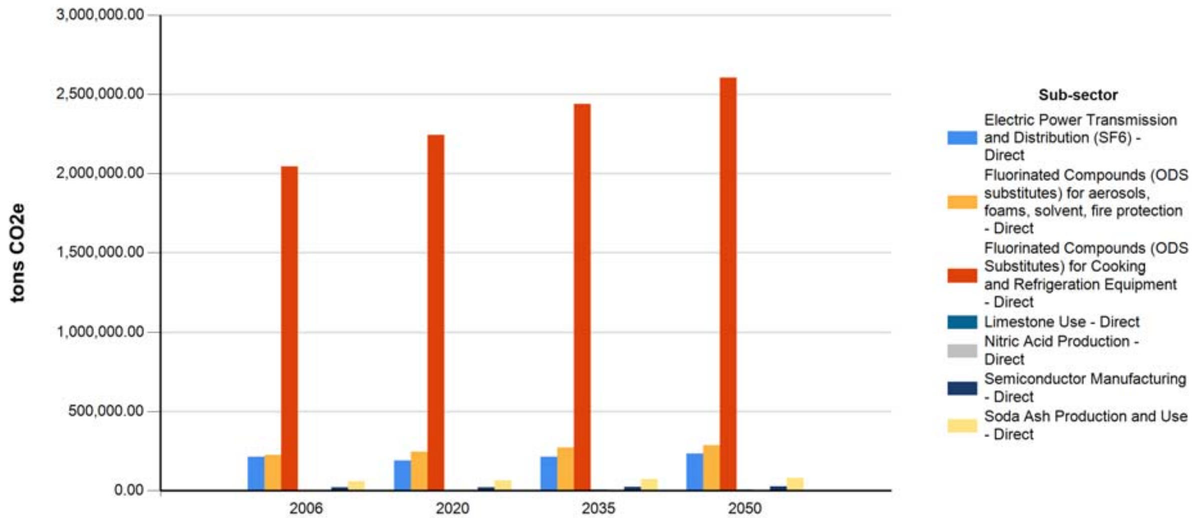
[23] Portland Cement Association, Life Cycle Inventory of Portland Cement Manufacture, 2006

[24] Worrell, Martin, and Price, Energy Efficiency and Carbon Dioxide Emissions Reduction Opportunities in the U.S. Iron and Steel Sector, Ernest Orlando Lawrence Berkeley National Laboratory, 1999.

Inventory & Forecast Results

Direct Emissions. A summary of the direct 2006 base year and forecast emissions for the industrial process sector in the NJTPA region are presented in Figure 3.4-1, below.

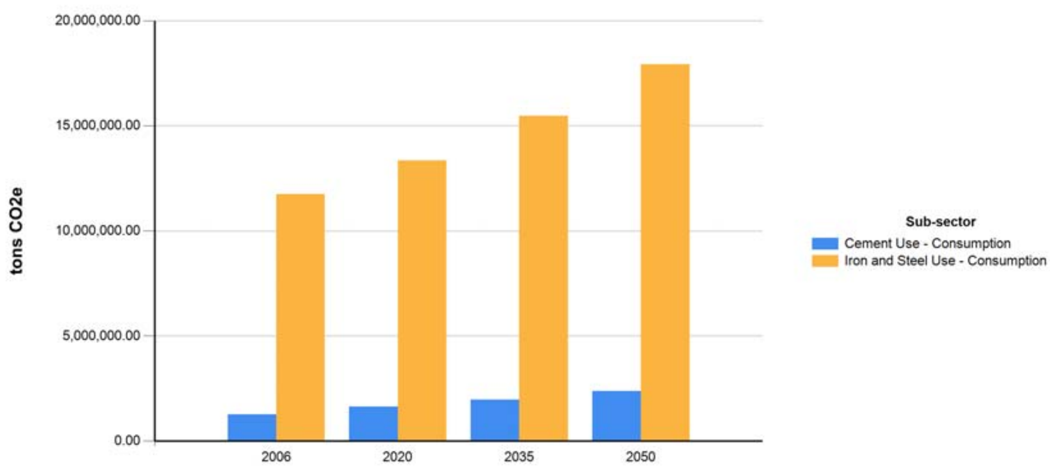
Figure 3.4-1 NJTPA Region Direct Emissions from Industrial Processes (sub-sector)



Consumption-Based Emissions

A summary of the consumption-based 2006 base year and forecast emissions for the industrial process sector (iron/steel and cement only) in the NJTPA region are presented in Figure 3.4-2.

Figure 3.4-2 NJTPA Region Consumption-Based Emissions from Industrial Processes (sub-sector)



Energy-Cycle Emissions

No energy-cycle emissions were developed for the industrial processes sector.

3.5 Fossil Fuel Industry

Source Description

Crude oil refining and natural gas distribution losses represent the only significant sources of GHG emissions associated with the fossil fuel industry in the NJTPA region. Note that the sector represents emissions associated with the processing and distribution of the fuels—not combustion, which is represented in other sectors. Both sources are presented as direct emissions only.

CH_4 emissions from crude oil refining processes and systems are released to the atmosphere as fugitive emissions, vented emissions, emissions from operational upsets, and emissions from fuel combustion. These emissions account for slightly less than two percent of total CH_4 emissions from the oil industry because most of the CH_4 in crude oil is removed or escapes before the crude oil is delivered to the refineries. Most of the fugitive CH_4 emissions from refineries are from leaks in the fuel gas system.

Also included in this sector are CH_4 emissions released from the distribution of natural gas. These include vented and fugitive emissions associated with system leaks.

Analysis Methods

Direct Emissions

Crude oil refining emissions were developed based on the EPA national inventory, using an emission factor, from EPA's State Inventory Tool, of 4.96 kg CH_4 per 1,000 barrels produced. There is only one refinery operating in the NJTPA region, in Linden (Union County), with an operating capacity of 238,000 barrels per day, representing 1.4 percent of the total capacity in the US.

Natural gas transmission and distribution losses of methane were estimated by allocating the emissions from this sector in the New Jersey I&F, based on the consumption of natural gas. State-wide natural gas transmission and distribution methane losses from the latest updates of the NJDEP inventory were 0.104 Mmt. Total natural gas consumption in New Jersey in 2006 was 547,206 million cubic feet.[25]

Consumption-Based & Energy-cycle Emissions

This approach was not included for this sector.

Forecast Method

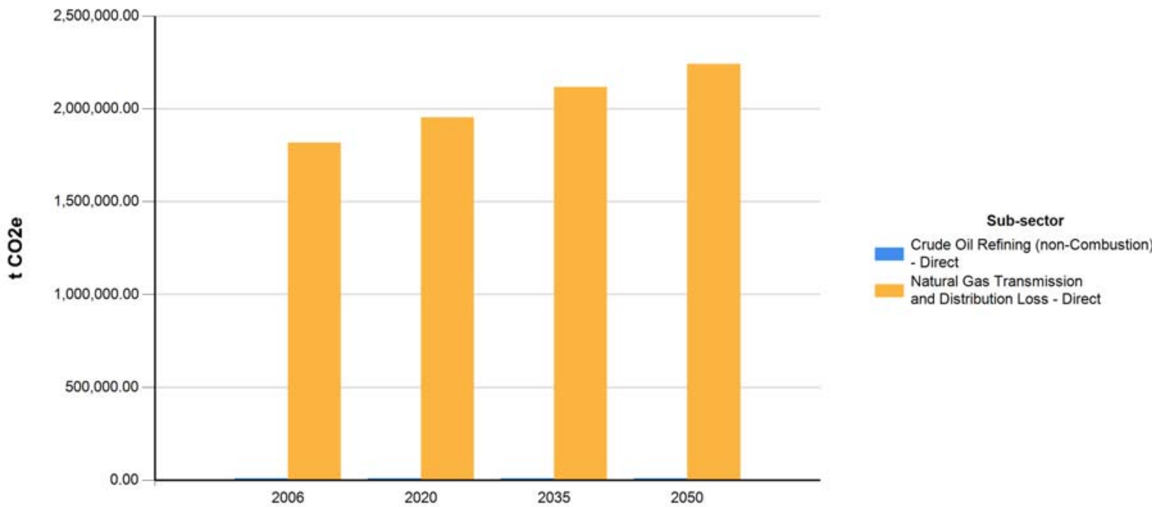
There are currently no known plans for expansion of oil refining in the NJTPA region. Given the past trend, it is assumed that emissions associated with oil refining will remain constant in future years. The forecast of natural gas distribution loss emissions was correlated to the forecast of natural gas usage.

[25] EIA, Natural Gas Consumption by End Use 2006, http://tonto.eia.doe.gov/dnav/ng/ng_cons_sum_dcu_SNJ_a.htm, accessed May 2010.

Inventory & Forecast Results

A summary of the direct 2006 base year and forecast emissions for the fossil fuel industry sector in the NJTPA region is presented in Figure 3.5-1.

Figure 3.5-1 NJTPA Region Direct Emissions from Fossil Fuel Industry



Consumption-Based Emissions

No consumption-based estimates were developed for fossil fuel sector.

Energy-Cycle Emissions

No energy-cycle emissions were developed for the fossil fuel sector.

3.6 Agriculture

Source Description

Analysis Methods

Direct Emissions. In most inventories, the agriculture sector covers only non-fuel combustion emissions associated with production of crops and livestock management. For the NJTPA regional inventory, emissions from agricultural non-road engines were also allocated to the Agriculture sector (see a description of non-road estimates under the Transportation – Non-road section above). This provides a better overall accounting of emissions from the sector. Given the relatively small contributions from the agricultural sector, the non-fuel combustion state-level estimates from the New Jersey I&F covering crop and livestock production were allocated down to the county and municipal level based on data from the U.S. Department of Agriculture's (USDA's) 2007 Census of Agriculture (COA)[26] and each MCD's fraction of agricultural land use[27] as described in the I&F Protocol.

Consumption-Based Emissions

Full consumption-based accounting for the agriculture sector would involve estimating the GHGs embedded within the agricultural products consumed by NJTPA residents and food service establishments. This type of analysis was beyond the scope of this project; however, it would have obvious benefits in mitigation planning (e.g., sourcing of locally produced agricultural products). Hence, there are no consumption-based estimates in the NJTPA inventory and forecast.

Energy-Cycle Emissions

Since no consumption-based estimates were developed, no energy-cycle estimates were developed as part of this project.

Forecast Method

Emissions were forecast based on agricultural growth factors from NJDEP's State I&F. These factors showed negative growth in the sector through 2020. Rather than continue this growth trend through 2050, a flat forecast was assumed for the 2020 through 2050 period.

Inventory & Forecast Results

Direct Emissions

Figure 3.6-1 provides a summary of the direct 2006 base year and forecast estimates for the agriculture sector in the NJTPA region. These summaries are provided at the subsector level; however, the Excel workbook developed for the project has estimates for each of the source categories listed in the Technical Appendix.

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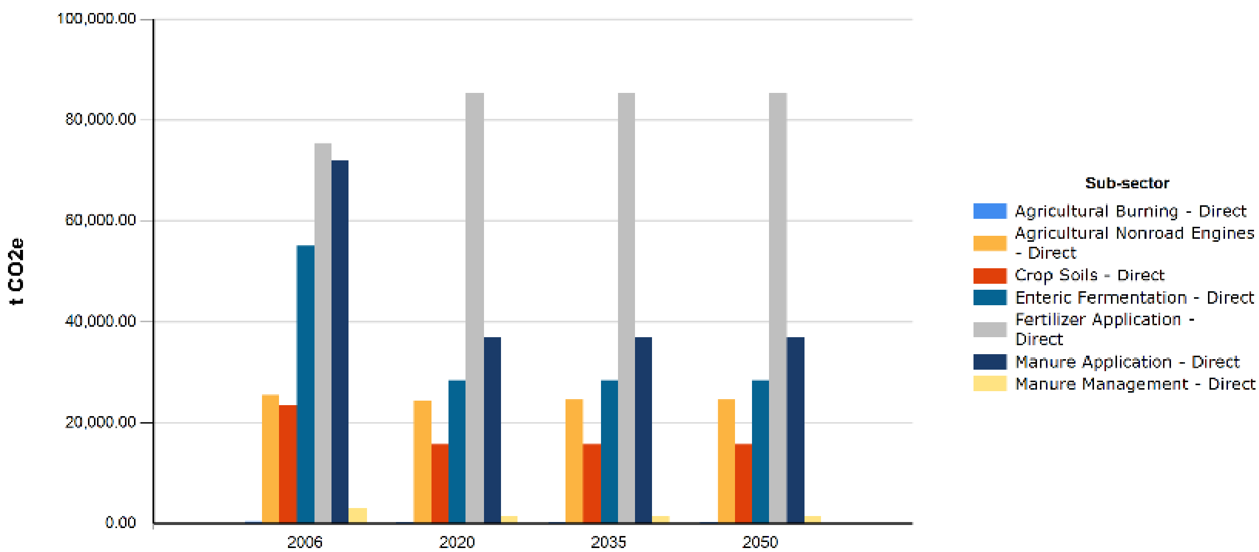
[26] 2007 Census of Agriculture, New Jersey State and County Profiles, US Department of Agriculture, 2007, http://www.agcensus.usda.gov/Publications/2007/Online_Highlights/County_Profiles/New_Jersey/index.asp

[27] 2002 land cover/land use data provided by NJTPA.

Figure 3.6-1. NJTPA Region Direct Emissions from Agriculture



Consumption-based Emissions

As mentioned above, development of a consumption-based inventory for the agriculture sector was beyond the scope of this project.

Energy-cycle Emissions

Since consumption-based estimates were not developed for the agriculture sector, energy-cycle emissions were also not developed.

3.7 Land Use, Land Use Change, and Forestry (LULUCF)

Source Description

Analysis Methods

Direct Emissions

This sector includes net CO_2 flux from both forested lands and urban forests. Hence, the CO_2 flux in any given area could represent a net source or a net sink. Also included are emissions of N_2O from non-agricultural fertilizer application (often captured within a category referred to as "settlement soils"). In addition, GHG emissions for fuel combustion in nonroad engines for the forestry sector were included in this LULUCF sector (also referred to as the Forestry and Land Use Sector).

For forest land use change, estimates of net CO_2 sequestration/emission were developed using county-level estimates of forest carbon density from the U.S. Forest Service (USFS) and National Council for Air and Stream Improvement (NCASI) Carbon On-Line Estimator (COLE)[28] and municipal-level estimates of forest acreage from DEP for 1986, 1995, and 2002 (2007 data were not available in time for use in this inventory). The annual rate of increase or decrease in forest acreage between 1986 and 2002 was used to determine the amount of land lost or gained and the average county-level carbon density was then applied to determine net loss or gain of carbon. Carbon gain/loss was then converted to CO_2.

Future work should also be conducted to add in the amount of carbon sequestered/lost on the remaining forest land base that has not been captured within the Forest Land Use Change estimates described above. This would likely show a stronger net carbon sink for the region. Available resources did not allow for this to be done under this project.

For urban forests, the Team developed the urban forest sequestration estimates from the bottom-up using the urban area for each municipality developed above from the NJDEP LULC data, USFS urban tree canopy cover data,[29] and a region-specific urban forest carbon accumulation rate.[30] For non-farm fertilizer application, state-level estimates from the EPA SIT Land Use, Land Use Change and Forestry module was allocated down to each municipality using USFS data on urban area available green space (non-tree canopy green space).

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[28] Carbon On Line Estimator (COLE). U.S. Forest Service (USFS) and National Council for Air and Stream Improvement (NCASI), http://www.ncasi2.org/COLE/index.html.

[29] Urban Forest Data for New Jersey, U.S. Forest Service, http://www.nrs.fs.fed.us/data/urban/state/?state=NJ

[30] Nowak, D.J. and E.J. Greenfield, *Urban and Community Forests of the Mid-Atlantic Region: New Jersey, New York, Pennsylvania*, Gen. Tech. Rep. NRS-47. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 38 p, 2009, http://nrs.fs.fed.us/pubs/9740.

Consumption-Based Emissions

As with the agriculture sector, full consumption-based accounting would involve estimating the GHGs embedded within the forest products consumed by NJTPA residents and, and was beyond the scope of this project.

Energy-Cycle Emissions

Since no consumption-based emission estimates were developed for the forestry and land use sector, no energy-cycle emissions were developed.

Forecast Method

Carbon sequestration/emission estimates were forecasted based on the historic trends observed in each municipality of growth/decline in forested landscape or urban area, respectively. Growth rates were assumed to be zero for the post-2020 period. For the Forest Land Use Change subsector, growth rates were also restricted for some MCD's that had very high or low growth rates in order to prevent unrealistic projections of gain/loss.

Inventory & Forecast Results

Direct Emissions

Table 3.7-1 provides a summary of the direct 2006 base year and forecast estimates for the forestry and land use sector in the NJTPA region. Net emissions shown for 2006 are negative, meaning an overall sequestration of CO_2 for the sector in 2006 of -1.1 $MMtCO_2e$. By 2050, the net sequestration is forecasted to be about the same (-1.2 $MMtCO_2e$). Note that these estimates exclude any additional net carbon flux on forested lands in the region that were not undergoing land use change. Development of these estimates was beyond the available resources in this project; however, future work should be conducted to develop these estimates.

Table 3.7-1. NJTPA Direct Emissions from LULUCF (tCO_2e)

Subsector	2006	2020	2035	2050
Forest Land Use Change	-44,959	-99,784	0.0	0.0
Forestry Non-road Engines	6,138	6,537	7,948	9,795
Non-Agricultural Fertilizer Use	7,843	7,243	7,089	6,936
Urban Forests	-1,083,945	-1,210,708	-1,210,708	-1,210,708
Totals[a]	**-1,114,924**	**-1,296,712**	**-1,195,671**	**-1,193,978**

[a] Note: these totals exclude net forest carbon flux on forested lands not undergoing land use change; see discussion in text.

Consumption-Based Accounting

As mentioned above, no consumption-based estimates were developed for the forestry and land use sector.

Energy-Cycle Emissions

No energy-cycle emissions were developed for the LULUCF sector.

3.8 Solid Waste Management

Source Description

The waste management sector is divided into solid waste management and wastewater treatment. The inventory and forecast methods for the solid waste management sector are documented in this section, while the wastewater sector emissions are documented in Section 3.9 of this report. For solid waste management, GHG emissions are often broken out into two primary subsectors: municipal solid waste (MSW) management; and industrial solid waste management. Data to support development of estimates for the industrial solid waste management subsector were not available. Because of this and that municipal planners are most able to influence municipal solid waste management, the MSW subsector was the focus of the Team's work on solid waste management.

The Team's experience indicates that up to 90 percent of the GHG reduction benefits of mitigation options such as source reduction or recycling can be attributed to upstream GHGs associated with the manufacturing and transport of products and packaging that become components of the waste stream. In particular, for certain components of the waste stream, such as steel and other metals, glass, and cement, a significant amount of energy is used and emissions generated during raw material extraction, processing, and transport. When waste is reduced at the source or recycled, significant GHG reductions are achieved. This is because the energy needed to produce a product or packaging is avoided (source reduction or re-use) or the net energy needed to recycle a product is lower than making it out of raw materials (e.g., recycling an aluminum can).

The concept of consumption and energy-cycle emissions accounting is applied to the solid waste management sector by allocating the emissions that result from a given waste management activity to the geographic location of where the waste was generated. Upstream emissions associated with the production and transport of the waste material can also be added in to get a full perspective of the GHG emissions associated with waste generation and management. In contrast, direct emissions from solid waste management only account for the emissions associated with the waste management activity (e.g., landfilling, waste combustion, composting).

Analysis Methods

Direct Emissions

The direct emission sources for the solid waste sector are solid waste landfills, waste combustion, and composting operations. Composting operations also represent a carbon sink. Therefore, while composting is listed as a "source" of CO_2 in this report, composting actually creates a net carbon "sink," resulting in negative values for composting CO_2 emissions, even after consideration of the CH_4 and N_2O emissions. While it is possible that some of the waste generated in a municipality or county could be recycled within that same municipality/county, the Team has assumed that this does not occur in the NJTPA region; hence, no direct emissions associated with recycling have been developed. Please see Appendix A for more details on the analysis approach and data sources.

Consumption-Based Emissions

Consumption-based emissions from this sector are associated with solid waste landfill disposal, composting, waste transportation (for landfilling, recycling, or composting), and waste combustion. In order to prepare the base-year inventory and reference case projection for the solid waste sector consumption-based and energy-cycle emissions, it was necessary to complete a historical and projected municipal solid waste management profile. The Team sent a survey to each county waste management director requesting the amount of waste generated that was disposed of in-county and exported outside the county to landfills and/or waste combustion units; the amount of waste collected that was eventually recycled and composted; and the composition of waste generated, disposed, or diverted within the county. Seven counties provided data. For all other counties, the NJDEP data for waste disposed and diverted were used to create the waste management profile.

Please see Appendix A for more details on the construction of the consumption-based estimates based on the county solid waste management profiles. The county profiles are provided in Appendix B.

Energy-Cycle Emissions

The sources of energy-cycle emissions include:

Landfill Disposal energy-cycle emissions: include the embedded energy of the waste disposed at landfills, based on the current mix of recycled and virgin materials that comprise the waste stream;

Recycling energy-cycle emissions: these are based on the embedded energy of the current mix of the waste stream, less the virgin input portion of the embedded emissions due to the fact that the materials that are being recycled will be replacing the necessary extraction of virgin materials. Therefore, the net embedded emissions from recycling are equal to the process energy and non-energy and upstream material transportation emissions that result from the recycling process;

Composting energy-cycle emissions: there are no composting energy-cycle emissions accounted for in this study, as there has been no literature identified by the Team which provides factors for the embedded energy of yard and food waste (e.g., that occurring during lawn/garden maintenance or food production); and

Waste Combustion energy-cycle emissions: the embedded emissions of waste combustion (residential open burning in NJTPA) represent the current input mix of embedded emissions in the portion of the residential waste combusted that is not yard or food waste.

This study does not attempt to assess the downstream GHG benefits that result from landfill gas utilization for energy generation and the application of compost to soils that increases soil carbon retention and replaces fossil-based fertilizers as soil nutrients. Also not included are the emissions from energy-cycle embedded energy in upstream transportation fuels used to transport raw materials to manufacturing facilities, or downstream to transport the generated waste to the landfill, recycling facility, or composting site. Please see Appendix A for more details.

Forecast Method

For direct emissions, the forecast MSW landfill emissions are based on the application of the FOD equation to the waste emplacement data for each landfill provided by NJDEP. This method assumes constant annual waste disposal at open landfills until the year they are anticipated to close. The composting emissions forecast are based on the average annual growth in waste composted between 2000 and 2006 in the state of New Jersey. The waste combustion (residential open burning) emissions are based on population growth projections through 2050 for each MCD.

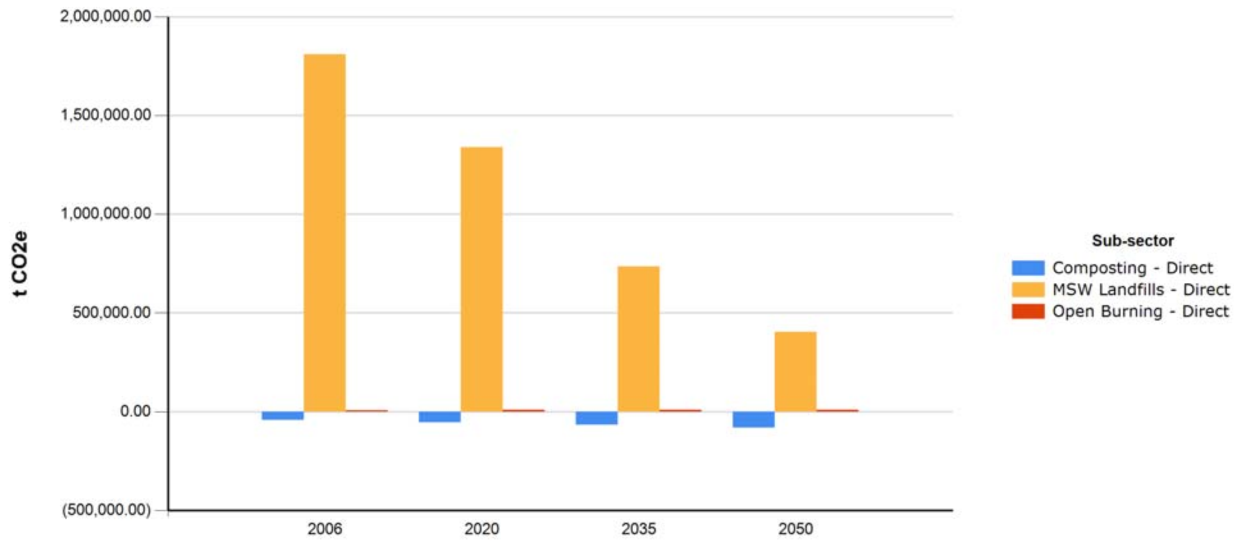
The forecast for consumption-based emissions was based on each county's average annual per-capita generation growth rate for 1995-2006. A key assumption is that the disposal, recycling, and composting rates for the most recent data year available were applied throughout the forecast period (i.e., meaning no change in solid waste management under business as usual conditions through 2050). Energy-cycle emissions were forecasted in the same manner as the consumption-based accounting emissions.

Inventory & Forecast Results

Direct Emissions

Figure 3.8-1 below provides the direct emission estimates for MSW management for the NJTPA region. Note that these emissions include both positive and negative values. The negative values associated with composting are the net of emissions from composting operations and carbon storage (sequestration) in municipal solid waste (MSW) landfills. Net direct emissions from solid waste management in 2006 were estimated to be about 1.8 MMtCO_2e. Emissions are shown to decline in the forecast years, as less waste is managed within NJTPA and the methane from existing landfills declines. By 2050, direct emissions for the region are estimated to be around 0.33 MMtCO_2e.

Figure 3.8-1. NJTPA Region Direct Emissions from MSW Management



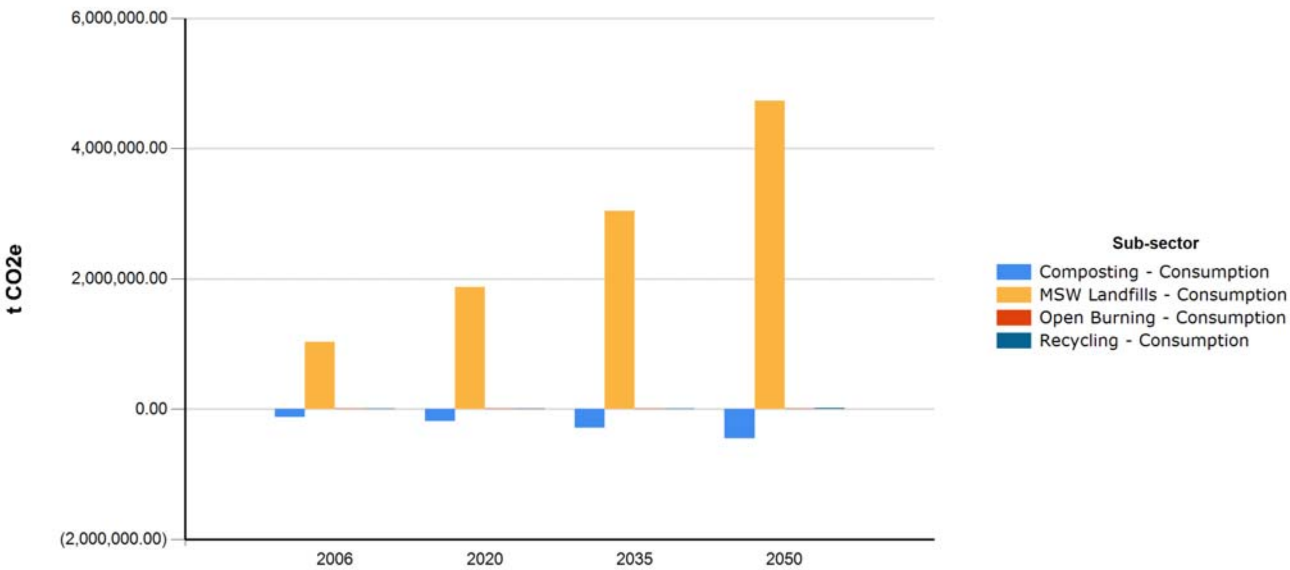
Consumption-Based Emissions

Figure 3.8-2 provides a summary of the consumption-based 2006 base year and forecast estimates for the solid waste sector in the NJTPA region. The figure shows nearly the opposite picture from the direct emissions accounting above in that emissions are increasing over time. This is because all of the waste generated within the region is being accounted for regardless of where it is managed. Base year 2006 emissions are about 0.92 MMtCO_2e and these are expected to grow to over 4.3 MMtCO_2e by 2050. Base year direct emissions are higher than consumption based emissions for the following reasons:

1. Consumption-based LF CH4 emissions were only modeled based on disposal beginning in 1990. If I back-cast disposal to 1960, those tons would make a difference.
2. The Direct LF Inventory includes closed landfills.
3. The Direct LF Inventory includes total WIP at landfills, including waste emplaced before 1990.
4. It was assumed that exported waste is disposed at large LFs with LFG collection. As we know, open LFs have lower LFG collection efficiencies than closed and capped LFs. Therefore, it is possible that the consumption-based emissions are underestimated.

As with the direct estimates, the MSW sector is dominated by methane emissions from waste decomposition in landfills. As described further in Appendix A, the consumption-based estimates include waste transport-related emissions associated with landfilling, recycling, and composting.

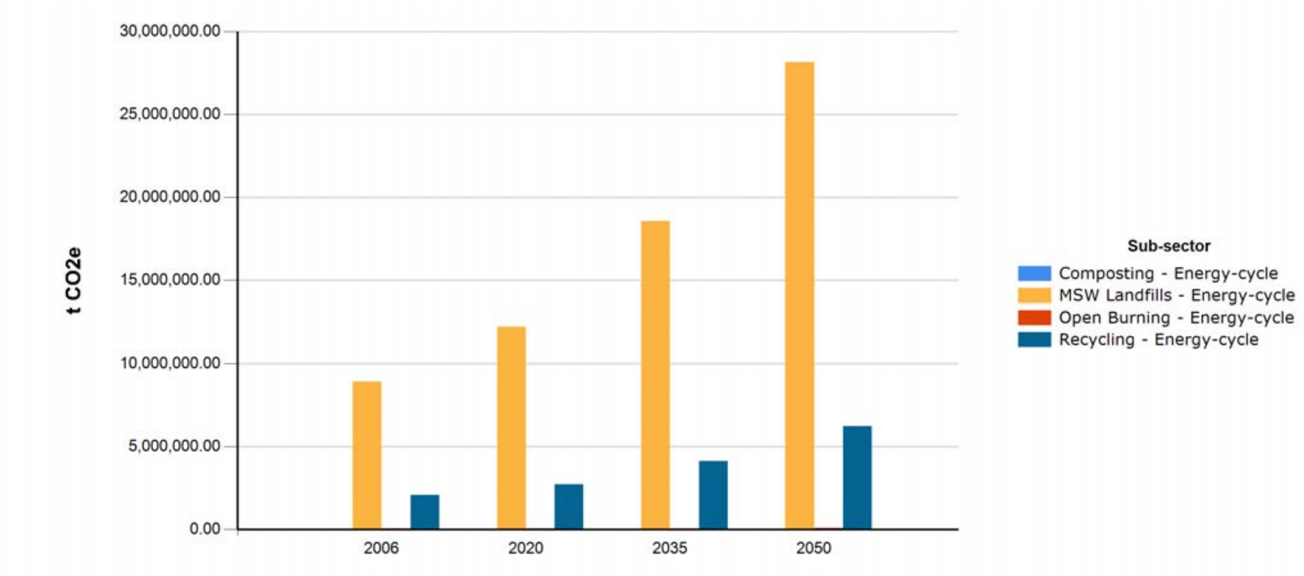
Figure 3.8-2. NJTPA Region Consumption-Based Emissions from MSW Management



Energy-Cycle Emissions

Figure 3.8-3 provides the energy-cycle GHG estimates for the NJTPA region. Again, these are the emissions associated with the production of packaging and products that end up in the MSW stream. These upstream emissions are shown separately for MSW managed by landfilling, recycling, and combustion. In 2006, the energy-cycle emissions total over 11 $MMtCO_2e$ and grow to over 34 $MMtCO_2e$ by 2050. As shown in the figure, most of these emissions are associated with landfilled waste; however, waste in the recycle stream also contributes to total energy-cycle emissions. See Appendix A for more details on how the energy-cycle emissions were modeled for each waste management practice.

Figure 3.8-3. NJTPA Region Energy-Cycle Emissions from MSW Management



The combination of consumption-based and energy cycle GHG emissions provide a much better indication of the merits of alternative waste management practices, including source reduction, reuse, recycling, and composting.

3.9 Wastewater Treatment

Source Description

The wastewater treatment (WWT) sector is typically divided into two subsectors: municipal wastewater treatment; and industrial wastewater treatment. Data covering the industrial WWT subsector were not readily-available during this project; hence, the emissions are not included in the results. More important to local GHG mitigation planners are the emissions for municipal WWT, which include emissions occurring from the WWT plant (WWTP) treatment processes and the large amounts of energy (especially electricity) consumed at these sites.

Analysis Methods

Direct Emissions

Direct emissions from the wastewater treatment (WWT) sector include CH_4 and N_2O emissions from municipal and industrial wastewater treatment facilities. These are process emissions only. Any fuel combustion-related emissions in the WWT sector are included within the industrial/commercial fuel combustion sector totals. Municipal WWT emissions were estimated using the population-based methods from the state I&F and recommended by EPA in the draft Regional Guidance to estimate emissions. County-level emissions were developed by applying CH_4 and N_2O emission factors to the population for each county. The county emissions were then allocated to each municipality with one or more WWT plants based on the average daily volume treated provided by NJDEP. As with the state I&F, emissions from industrial wastewater treatment were not estimated due to the lack of data for this sub-sector and their likely small contribution to regional GHG emissions.

Consumption-Based Emissions

As described in more detail in the technical appendix, preliminary estimates were made of both consumption-based and energy-cycle emissions for wastewater treatment to account for the energy consumed during treatment as well as the upstream energy consumed in the provision of potable water. Total regional and county-level consumption-based emissions in the wastewater sector do not differ from direct emissions; however, the geographic allocation at the MCD-level differs between direct and consumption-based accounting. Direct emissions are associated with the location of wastewater treatment plants, while consumption-based emissions are associated with the location of the generators of wastewater (see the technical appendix for more details).

Energy-Cycle Emissions

Energy-cycle emissions from wastewater treatment include the emissions associated with the electricity usage at wastewater treatment plants, as well as the upstream potable water system. A separate estimate of energy-cycle emissions was developed for this project due to its importance in subsequent GHG mitigation planning; however, it is important to note that these emissions will overlap with electricity consumption emissions for the commercial/industrial sectors. The emission estimates for WWT energy-cycle emissions were modeled using the methods described in the technical appendix. Those for commercial/industrial consumption are based on the actual electricity usage reported by NJTPA utilities, however the details to quantify energy usage specifically at WWT are not available in the utility data. Therefore, the user of the estimates presented here needs to understand that these estimates overlap and adjustments will be needed, if they are used along with those from the broader commercial/industrial sectors.

Forecast Method

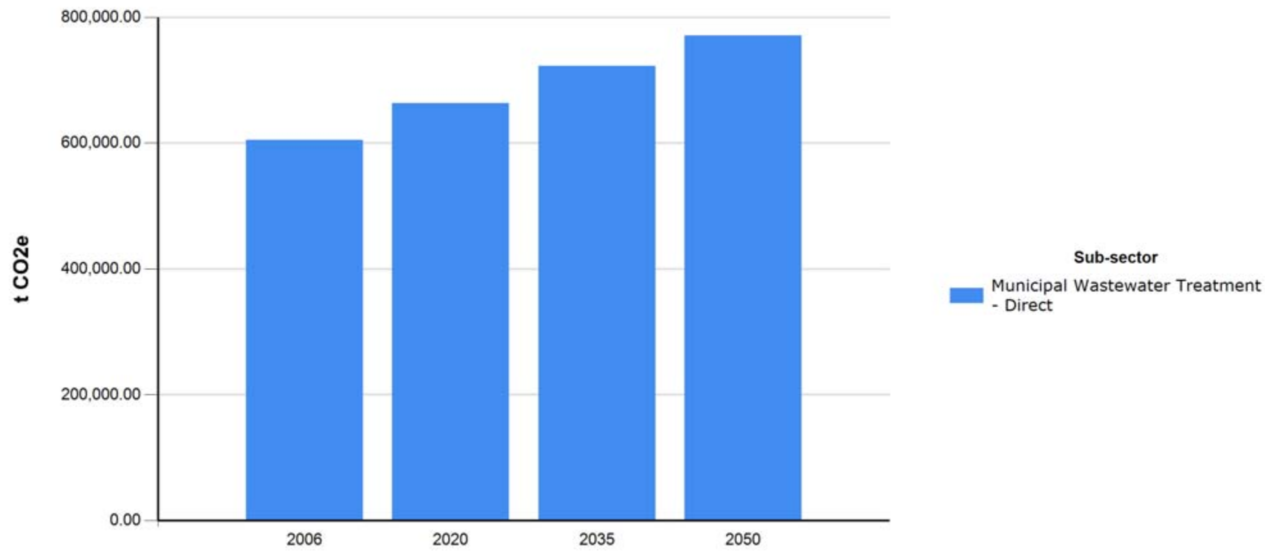
Direct emission associated with WWT plants were forecasted based on county-level population growth. Consumption-based emissions were projected based on MCD-level population growth.

Inventory & Forecast Results

Direct Emissions

Figure 3.9-1 provides a summary of the direct 2006 base year and forecast estimates for the wastewater treatment sector in the NJTPA region. As mentioned above, these estimates only cover municipal WWT, since data for industrial WWT were not readily available. These summaries include all of the direct emissions source categories and gases listed under Section 3.9 above.

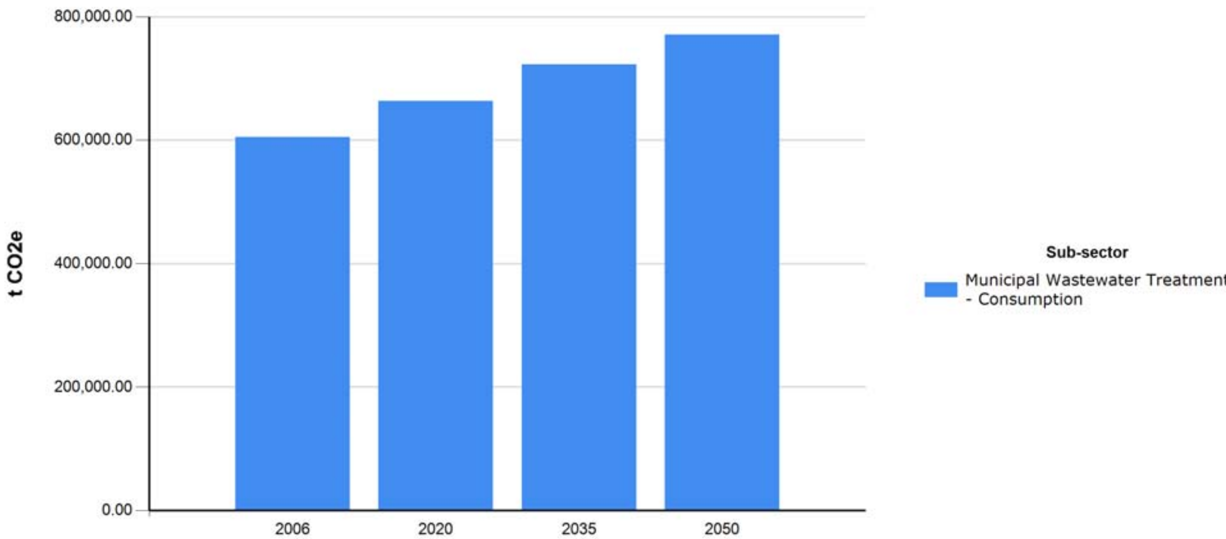
Figure 3.9-1. NJTPA Region Direct Emissions from WWT



Consumption-Based and Energy-Cycle Accounting

As mentioned above, NJTPA regional and county-level consumption-based emissions for the WWT sector are the same as those for direct. Accounting for the GHGs associated with the energy-cycle of wastewater treatment adds an additional 402,000 tCO_2e to the 2006 base year estimates. The user of these GHG estimates is strongly encouraged to read the details of the preliminary assessment of the WWT sector in Appendix A before using the results.

Figure 3.9-2. NJTPA Consumption-Based Emissions from WWT



ACRONYMS

ACRP	Airport Cooperative Research Program
AEDT	Aviation Environmental Design Tool
AEO	Annual Energy Outlook (prepared by EIA)
AFW	Agriculture, Forestry, and Waste Management
AP-42	EPA's *Compendium of Air Pollutant Emission Estimation Methods*
ARC	Access to the Region's Core
BAU	Business as usual
BMC	Baltimore Metropolitan Council
BTU	British thermal unit
CCAR	California Climate Action Registry
CCS	Center for Climate Strategies
CCWG	Climate Change Working Group
CH_4	Methane
CMAQ	Congestion Mitigation and Air Quality
CMV	Commercial marine vessel
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
COLE	Carbon On-Line Estimator
DOE	U.S. Department of Energy
DVRPC	Delaware Valley Regional Planning Commission
EDMS	Emissions and Dispersion Modeling System
eGRID	Emissions & Generation Resource Integrated Database
EIA	Energy Information Administration
EPA	U.S. Environmental Protection Agency
FAA	Federal Aviation Administration
FIA	USFS Forest Inventory & Analysis program
FTA	Federal Transit Administration
GHG	Greenhouse Gas
GIS	Geographic information systems
GREET	GHG, Regulated Emissions, and Energy use in Transportation
GWP	Global warming potential
GWRA	*Global Warming Response Act*
HCFC	Hydrochlorofluorocarbon
HFCs	Hydrofluorocarbons
HPMS	Highway Performance Monitoring System
I&F	Inventory & Forecast
IPCC	Intergovernmental Panel on Climate Change
LandGEM	EPA's Landfill Gas Emissions Model
LTO	Landing & Takeoff
LULUCF	Land Use, Land Use Change, & Forestry

MCD	Municipal Civil Division
$MMtCO_2e$	Million metric tons of carbon dioxide equivalent
MOBILE6.2	EPA's Motor Vehicle Emission Factor Model
MOVES	EPA's Motor Vehicle Emission Simulator
MPO	Metropolitan Planning Organization
MSW	Municipal solid waste
N_2O	Nitrous oxide
NAICS	North American Industry Classification System
NCASI	National Council for Air and Stream Improvement
NEI	National Emissions Inventory
NJDEP	New Jersey Department of Environmental Protection
NJRTM-E	North Jersey Regional Transportation Model—Enhanced
NTD	National Transit Database
NYMTC	New York Metropolitan Transportation Council
NYSDOT	New York State Department of Transportation
NYSERDA	New York State Energy Research and Development Authority
ODS	Ozone depleting substances
PANYNJ	Port Authority of New York and New Jersey
PFCs	Perfluorocarbons
RCI	Residential, commercial, and industrial
RFCE	(Mid-Atlantic) eGRID Subregion and Geographic Descriptor
RGGI	Regional GHG Initiative
RTAC	Regional Technical Advisory Committee
RTP	Regional Transportation Plan
SAGE	System for Assessing Aviation's Global Emissions
SEEDS	Sustainable East End Strategies
SF_6	Sulfur hexafluoride
SIP	State Implementation Plan
SIT	EPA's State Inventory Tool
TAC	Technical Advisory Committee (for this project)
TAZ	Traffic analysis zone
TCAM	Transportation Clean Air Measures
TDOT	Tennessee Department of Transportation
TLU	Transportation and Land Use
USFS	U.S. Forest Service
VMT	Vehicle miles traveled
WARM	Waste Reduction Model
WMA	Watershed management area

GLOSSARY OF TECHNICAL TERMS

Aerobic treatment: the treatment of wastewater using bacteria that live in oxygen-rich environments. The bacteria break down and digest the wastewater. Unlike with anaerobic treatment, significant amounts of methane are not formed with this process.

Anaerobic treatment: the treatment of wastewater in the absence of oxygen, using bacteria that produce methane, a GHG. The methane produced from wastewater treatment plants can be burned as a natural gas substitute for facility equipment such as boilers, hot water heaters, reciprocating engines, turbines and fuel cells.

Cap-and-trade: a market-based policy tool to reduce emissions. Under such a program, specific sources are legally committed to a region-wide limit ('cap') on emissions (normally on an annual basis). The cap is reduced over time. Emission rights (allowances) are tradable, so that those who can reduce pollution cheaply earn a return on their pollution reduction investment by selling extra allowances. The electric power sector in New Jersey is part of a regional cap-and-trade program – the Regional GHG Initiative (RGGI).

Carbon sink : a natural or artificial reservoir that accumulates and stores some carbon-containing chemical compound for an indefinite period.

Carbon sequestration (agriculture and forestry): the process through which CO_2 from the atmosphere is absorbed by trees, plants and crops through photosynthesis, and stored as carbon in biomass (tree trunks, branches, foliage and roots) and soils.

Carbon dioxide equivalent (CO_2e): a sum which includes the quantity of each GHG weighted by a factor of its effectiveness as a GHG, using CO_2 as a reference. This is achieved by multiplying the quantity of each GHG by a factor called GWP, specific to each GHG, where the GWP for CO_2 is 1.

Cogeneration: the simultaneous generation of both electricity and useful heat. In separate production of electricity, some energy is rejected as waste heat, but in cogeneration this thermal energy is put to good use. Cogeneration is therefore a more efficient use of fuel.

Combustion emissions: emissions resulting from fossil fuel consumption.

Consumption-based accounting: considers all the emissions that result from energy consumed, waste generated, and transportation trips generated in an area, even if the emissions occur outside of the boundaries of the geographic area considered. Consumption-based accounting is useful to policy makers wishing to reduce emissions by affecting activities they have control over.

Criteria air pollutants: air pollutants for which EPA has set health-based National Ambient Air Quality Standards, or pollutant concentrations in ambient air not to be exceeded. The criteria pollutants are particulate matter, ground-level ozone, carbon monoxide, sulfur oxides, nitrogen oxides, and lead.

Direct emissions: emissions occurring at the emission source, for example exhaust from the vehicle tailpipe or power plant stack.

Direct emissions accounting: these emissions will include only direct emissions allocated to the location from which they are emitted (e.g., power plant emissions from the power plant).

Downstream emissions: Emissions that will occur after a product has been used for its intended purpose; for example emissions from disposal of waste at a landfill.

Emission factor: an indication of the average amount of a pollutant emitted into the atmosphere from a specific activity per amount of fuel used, industrial product manufactured, electricity produced, miles driven, or other usage measure.

Enteric fermentation: methane-generating process that takes place in the digestive systems of ruminant animals. Most of the methane byproduct is belched by the animal, however, a small percentage is also produced in the large intestine and passed out as gas.

Global Warming Potential (GWP): a weighing factor indicating the effectiveness of a specific GHG in contributing to global warming, as compared with CO_2. GWPs account for the lifetime and the influence on the global energy balance of each chemical over a period of 100 years (e.g., CO_2 has a much shorter atmospheric lifetime than SF_6, and therefore has a much lower GWP).

Lifecycle emissions: involves a cradle-to-grave view of GHG emissions associated with an activity (e.g., driving) or use of product (e.g., plastic bottle). Such an assessment includes the extraction and transport of raw materials, manufacture, packaging, freight, usage and finally disposal. It also generally includes the emissions from construction of all facilities within the value chain.

Energy-cycle emissions: defined for this inventory, these emissions include upstream emissions associated with the production of fuels used. In this study, these emissions are associated with the consumption-based accounting method only, and are allocated to the location in which the activity takes place (e.g., power plant emissions plus fuel production and transport associated with electricity consumption, allocated by electricity consumption in each area). In the data files from this study, "energy-cycle" emissions are only upstream emissions component. The full energy-cycle emissions would be the sum of consumption-based emissions + energy-cycle emissions.

Load factor: an indication of the power that an engine is operating at on average, as compared with the maximum (rated) power that the engine is designed to produce. Engines typically operate at a variety of speeds and loads, and operation at rated power for extended periods is rare. To take into account the operation of the engine at less than maximum power (partial load), as well as transient operation, a load factor is developed to indicate the average proportion of rated power used.

Nonattainment area: an area defined by EPA as in exceedance of the National Ambient Air Quality Standards, or contributing to air pollution in a nearby area that fails to meet standards, as defined by the Clean Air Act.

ODS substitutes: chemicals (primarily HFCs and PFCs) intended to replace substances that deplete the ozone layer. Ozone depleting substances (ODS) are being phased out, in accordance with the Montreal Protocol. However ODS substitutes are a concern due to their role as GHGs.

Process emissions: GHG emissions resulting from chemical reactions needed to manufacture certain products. For example, in cement production, limestone is heated to a high temperature to start a chemical reaction that makes lime. The byproduct of that chemical reaction is CO_2, a GHG.

Production-based accounting: considers the emissions that occur within a geographic boundary, regardless of where the demand that caused those emissions is located. Production based accounting does not consider emissions occurring outside of the geographic bounds of the inventory, as a result of activity taking place within the geographic bounds. For example, production-based accounting considers emissions from power plants within the area, but not emissions associated with imported electricity.

Renewable energy: energy from sources that are perpetual or that are replenished more quickly than they are used up. Renewable energy includes solar, wind, wave, tidal, geothermal, landfill gas, anaerobic digestion, and certain other forms of biomass and hydro power.

Renewable Portfolio Standard (RPS): a state policy that requires electricity providers to obtain a minimum percentage of their power from renewable energy resources by a certain date. New Jersey's RPS goal is 22.5 percent power from renewable resources by 2021.

Ruminant animals: animals having four stomachs, including cows, sheep, and goats.

Ton-mile: a unit of freight transportation equivalent to a ton of freight moved one mile.

Truck hotelling: the idling of truck engines at rest stops over long time periods. Truck drivers must rest after a long period of driving, to comply with federal safety regulations. During this rest period, truck engines are often left on, in idling mode, so that the drivers can use air conditioning, heat, or on-board appliances such as a television or microwave. Emissions associated with truck hotelling can be reduced by providing alternatives to engine idling, such as truck stop electrification.

Upstream emissions: Emissions that occur before a product is used for its intended purpose; for example drilling, refining, and transportation of oil to be used as vehicle fuel; emissions during manufacturing of a product (metal can, glass bottle, steel beam, etc).

TECHNICAL APPENDIX

A. Cross Sector Approach, Data, and Methods

A.0.1 Framework and Accounting Approach

The I&F presents GHG emissions from direct fuel consumption and electricity use in the residential, commercial, industrial sectors, including production in the power sector; on-road, nonroad, aviation, marine, and rail transportation sectors including freight; industrial processes; agricultural sources, including soils, manure and livestock; waste management; and land use, land use change, and forestry. Emissions were analyzed for a baseline year 2006, and forecast for the years 2020, 2035, and 2050. In cases where more recent data were used, a 2006 baseline was estimated by back-projecting growth using the same growth metric applied for future years. Emissions were then allocated to the NJTPA subregions and municipalities to the extent practicable. Note that in some case it was not practicable to allocate down to the subregion or MCD level (e.g., nonroad equipment), and therefore, even within a given sector, some sources may be presented only at the subregion or MPO level.

Emissions have been calculated and allocated using two accounting approaches: a direct approach, and a consumption-based approach. The direct approach is similar to the methods applied in most GHG Inventories, including the NJ state-wide inventory. The direct approach presents emissions at the location from which they are emitted. Consumption-based emissions associate the emissions with the activity, or the 'consumption' leading to those emissions. Thus, for example, vehicle emissions within a certain MCD will be allocated to that MCD for the direct approach, but will be split between the origin and destination of the trip for the consumption based approach. Similarly, direct emissions from electricity production are associated with the power plants producing the emissions, whereas consumption-based emissions are associated with the locations at which the electricity is used. Note that the sum of these two approaches is not necessarily equal; for example, consumption-based trips may include emissions from outside of the NJTPA region.

For the consumption-based method only, the emissions associated with energy production and transport, or "energy-cycle emissions", are included as well.

As it pertains to both spatial and temporal boundaries—

- Direct emissions are allocated to the MCD where the activity (e.g., fuel combustion) occurred and within the year in which it occurred.
- Consumption-based and energy-cycle emissions are allocated to the location where the consumption-based activity occurred (e.g., trip origin/destination, point of waste generation) and the full set of emissions, including energy cycle emissions, are assumed to occur within the same year.

A.0.2 Gases Included and Units

CO_2, methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF6), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs) were included to the extent practicable. All emissions are presented in million metric tons (MMt) unless otherwise noted. Emissions of the various GHGs were added together and presented as carbon dioxide equivalent (CO_2e) emissions—a sum which includes the quantity of each GHG weighted by a factor of its effectiveness as a GHG, using CO_2 as a reference. This is achieved by multiplying the quantity of each GHG emitted by a factor called global warming potential (GWP), specific to each GHG, where the GWP for CO_2 is 1. The GWP accounts for the lifetime and the radiative forcing of each gas over a period of 100 years (e.g., CO_2 has a much shorter atmospheric lifetime than SF_6, and therefore has a much lower GWP). Following standard protocol for GHG inventories, and consistent with the US GHG inventory, the GWP factors from IPCC's Second Assessment Report (1996), presented in Table A.0-1, were used.

Table A.0-1. Global Warming Potential (GWP)

GHG	Chemical Formula or Class	GWP
Carbon Dioxide	CO_2	1
Methane	CH_4	21*
Nitrous Oxide	N_2O	310
Sulfur Hexafluoride	SF_6	23,900
Hydrofluorocarbons	HFC-23	11,700
	HFC-32	650
	HFC-125	2,800
	HFC-134a	1,300
	HFC-143a	3,800
	HFC-152a	140
	HFC-227ea	2,900
	HFC-236fa	6,300
	HFC-4310mee	1,300
Perfluorocarbons	CF_4	6,500
	C_2F_6	9,200
	C_4F_{10}	7,000
	C_6F_{14}	7,400

Source: EPA, Inventory of U.S. GHG Emissions and Sinks, multiple versions, 2007-2010, based on IPCC (1996).

* The CH_4 GWP includes the direct effects and those indirect effects due to the production of tropospheric ozone and stratospheric water vapor. The indirect effect due to the production of CO_2 is not included.

A.0.3 Common Data: Emissions, Growth, and Allocation Factors

Fuel Emission Factors

Emission factors for transportation fuels are presented in Table 2.0-2. These factors were applied for all transportation fuels and all nonroad fuels in all sectors excluding commercial marine vessels, which calculated emissions using the GREET model and on-road vehicles which calculated emissions using the MOVES model.

Table A.0-2. Transportation and Nonroad Fuel Emission Factors

Fuel	**Direct Emissions Factor** ($tCO_2/MMBtu_{hhv}$)	**Direct Emissions Factor** (tCO_2/gal) or (tCO_2/scf) for NG	**Well-to-Pump* Emissions Factor** (tCO_2e/MMBtu)	**Well-to-Pump* Emissions Factor** (tCO_2/gal) or (tCO_2/scf) for NG
Gasoline	0.0702	0.00878	0.01838	0.00230
Diesel	0.0740	0.0102	0.01816	0.00251
Natural Gas	0.0531	0.0000540	0.01769	18.2
LPG	0.0630	0.00579	0.01342	0.00123

Source: The Climate Registry, Jan. 2010, General Reporting Protocol, Table 13.1. Well-to-pump data from GREET 1.8c and GREET Fleet Footprint Calculator for LPG.

* "Well-to-pump" refers to the energy-cycle emissions associated with production and transport of fuels.

t--metric ton; MMBtu--million British thermal units; hhv--higher heating value; scf--standard cubic foot

In order to account for the existing federal renewable fuel standard, emissions were adjusted to include ethanol and biodiesel requirements under the 2010 Renewable Fuel Standard (RFS2). This standard requires specific minimum quantities of renewable fuels to be produced, including advanced ethanol and biodiesel. Adjustments and factors estimated based on the RFS2 rule were calculated. The exact distribution of these fuels nationally is unknown. It is possible that New Jersey may have higher or lower quantities of these fuels, but since that is unknown, the assumption was that the national average would apply. For direct emissions, since fuel cycle is not included, the fractions of ethanol in gasoline and biodiesel in diesel by year were subtracted from the total, since biogenic emissions are excluded from the inventory (carbon sequestered biologically and re-emitted as combusted fuels result in a net-zero atmospheric increase). This mix was applied equally for all sectors. For consumption based emissions, fuel cycle emissions were calculated, accounting for the additional emissions associated with the production of biofuels. When combined, the consumption based and fuel cycle emissions provide the complete net emissions associated with the use of these fuels.

The adjustments and factors estimated based on the RFS2 rule are presented in Table 2.0-3. For direct emissions, emissions calculated based on gasoline or diesel were reduced by the fractions presented in the first column and fuel-cycle emissions were calculated based on the emission factors presented in the second column, for gasoline and diesel, respectively. Note that these represent average numbers for combined gallons of standard and bio fuels, and therefore the emission factor for fuel-cycle emissions increases over time since larger quantities of biofuels are included and since the upstream emissions for these fuels is larger than the upstream emissions for standard fuels. The total emissions will diminish over time since the fraction of biofuels increases and there are no direct emissions associated with the biofuels. For years after 2022, the rate for 2022 was assumed. This approach is conservative, since it does not account for larger quantities of biodiesel which the law will require in future years but which are not yet specified.

Table A.0-3. Renewable Fuel Standard Impact on Fuel Quantities and Energy-Cycle Emissions

	Gasoline + Ethanol		Diesel + Biodiesel	
Year	% of Gasoline + Ethanol that is Ethanol (Total Energy)	Combined Average Well to Pump Emissions Factor (tCO_2e/gal)	% of Diesel + Biodiesel that is Advanced Biodiesel (Total Energy)	Combined Average Well to Pump Emissions Factor (tCO_2e/gal)
2008	4.9%	0.00262	0.0%	0.00251
2009	5.8%	0.00267	1.2%	0.00255
2010	6.6%	0.00272	1.5%	0.00257
2011	7.2%	0.00276	1.8%	0.00258
2012	7.2%	0.00275	2.2%	0.00259
2013	7.7%	0.00277	2.1%	0.00259
2014	8.5%	0.00280	2.1%	0.00259
2015	9.7%	0.00284	2.1%	0.00259
2016	10.6%	0.00287	2.0%	0.00259
2017	11.5%	0.00289	2.0%	0.00259
2018	12.6%	0.00292	2.0%	0.00258
2019	13.6%	0.00294	2.0%	0.00258
2020	14.6%	0.00296	1.9%	0.00258
2021	16.1%	0.00300	1.9%	0.00258
2022	17.9%	0.00304	1.9%	0.00258
Assume constant for years >2022	*Reduce direct/consumption emissions by this fraction*	*Use this factor for Fuel-Cycle*	*Reduce direct/consumption emissions by this fraction*	*Use this factor for Fuel-Cycle*

Source: Calculated based on quantities and fuel lifecycle emissions reductions dictated by RFS2 rulemaking, and on AEO national fuel consumption projections.

Electricity Emission Factors

Emission factors used for electricity consumption (consumption-based and energy cycle emissions only) in all sectors are presented in Table 3.0-4. For detailed discussion of the electricity emission factors, see Section 2.1.1, “Electrical Power Production and Use”. Note that for years between 2006 and 2020, the emission factors are interpolated linearly. The electricity emission factors for 2020 were used for projecting consumption-based and energy cycle emissions through 2035, since there are currently no enforceable goals that would result in reducing the emission factor for electricity beyond 2035.

Table A.0-4. Consumption and Energy Cycle Emission Factors for Electricity Consumption (Includes Grid-Loss)

Base Year Emission Factors	Base Year (2006)	2020 and Later
Consumption Based Emissions:		
CO_2 (metric tons/MWh)	0.5498	0.3354
CH4 (metric tons/GWh)	0.0146	0.0089
N2O (metric tons/GWh)	0.0090	0.0055
CO_2e (metric tons/MWh)	0.5529	0.3373
Energy Cycle Emissions:		
CO_2e (metric tons/MWh)	0.0349	0.0210
Sources: eGRID2007 for RFCE Subregion (2005 data); 2020 emission factors account for the 2020 NJ RFS goal (22.5% renewables), assuming that the emission reduction benefits would be achieved throughout the RFCE Subregion by 2020.		

Growth Factors for Inventory Forecast

In many cases, demographic and other information from *Plan 2035 Regional Transportation Plan for Northern New Jersey*, adopted in August 2009, was used to predict growth rates. Relevant demographic data used in developing the GHG emissions forecast are included in Appendix A.

A.1 Electrical Power Production and Use

A.1.1 Source Description

Emissions from electricity production and consumption stem mainly from the combustion of fossil fuels used in generating electricity. According to eGRID, coal and nuclear energy constitute the majority of the resource mix used in electricity generation within the RFCE subregion (45 percent and 38 percent, respectively). Emissions from electricity produced within New Jersey (i.e. not imported from the rest of the region) are lower on a per kilowatt-hour basis. In New Jersey, the fuels used for most of the electricity generation in 2006 were nuclear (53.7 percent), natural gas (25.8 percent), and coal (17.9 percent). The direct emissions inventory considers the GHG emissions from electricity produced in the NJTPA region at the location at which the GHGs are emitted. It does not account for the imported electricity or the resource mix within the larger electricity grid (RFCE subregion). The consumption/energy-cycle based inventories consider the emissions from all electricity used throughout NJTPA, regardless of where the electricity is produced.

The most significant GHG emitted through electricity generation and consumption is CO_2. CH_4 and N_2O are emitted as well and are included in the inventory. Although emissions of SF_6 result from the transmission and distribution of electricity, those emissions are included with the Industrial Processes sector for consistency with other inventory efforts. The SF_6 emissions are included in the Industrial Processes sector in the national and state inventories.

The electricity sector inventory is provided using both the direct and consumption/energy-cycle approaches. The inventory includes the emissions resulting from production of electricity in the NJTPA region by MCD in the direct approach, and also the emissions resulting from producing in-state generated and imported electricity that is consumed in the region in the consumption/energy-cycle approach. The lifecycle inventory includes emissions associated with the production of fuels used to generate electricity (for example oil drilling and refining) and fuel transport.

A.1.2 General Inventory Approach

Direct Emissions

The NJDEP point source inventory for 2007 was used in developing the emissions resulting from electricity production in the NJTPA region. The NJDEP inventory was developed for all of New Jersey using annual emissions statements. While the NJDEP point source inventory for the 2006 base year was also available, only the 2007 NJDEP inventory included fuel consumption data by fuel type that were needed for calculating the emissions for each GHG by source and fuel type. Electricity generation facilities included in EPA's Clean Air Markets Database (CAMD)[31] and the eGRID[32] database within the NJTPA area were included in the direct emissions inventory. All GHG emission sources within each power generating facility were included. EPA's CAMD, eGRID data, and the National Emissions Inventory (NEI) were used to determine facility locations and verify fuel type and consumption. The emission factors by fuel type were based on the factors recommended by The Climate Registry (see section A.0 above), with the exception of biogenic sources of CO_2 emissions, which were set to zero.

The direct fuel consumption for electricity generation in the NJTPA region is presented in Table A.1-1.

Table A.1-1. Fuel Consumption for Electricity Generation in the NJTPA Region (2006)

County	Fuel Oil (gallons)	Kerosene (gallons)	Natural Gas (mil. cf)	Butane (mil. cf)	Digester Gas (mil. cf)	Landfill Gas (mil. cf)	Petroleum Refinery Gas (mil. cf)	Municipal Solid Waste (tons)
Bergen	63,402	7,044,554	37,796	-	-	512	-	-
Essex	627,279	727,228	6,947	-	-	-	-	888,078
Hudson	745	346,853	5,814	-	-	-	-	-
Hunterdon	1,379,470	-	1,044	-	-	-	-	-
Middlesex	6,108,564	144,148	28,357	-	-	2,140	-	-
Monmouth	7,296	-	80	-	-	1,818	-	-
Ocean	1,134,719	341,081	3,777	-	122	1,896	-	-
Passaic	349,074	-	1,201	-	16,949	-	-	5
Somerset	111,499	-	670	-	-	-	-	-
Sussex	-	-	-	-	-	162	-	-
Union	1,249,274	1,676,287	64,455	172	-	-	18,491	541,550
Warren	373,390	-	1,844	-	-	306	-	148,077

Source: Pechan Team, based on analysis of CAMD and eGRID2007 data.

[31] U.S. Environmental Protection Agency, Clean Air Markets. http://www.epa.gov/airmarkets/

[32] The Emissions & Generation Resource Integrated Database for 2007 (eGRID2007), http://www.epa.gov/cleanenergy/documents/egridzips/eGRID2007V1_1_year0504_STIE_USGC.xls, prepared for EPA by E.H. Pechan and Associates, Inc, September 2008

Consumption-Based & Energy-cycle Emissions

To facilitate mitigation efforts targeted at reducing electricity consumption, it was important to develop a consumption-based inventory. Based on the New Jersey I&F for 2005, 26 percent of the electricity consumed in the State is imported. The emissions resulting from electricity consumed in the NJTPA region include both the emissions from electricity generated within the region and the emissions imported into it. The consumption-based inventory was developed using data by geographic area (MCD or zip code) and by subsector (residential, commercial, and industrial) provided by the major power suppliers within the region. These include Jersey Central Power and Light (First Energy), Public Service Electric and Gas Company (PSE&G), Rockland Electric, and Atlantic City Energy.

In addition, Sussex rural cooperative and Park Ridge borough municipal utility provided annual consumption data for the residential and commercial sectors for their service territory. There are six additional municipal utilities from which data were not obtained. For MCDs that receive most of their electricity from those municipal utilities, consumption was estimated assuming an average annual consumption of 10,275 kWh per household for the residential subsector and 7,000 kWh per employee for the commercial subsector. Industrial consumption within those MCDs was assumed to be captured within the commercial estimate. In the case of Madison borough, for which total annual consumption data for the residential, commercial, and industrial subsectors were obtained, the industrial sector consumption was calculated by subtracting the above assumed average residential and commercial consumption rates from the total provided by the borough. While some companies were able to provide consumption for municipal use, or for municipally-owned street lights, these details were not available for each MCD within the NJTPA region. Therefore, the inventory does not present GHG emissions from municipal and street light electricity consumption separately. Instead emissions from government and street light electricity consumption were included as part of the commercial sector emissions.

Some companies provided 2009 to 2010 consumption data instead of the 2006 base year data. To adjust the consumption to the baseline year, the changes in consumption for each sector within each NJTPA MCD were assumed to be the same as the growth in consumption across the State for that sector, obtained from the State Energy Data System information for New Jersey.

The total 2006 baseline and future projected electricity consumption is presented in Table A.1-2. (For information on allocation and growth projection, see Sections A.1.3 and A.1.4 below.)

Table A.1-2. Projected Electricity Consumption (GWh per year)

County	2006	2020	2035	2050
Bergen	7,989	6,848	7,458	7,997
Essex	6,083	5,176	5,527	5,834
Hudson	5,104	4,803	5,567	6,289
Hunterdon	1,172	1,092	1,268	1,374
Middlesex	8,261	7,641	8,902	9,956
Monmouth	5,254	4,656	5,152	5,606
Morris	5,058	4,401	4,943	4,943
Ocean	4,031	3,719	4,416	4,949
Passaic	3,172	2,798	3,123	3,381
Somerset	3,412	3,158	3,651	4,073
Sussex	1,055	1,024	1,204	1,383
Union	4,087	3,538	3,839	4,075
Warren	1,068	944	1,018	1,087
Grand Total	*55,747*	*49,797*	*56,070*	*60,946*

Source: Pechan Team, based on utility data and forecast metrics.

Consumption-based emissions were calculated by multiplying the above electricity consumption by the electricity emissions factor for the RFCE subregion obtained from the eGRID2007 database, adjusted to include emissions from energy lost through transmission and distribution. The factors used for the baseline year are presented in Table A.1-3.

Table A.1-3. Baseline Year Emission Factors

Base Year Emission Factors	Consumption Emission Factors	Energy-Cycle Emission Factors
CO_2 (metric tons/MWh)	0.5498	N/A
CH_4 (metric tons/GWh)	0.0146	N/A
N_2O (metric tons/GWh)	0.0090	N/A
CO_2e (metric tons/MWh)	0.5529	0.0349

Source: The consumption emission factors are the eGRID 2007 factors for the RFCE subreagion (eGRID 2007 is based on 2005 data), adjusted to include a transmission and distribution loss of 6.41 percent. The energy-cycle emission factors were developed using the GREET model.

Based on eGRID, the transmission and distribution loss in RFCE subregion is 6.41 percent. This figure is consistent with the default factor for Eastern U.S. recommended in The Climate Registry (TRC) Electric Power Sector Protocol for the Voluntary Reporting Program.[33]

[33] The Climate Registry, *Electric Power Sector Protocol for the Voluntary Reporting Program*, Annex 1 to the General Reporting Protocol, Version 1.0, June 2009.

The eGRID emission factor is based on 2005 data. While in the future the use of verified utility-specific emission factors could be used, at this time the eGRID factor provides the best estimate for a region-wide factor, and is also suggested as the best factor to use in absence of utility-specific information in The Climate Registry General Reporting Protocol. Since emissions from electricity generation would be controlled in the future on a regional basis, such as the existing Regional GHG Initiative (RGGI) or potential future federal programs, this is the most appropriate approach for consumption-based emissions.

The energy-cycle inventory accounted for the emissions associated with fossil fuel production and transport. The electricity module of the GREET model was used to develop a factor that accounts for energy-cycle emissions. The input to the GREET model was the RFCE subregion energy source mix in 2005, as reported in eGRID2007. The energy-cycle emissions for the baseline year were calculated to be an additional 6.3 percent of the consumption-based emissions. The energy-cycle emissions for fossil fuels (oil and natural gas) represent a more significant portion of overall emissions from those fuels (20 to 30 percent). The 6.3 percent considers all the fuels used to produce electricity (fossil, nuclear, and renewable), which reduces the relative contribution of energy-cycle emissions to overall emissions (from 20 to 30 percent to 6.3 percent).

A.1.3 Inventory Allocation Method

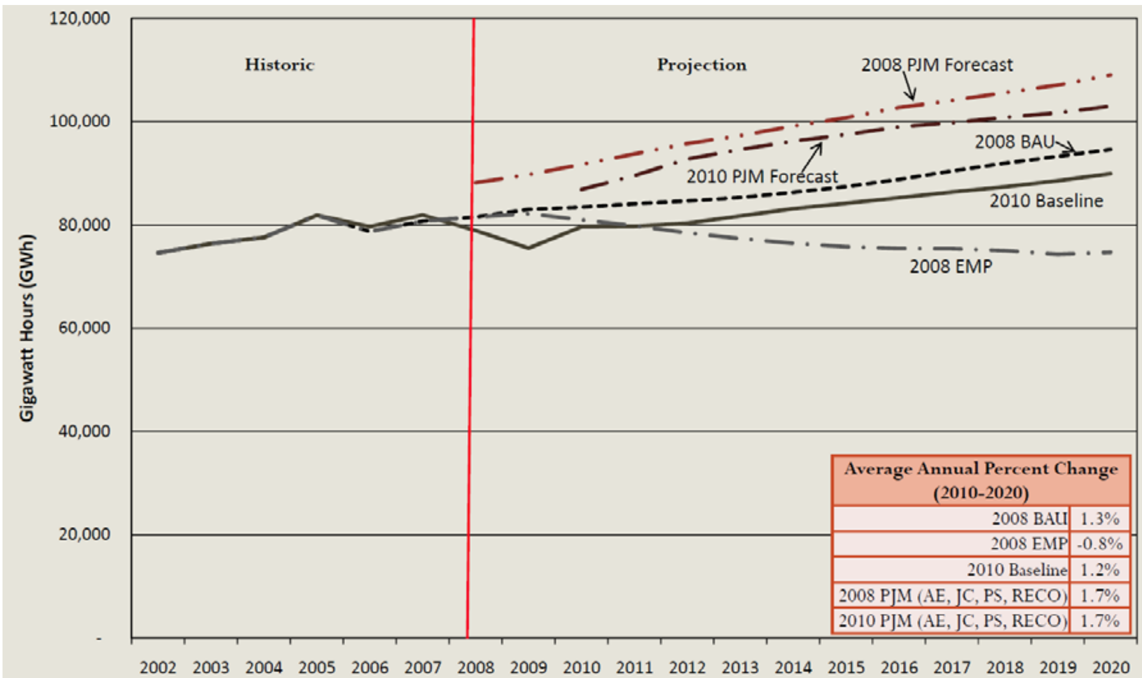
For the direct approach, facility-specific electricity production emissions from the NJDEP point source inventory were allocated to the appropriate MCD based on the address for each specific facility. The allocation of the consumption-based and energy-cycle emissions was straight-forward for electricity consumption that was provided by the utilities by MCD. Residential consumption provided by zip code was allocated to MCDs based on the proportion of households of an MCD within a zip code. Similarly, commercial and industrial consumption by zip code were allocated to MCDs based on the proportion of employment of an MCD within a zip code. As discussed in Section 2.1.2, rather than providing consumption information by MCD or zip code, the Sussex Rural Cooperative provided information on the total residential and commercial consumption on their service territory. Therefore, the Sussex Rural Cooperative emissions were allocated to MCDs within the Cooperative service territory by proportion of territory-wide households and employment within each of the MCDs.

A.1.4 Forecast Method

The direct emissions from electricity production were assumed to remain constant, since any projections of changes in electricity production and efficiency, and therefore emissions for individual facilities would be highly speculative. Furthermore, in the future, some of the facilities included in the baseline inventory would likely be shut down or renovated, and new facilities at new locations could be started.

Note that in the state-wide inventory, NJDEP projected growth in electricity consumption and net growth in the ensuing emissions (including a reduction in imported electricity), representing the reference case for that analysis. For this NJTPA inventory, the projections assume the implementation of the Energy Master Plan (EMP), which is not part of the state-wide inventory’s reference case. The latest data for the EMP, presented in Figure 3.1-1 below, indicate a projected average annual reduction of 0.8 percent in state-wide electricity demand for the 2008 EMP scenario. The EMP assumes that reductions would first reduce imported electricity before reducing any in-state production (NJ is a net importer of electricity). Therefore, the assumption that direct emissions remain constant for future years is in line with those projections. There is no information for further future years, so the emissions projected out to 2050 are less certain. Since this NJTPA inventory allocates direct emissions to specific MCDs based on the plant location, and since no information is available regarding potential new electricity production facilities in the future, such an estimate would not be possible.

Figure A.1-1. Draft Future Forecasts of Electricity Consumption in NJ for the Energy Master Plan Update



Notes: R/ECON not weather normalized, PJM weather normalized.
PJM forecast is at transmission-distribution interface.

Source: CEEEP, Preliminary Data Update of the 2008 New Jersey Energy Master Plan (working draft), revised August 25, 2010.

The forecast of consumption-based and energy-cycle emissions accounted for several factors. The first was the growth projected for the region. Data for the Business as Usual (BAU) scenario from *Plan 2035* Appendix B were used. Household growth was used to forecast BAU consumption in the residential sector, while employment growth was used to forecast BAU consumption in the commercial and industrial subsectors.

The second factor accounted for was the goal in the New Jersey Energy Master Plan to reduce energy consumption in buildings by at least 20 percent from 2010 to 2020. Consumption in the residential and commercial subsectors for 2020 target year were calculated for each MCD, by assuming a 20 percent reduction in total electricity consumed (kWh) as compared with BAU for 2020. The planned improvements in efficiency and therefore reduction in electricity consumption were assumed to occur gradually from 2010 to 2020; therefore a linear change in consumption was used in developing the forecast. The reduction in consumption was not assumed for the industrial subsector, because the energy efficiency improvements described in the Energy Master Plan target buildings, rather than major industries.[34] Beyond 2020, no further reduction in electricity consumption was assumed.

[34] The 2008 Energy Master Plan Goal is to reduce total energy consumption (electricity and heating fuel use) by 20 percent from 2010 to 2020 as compared to the 2020 energy BAU. To some extent, the goals of the energy master plan would affect all

The third factor accounted for in the forecast of emissions from electricity consumption was a transition to cleaner energy sources. Emission factors associated with electricity consumption are expected to decrease as a result of the Renewable Portfolio Standard (RPS), Regional GHG Initiative (RGGI), and the goals of the New Jersey Energy Master Plan. By 2020, the State's goal is to produce 22.5 percent of its electricity from renewable resources.35 The goal was included in the NJTPA inventory forecast, by adjusting the RFCE source mix for 2005 to account for the increased proportion of renewables in the mix, while maintaining the relative proportions of fossil fuels (mainly oil and gas) and nuclear energy. It was assumed that the RFCE source mix would be comparable to the New Jersey source mix in 2020. Using the electricity module of GREET, the energy-cycle emissions were calculated to be 6.2 percent greater than the consumption-based emissions only.

Table A.1-4. Emission Factors Projected for 2020

Base Year Emission Factors	Consumption Emission Factors	Energy-Cycle Emission Factors
CO_2 (metric tons/MWh)	0.3354	N/A
CH_4 (metric tons/GWh)	0. 0089	N/A
N_2O (metric tons/GWh)	0.0055	N/A
CO_2e (metric tons/MWh)	0.3373	0.0210

Note: The consumption-based emission factors are projected by adjusting the eGRID 2007 factors for the RFCE subregion (eGRID 2007 is based on 2005 data), to include the expected future increase in renewable power sources and to account for the transmission and distribution loss, assumed to remain 6.41 percent in the future. The energy-cycle emission factors were developed using the GREET model, assuming the projected resource mix with 22.5 percent of electricity generated from renewable sources.

Source: AKRF, based on eGRID and GREET.

The decrease in the emission factor, representing the introduction of cleaner energy sources, was assumed to occur linearly from the 2006 baseline to 2020. Post 2020, the emission factor was assumed to remain constant.

A.1.5 Inventory & Forecast Update Methods

Future updates to the inventory of electricity production (direct) would rely on newer facility level point source data from NJDEP. Information from utilities and other electricity providers would periodically need to be updated for the consumption/energy-cycle inventory. This information should be requested by MCD, rather than by zip code, to avoid difficulties encountered with allocating to MCD level. Municipal electricity consumption information when it becomes separately tracked by each utility could be separated out in the future. As eGRID factors are updated, they should be used in updates to the inventory, unless verified utility-specific emission factors become available. When developed, more specific long-term energy goals could be incorporated, as well as new demographic projections.

A.1.6 Inventory & Forecast Results

See the body of the report for results at the regional level.

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sectors, and may affect electricity use to a greater of lesser extent than direct fuel use. Here, we assume that 20 percent of the 2020 BAU electricity demand, as calculated using population and employment growth projections would be reduced from the residential and commercial sector consumption only, as these two sectors account for the majority of energy use in buildings, where most of the Energy Master Plan measures would be implemented.

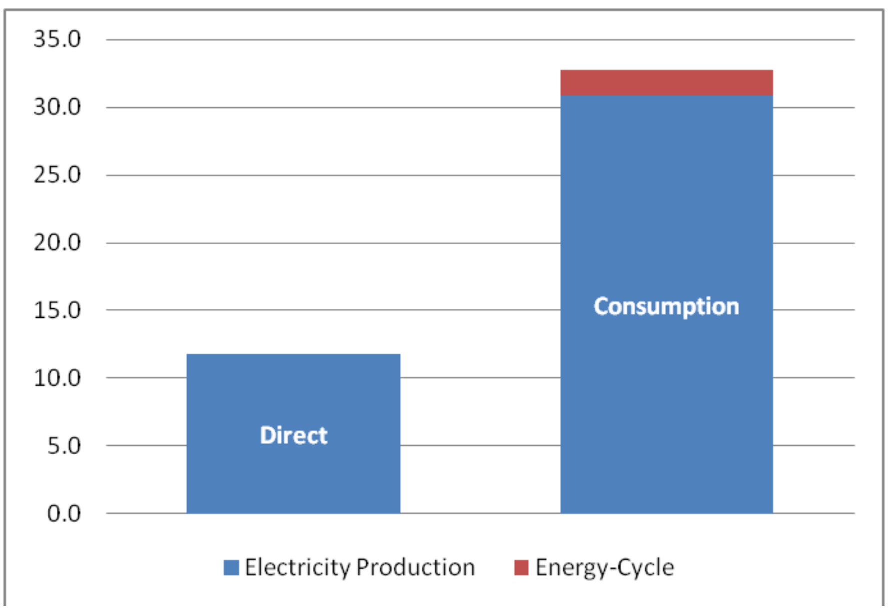
[35] State of New Jersey, Draft New Jersey Energy Master Plan, April 17, 2008.

It is important to note that there are substantial differences between the direct emissions and the consumption-based emissions:

- Direct emissions represent only the power production within the NJTPA region, excluding imported power.
- Consumption–based emissions are based on the region-wide power grid average power production fuel mix. Since NJ has a higher level of nuclear and less coal-based power, and since power supplied to the grid is not specific to the location at which it was produced, the total consumption-based emissions are significantly higher than the total direct emissions in the NJTPA region, as presented in Figure A.1-2 below.
- The county distribution of electricity related emissions vary considerably, as depicted in Figure A.1-3 below. When using the consumption-based data at the county or municipal levels, caution should be taken in prioritizing electricity measures versus other sectors, due to the above mentioned differences between the NJ and the regional power production. Counties and municipalities may wish to apply a lower weight to the electricity emissions.

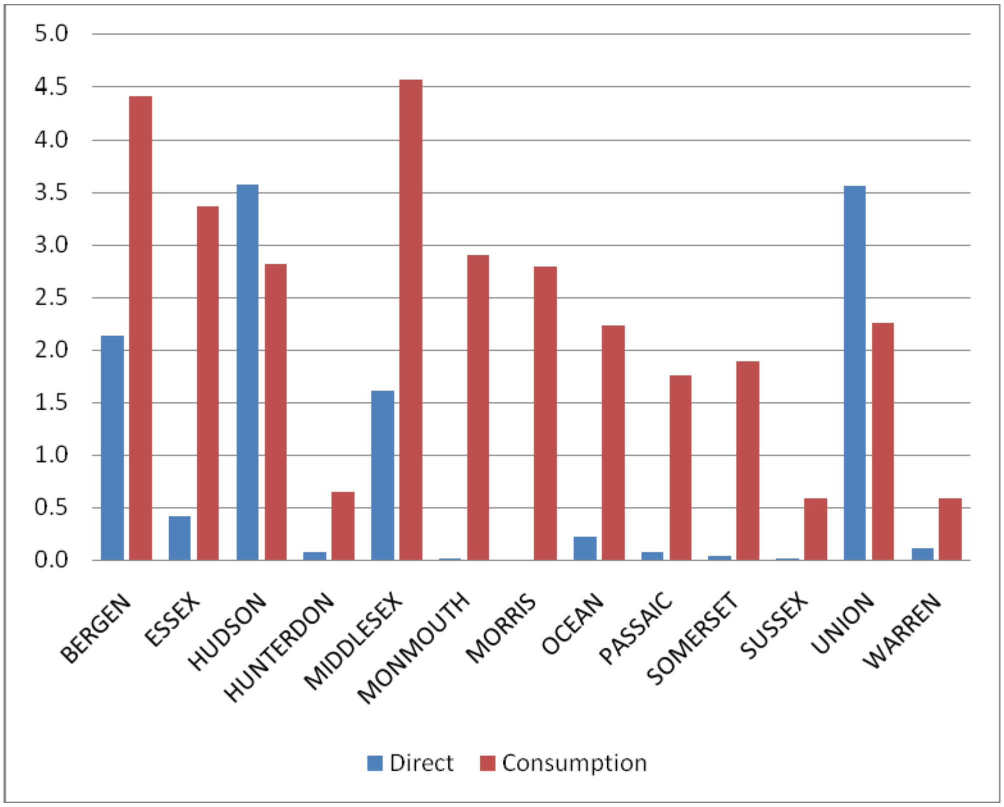
At the county level, the fraction of emissions associated with the residential, industrial, and commercial sectors will vary greatly, as depicted in Figure A.1-4. Municipal consumption would, similarly, vary as well.

Figure A.1-2. Total Electricity Emissions, 2006 (MMtCO$_2$e)

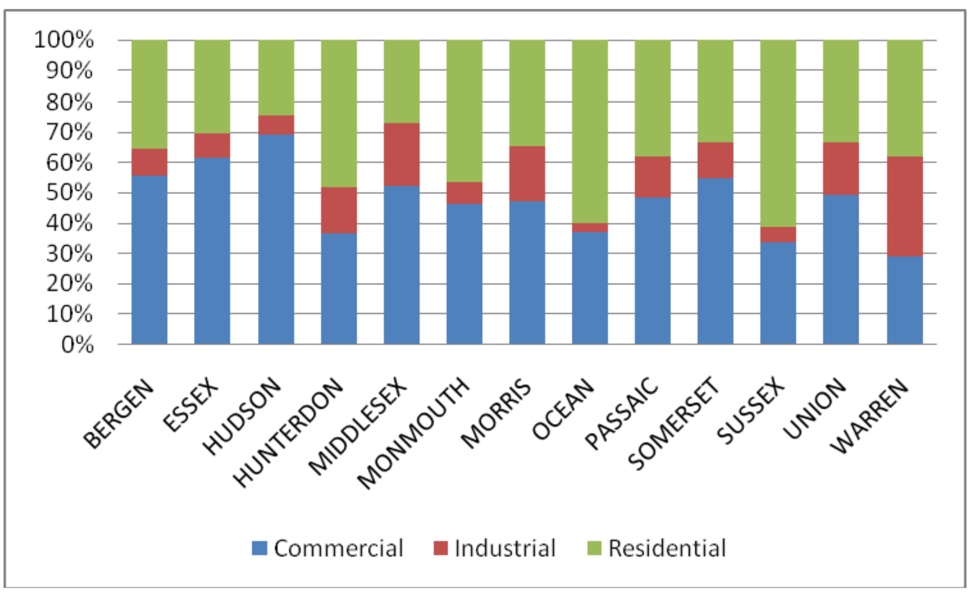


Note: Energy cycle emissions were not analyzed for the Direct scenario.

Figure A.1-3. Electricity Emissions by County, 2006 ($MMtCO_2e$)



A.1-4 Consumption-Based Electricity Emissions by Sub-Sector, 2006



A.1.7

Recommendations for Future Improvements

For future updates consumption data should be requested exclusively by MCD, since the allocation from zip code to MCD proved to be a labor-intensive process that introduced some level of uncertainty to the allocation of emissions within specific zip codes. The point source inventory could further be refined to include only those specific sources at a facility that are directly involved in electricity production, while emission sources at an electricity producing facility not directly engaged in electricity production would be included as part of the direct fuel use sector emissions, under the industrial subsector.

Future direct emissions may be better developed from data now being collected by EPA specifically for GHG reporting.

MCD-level data by subsector could be requested from each municipal utility and a more refined estimate of the geographic distribution of the electricity consumption for Sussex Rural Cooperative members could be developed with additional information from the Cooperative.

Municipal government, other government, and street light electricity consumption information, if tracked separately by each of the utilities, could be used to report the associated emissions separately in the future. As more customers opt to participate in clean energy programs, the benefits of those programs could also be accounted for in the future and allocated by the location of clean power consumers.

A.2 Residential, Commercial and Industrial Fuel Use

A.2.1 Source Description

Direct emissions from fuel use in the residential, commercial, and industrial (RCI) sector include fuel used for building heat and hot water, as well as fuel for industrial processes. The fuel most commonly used in New Jersey by the RCI sector for space and water heating and for industrial processes is pipeline natural gas. Other fuels include fuel oil (residual and distillate), kerosene, liquefied petroleum gas, and wood. Coal, landfill gas, solid waste, and digester gas are used as fuel by some industries.

Since emissions from direct fuel use occur at the point of consumption, the direct emissions and consumption-based emissions are the same for fuel use in the RCI sector. Note that emissions from electricity production or consumption are not included under the inventory for the fuel use in the RCI sector, as those emissions are accounted for within the electricity sector. Energy-cycle emissions are accounted for and include emissions from fuel extraction, transport, and delivery. The most significant GHG emitted through fuel combustion is CO_2. CH_4 and N_2O are emitted as well and are included in the inventory.

A.2.2 General Inventory Approach

Since direct and consumption-based emissions are the same for RCI fuel use, the discussion below presents the methods used for both approaches.

The following data sources were used to obtain information on RCI fuel use in the NJTPA region:

- Data from utilities that deliver natural gas to RCI customers in the NJTPA region;
- EIA data for natural gas delivered to New Jersey customers by sector and utility;[36]
- American Community Survey data on fuels used in households by geographic area;[37]

[36] U.S. Energy Information Administration, Natural Gas Consumption by End Use, http://www.eia.gov/dnav/ng/ng_cons_sum_dcu_SNJ_a.htm

EIA-176 Query System 2006, Consumption by sector, all companies http://www.eia.doe.gov/oil_gas/natural_gas/applications/eia176query06.html

- NJDEP inventory for all fuels used in RCI; and
- SEDS data regarding total consumption by fuel for New Jersey.[38]

Three utility companies provide pipeline natural gas to the NJTPA region including New Jersey Natural Gas (NJNG), Elizabethtown Gas, and Public Service Electric and Gas (PSE&G). Data on annual consumption of natural gas by zip code of the metered location or by MCD obtained from these utilities, for each customer class (residential, commercial, and industrial). Data on municipal or other government sector consumption were not readily available; therefore, municipal and other government consumption of natural gas and associated emissions are included as part of commercial or industrial sector consumption and emissions. Some companies noted that natural gas use in some apartment buildings is included as part of the commercial sector consumption.

Natural gas consumption for 2006 was obtained from one company; another provided aggregated consumption over a two year period from 2008 to 2010; the third provided data for one year between 2009 and 2010. Annual change in natural gas consumption by sector as reported for New Jersey within SEDS data were used to adjust 2008-2010 consumption provided by the utilities to the 2006 inventory baseline year. The comparison with SEDS and EIA data reported on Form EIA-176 revealed that one of the utilities did not provide complete data for any of the sectors, and another did not provide total consumption for the industrial sector. The explanation provided was that accounts for large industrial consumers of natural gas are tracked within a different database or department within the utility company. To resolve this data gap, consumption reported on EIA-176 by utility and by end use sector was allocated to MCD's using household, employment and utility service territory information.

Detailed information on the RCI consumption of fuels other than natural gas, most importantly fuel oil, is not available at MCD level. However, for the residential sector, the 2000 Census data and the American Community Survey (2006-2008) include estimates of the number of households in a geographic area using each fuel type (utility gas, fuel oil, coal, wood, solar, etc.). The data are available for each of the NJTPA counties and for some MCDs. The residential use of fuels other than natural gas was estimated using this information along with the data on natural gas consumption, as reported by the utilities. It was assumed that, on average, residents within the same MCD use the same amount of energy for heat and hot water, regardless of the type of fuel they use. The amount of fuel use for home heating is more a function of the floor area heated and the type of housing unit (for example single-family vs. multifamily), than of the number of residents. Therefore, utility natural gas data and the American Community Survey information on the percentage of households using various types of fuel for heating were used to determine total heating energy data (in BTU) by geographic area, and the amount of heat used by fuel type.

To calculate emissions from the use of fuel other than natural gas in the commercial and industrial sectors, the 2007 NJDEP point source inventory, EIA SEDS data, and NJDEP area source inventories were

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[37] U.S. Census Bureau, Census 2000 Summary File 3, House Heating Fuel.

[38] U.S. Energy Information Administration, State Energy Data System, http://www.eia.doe.gov/states/_seds.html

used. The NJDEP point source inventory includes information on the fuel consumption by commercial and industrial sources that are required to report emissions to NJDEP. While the 2006 point source inventory was available, it included CO_2 emissions but did not include the fuel consumption, and therefore emissions for each of the GHGs or energy cycle emissions could not be estimated using the 2006 point source inventory. Emissions from the facilities included in the 2007 point source inventory were allocated to MCDs based on each facility's location. Smaller commercial and industrial fuel consumers are not required to file emissions statements with NJDEP are not accounted for in the point source inventory. To account for the fuel consumption and resulting emissions by these "area" sources, the statewide 2006 fuel consumption for those sectors, as reported by EIA in SEDS was allocated to counties. The NJDEP area source 2002 inventory was used to determine the allocation of statewide consumption to counties by sector. NJDEP used employment statistics to allocate commercial consumption and industrial employment statistics to allocate industrial consumption to counties. Based on NJDEP data, approximately 74 percent of the statewide fuel consumption by the commercial subsector and approximately 77 percent of the statewide consumption by the industrial subsector was allocated to the NJTPA area. The fuel consumption by point sources was subtracted from the consumption reported by EIS as allocated to the NJTPA area to avoid double counting. The remaining "area" source consumption was allocated to counties within NJTPA using NJDEP allocation factors, which are included in the detailed spreadsheets for the inventory. Allocation of county consumption to MCDs was based on 2006 employment data from *Plan 2035*.

It should be noted that NJDEP point source data include commercial and industrial natural gas use. The natural gas use within NJTPA calculated from the point source inventory greatly exceeded the natural gas use for NJTPA estimated from SEDS data and could not be reconciled with the statewide reports. Natural gas consumption and emissions were therefore based on the utility and EIA information. Point source inventory entries for natural gas usage (such as facility name, location, SCC code, and fuel consumption) are included in the detailed NJTPA inventory database, as the information could be useful for mitigation planning, but the emissions stemming from these sources are set to zero to avoid double-counting.

After estimating the consumption of each fuel by geographic area and subsector, the emission factors from The Climate Registry General Reporting Protocol were used to calculate direct and consumption-based emissions, with the exception of biogenic sources of CO_2 emissions, which were set to zero. Energy-cycle emissions, including upstream emissions for biogenic and fossil fuels, as appropriate, were developed using the GREET model.

The fuel consumption within the residential, commercial, and industrial sector in the NJTPA region is presented in Table A.2-1. The consumption does not include fuel used to generate electricity, as this consumption was reported as part of the electricity sector inventory.

Table A.2-1. Baseline Residential, Commercial, and Industrial Fuel Consumption in the NJTPA Region

County	Fuel Oil (gallons)	Kerosene (gallons)	Natural Gas (mil. cf)	Liquefied Petroleum Gas (gallons)	Waste oil (gallons)	Wood (tons)	Coal (tons)
Bergen	50,587,111	3,381,781	44,746	7,424,312	-	554	230
Essex	50,541,601	2,266,191	44,686	7,127,057	324,413	228	192
Hudson	23,310,629	1,402,527	29,827	3,696,639	-	175	130
Hunterdon	16,213,394	344,357	4,909	5,511,151	-	5,023	26
Middlesex	36,981,197	3,373,110	93,485	6,830,269	588,833	692	199
Monmouth	25,988,046	1,270,188	27,079	4,562,125	-	2,675	131
Morris	55,793,477	1,959,487	23,592	7,000,656	397,766	6,737	145
Ocean	20,602,063	780,799	19,026	5,874,477	-	8,637	75
Passaic	25,491,046	1,696,167	19,638	6,411,251	1,074,263	3,049	85
Somerset	17,304,334	1,410,193	21,609	2,877,673	232,252	1,798	88
Sussex	20,365,128	209,474	2,488	4,948,830	-	5,570	21
Union	34,606,259	2,520,085	37,705	4,916,559	-	425	110
Warren	16,781,008	426,949	5,776	3,026,477	321,358	5,564	19

Source: Pechan Team, based on utility, NJDEP inventory and EIA data.

Note: Fuel use in electricity generating facilities is not included, as that use is accounted for through the consumption by the power sector. Municipal solid waste and petroleum refinery gas consumption was accounted for in the inventory, but is not presented in this table, as the consumption is not significant.

A.2.3 Inventory Allocation Method

Natural gas consumption provided by MCD did not require allocation. For utilities that reported natural gas consumption by zip code, the residential consumption was allocated to MCDs using the percentage of the households within each zip code area that are within each MCD. The commercial and industrial sector natural gas consumption was similarly allocated using the zip code employment distribution by MCD. Fuel consumption from the NJDEP point source inventory were allocated to the appropriate MCD based on the address for each specific facility. Remaining commercial and industrial source fuel consumption (sources accounted for in the NJDEP area-source inventory) within the region was allocated using employment data.

A.2.4 Forecast Method

Plan 2035 Appendix B data were used to project the change in emissions in future years. Residential emissions were projected to change in direct correlation to the number of households, while commercial and industrial emissions were projected to change in direct correlation to employment.

The New Jersey Energy Master Plan (EMP) includes goals to reduce building energy consumption by 20 percent by 2020. Achieving these goals would require implementation of energy efficiency measures at the local level. Therefore, for local and regional planning purposes, the projected baseline emissions are developed using a business-as-usual that does not include the EMP goal. This enables the local planning authorities to determine the local emissions reductions required to meet the state goals, as well as to track progress in achieving those goals.

An increase in the use of biodiesel (up to 5 percent of total diesel consumption in 2020) is also being considered under the EMP. When fully implemented, this strategy would reduce emissions from diesel use by approximately 3 percent, on an energy-cycle basis. This measure is not currently included in the inventory

A.2.5 Inventory & Forecast Update Methods

Future updates to the inventory of RCI fuel use would rely on more recent utility data, point-source data from NJDEP, and EIA data. When developed, more specific long-term energy goals could be incorporated, as well as new demographic projections.

A.2.6 Inventory & Forecast Results

A summary by county of the baseline year direct/consumption-based emissions (direct- and consumption-based emissions are the same for this sector) and energy-cycle emissions in the NJTPA region for fuel use in the RCI sectors is provided in Figure A.2-1. The contribution by subsector (residential, commercial, industrial, and non-road) to overall consumption/energy-cycle based emissions from fuel use in the RCI sector is presented in Figure A.2-2.

Figure A.2-1. RCI Fuel Use Emissions by County (tCO_2e)

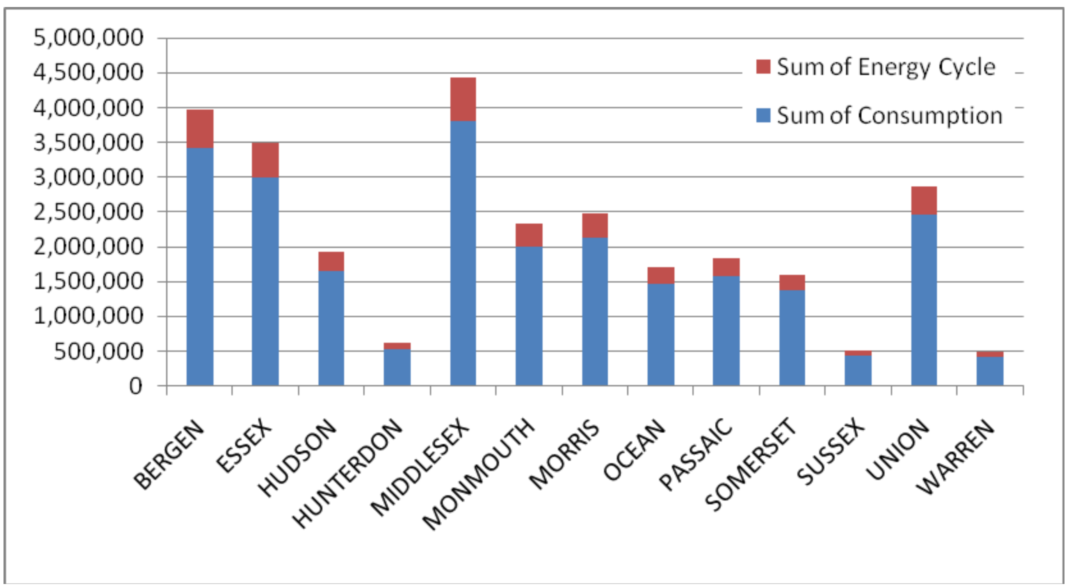
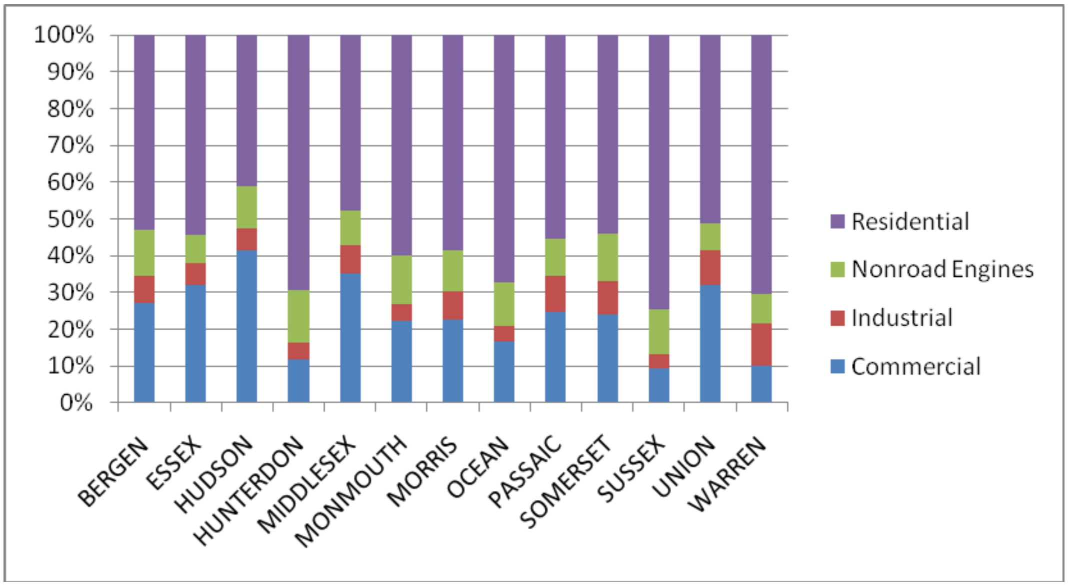


Figure A.2-2. RCI Fuel Use Emissions by County and Sub-Sector



A.2.7 Recommendations for Future Improvements

For future updates, consumption data should be requested from utilities exclusively by MCD, since the allocation from zip code to MCD proved to be a labor-intensive process that introduced some level of uncertainty to the allocation of emissions within specific zip codes. In addition, when requesting data from utilities, the importance of receiving information on all natural gas delivered (regardless of which department within the company tracks the data and regardless of the rate structure) should be stressed. Municipal government consumption information, if it becomes tracked separately by each of the utilities in the future, could be used to report the associated emissions separately as part of future updates. Fuel use other than natural gas for sources not included in the NJTPA point source inventory were allocated from county level estimates to MCDs based on demographic data; in the future, if information on the use of other fuels becomes available at MCD level, that information could be used in an update to the NJTPA inventory.

A.3. Transportation

A.3.1 On-road Transportation

A.3.1.1 Source Description

The on-road transportation sector includes motor vehicles that typically travel on public roads. These include passenger cars and trucks, motorcycles, commercial trucks, heavy-duty vehicles, and buses. These vehicles may be fueled by gasoline, diesel, or other alternative fuels. The gasoline used by on-road vehicles in the North Jersey region in all years of the analysis is primarily gasoline with 10 percent ethanol by volume (E10). Although CO_2 is the main GHG emitted from this sector, CH_4 and N_2O are emitted as well. Emission factors are estimated using EPA's Motor Vehicle Emission Simulator (MOVES 2010) model. All three pollutants are addressed in the estimation of direct emissions, consumption-based emissions, and energy cycle emissions, which include upstream well-to-pump emissions.

Table A.3.1-1 summarizes the SCC codes that were used to identify the emissions sources for this sector. These SCCs were developed specifically for use in this project, and are not EPA-specified SCCs. This is because emissions were calculated at the level of detail of the 13 MOVES source types and the 4 MOVES road types, which differ from the vehicle types and road types used with EPA's SCCs. These new SCCs are divided into three parts: 1) a code indicating the source is a highway vehicle source (e.g., 2200000 for all on-road vehicles), plus 2) a code indicating the source type (e.g., 11 for motorcycles), plus 3) a code indicating the road type (e.g., 2 for restricted rural roads). For example, emissions from a passenger car traveling on a restricted urban road would have an SCC code of 2200000214. Note that energy cycle emissions were only broken down by source type, with no corresponding road type, so the SCC for all energy cycle emission estimates ends with a "0" indicating all road types combined.

Table A.3.1-1. Source Categories for the Transportation Sector

SCC Level	SCC Code	SCC Code Description
SCC Level 1 and 2	2200000	Mobile Sources--Highway Vehicles
SCC Level 3 (Source Type)	11	Motorcycle
	21	Passenger Car
	31	Passenger Truck
	32	Light Commercial Truck
	41	Intercity Bus
	42	Transit Bus
	43	School Bus
	51	Refuse Truck
	52	Single Unit Short-haul Truck
	53	Single Unit Long-haul Truck
	54	Motor Home
	62	Combination Short-haul Truck
	62	Combination Long-haul Truck
SCC Level 4 (Road Type)	2	Restricted Rural
	3	Unrestricted Rural
	4	Restricted Urban
	5	Unrestricted Urban
	0	Total: All Road Types

A.3.1.2 General Inventory Approach

Direct Emissions

The direct emissions associated with on-road transportation include all of the GHG emissions for highway vehicle travel that occurs within the geographical boundaries of the NJTPA region, including emissions associated with vehicle starts and stops, and exclude the portion of a trip's emissions that might occur outside the region. The base year for which direct emissions were estimated was 2006.

Activity Estimation

The primary activity used in the emissions calculation for on-road transportation is vehicle miles of travel (VMT). VMT for the North Jersey region was estimated using NJTPA's North Jersey Regional Transportation Model – Enhanced (NJRTME) which provides link-based VMT by vehicle type. NJRTME provides traffic volume and logistical information, which are necessary inputs for calculating emissions. However, post-processing is required to convert the physical, operating, and traffic volume data contained in NJRTME to a form and format that can be input into MOVES. AECOM's PPSUITE software package is designed to provide a flexible framework for linking traffic demand models to MOVES, and for computing a variety of transportation system performance measures. PPSUITE has been used to establish consistency between the Federal Highway Administration's (FHWA's) Highway Performance Monitoring System (HPMS) VMT estimates and methods used by various agencies in calculating emissions. The software is based upon accepted transportation engineering methodologies. For example, PPSUITE utilizes speed and delay estimation procedures based on analysis methods provided in the Highway Capacity Manual, a methodology prepared by the Transportation Research Board (TRB) for capacity and level-of-service analyses of the transportation system. In developing the VMT estimates for this NJTPA GHG emissions inventory, the PPNET module of PPSUITE was used to analyze highway operating conditions, calculate highway speeds, and compile VMT and vehicle type mix data.

HPMS VMT adjustment

HPMS is a standardized procedure by which states determine and report VMT to FHWA. Based on statistical expansion of a system of traffic counts, existing VMT totals are estimated for each current year. EPA recommends that regional emissions estimates be based upon VMT quantities that are consistent with the reported HPMS totals for the area. Since the travel model is a simulation and provides only an approximation of actual conditions, it is inevitable that the traffic volumes produced by the model need to be adjusted to be precisely consistent with reported HPMS totals. HPMS represents Average Annual Daily Traffic (an overall average day of the year including weekend days). The annual GHG emissions estimates were computed for a typical weekday and weekend of each month with corrections applied by using seasonal factors developed from HPMS. The daily estimates thus derived were then annualized using standard temporal VMT factors derived from NJDOT traffic data. The 2006 HPMS and seasonal VMT adjustments were applied within PPSUITE to each analysis condition (year, season, and day type), both base and future.

MOVES Source Type and Road Type

The NJRTME transportation model and PPSUITE utilize *vehicle types* and *facility types* to classify vehicles and roadways. In order to calculate GHG emissions using MOVES emission factors, the vehicle types provided by transportation model were mapped into MOVES source types using an aggregate version of New Jersey vehicle registration data for the NJTPA region. Table A.3.1-2 shows the mapping of the HPMS vehicle types to MOVES source types and Table A.3.1-3 shows the mapping of the NJRTME vehicle types to the MOVES source types. Table A.3.1-4 shows how the NJRTME facility and area types were mapped to the MOVES road types.

Table A.3.1-2. MOVES Source Type Classification

Source Type ID	Source Types	HPMS Vehicle Type ID	HPMS Vehicle Type
11	Motorcycle	10	Motorcycles
21	Passenger Car	20	Passenger Cars
31	Passenger Truck	30	Other 2 axle-4 tire vehicles
32	Light Commercial Truck	30	Other 2 axle-4 tire vehicles
41	Intercity Bus	40	Buses
42	Transit Bus	40	Buses
43	School Bus	40	Buses
51	Refuse Truck	50	Single Unit Trucks
52	Single Unit Short-haul Truck	50	Single Unit Trucks
53	Single Unit Long-haul Truck	50	Single Unit Trucks
54	Motor Home	50	Single Unit Trucks
61	Combination Short-haul Truck	60	Combination Trucks
62	Combination Long-haul Truck	60	Combination Trucks

Table A.3.1-3. Transportation Model Vehicle Types Split to Source Types

MOVES Source Types	NJRTME Vehicle Type	Split
11	Auto:	3.0%
21	Auto:	59.8%
31	Auto:	37.0%

MOVES Source Types	NJRTME Vehicle Type	Split
54	Auto:	0.2%
51	Heavy Truck:	4.45%
61	Heavy Truck:	18.95%
62	Heavy Truck:	76.60%
32	Commercial”	100.0%
41	Medium Truck:	3.0%
43	Medium Truck:	42.9%
52	Medium Truck:	50.3%
53	Medium Truck:	3.8%
42	From NJ TRANSIT Model	

Table A.3.1-4. Transportation Model Facility Types Grouping to Road Types

MOVES Road Type	Road Type ID	NJRTME Area Type	NJRTME Facility Type
Off-Network	1		
Rural Restricted	2	3 and 4	1,2,9,10,11, 21, 22, 23, 24
Rural Unrestricted	3	3 and 4	3,4,5,6,7,8,12
Urban Restricted	4	1 and 2	1,2,9,10,11, 21, 22, 23, 24
Urban Unrestricted	5	1 and 2	3,4,5,6,7,8,12

Table A.3.1-5 shows the resulting total annual VMT for the NJTPA region by the MOVES2010 classification of source types.

Table A.3.1-5. NJTPA Direct Annual VMT Summary by Source Type (thousand miles)

Source Type ID	Source Type	2006	2020	2035	2050
11	Motorcycle	171,443	200,218	226,098	249,912
21	Passenger Car	30,624,693	35,677,878	39,864,463	43,812,664
31	Passenger Truck	12,107,740	14,093,337	15,712,503	17,243,385
32	Light Commercial Truck	9,630,516	11,203,385	12,448,537	13,631,744
41	Intercity Bus	89,282	102,660	106,611	111,475
42	Transit Bus	33,283	38,310	39,784	41,607
43	School Bus	269,157	309,463	321,356	335,983
51	Refuse Truck	4,624	5,355	5,571	5,845
52	Single Unit Short-haul Truck	571,419	656,995	682,262	713,302
53	Single Unit Long-haul Truck	49,376	56,778	58,961	61,646
54	Motor Home	26,132	30,072	31,247	32,691
61	Combination Short-haul Truck	182,174	209,460	217,536	227,430
62	Combination Long-haul Truck	143,219	164,675	171,001	178,790
Total		**53,903,058**	**62,748,586**	**69,885,930**	**76,646,474**

Emission Factor and Emission Estimation

Direct emissions include running emissions resulting from motor vehicles operating on the roadways, as well as emissions associated with vehicle starts and stops. After the PPNET module of PPSUITE was used to analyze the vehicle operation on each link of the NJRTME network, and to determine vehicle volumes and speeds, the Pre-MOVES module of PPSUITE was then used to format transportation data according to MOVES input requirements. Other MOVES inputs not related to the transportation data were obtained from currently available data from NJDEP during the time of analysis. This included meteorology, vehicle age distributions, aggregated motor vehicle registrations, fuel properties, and vehicle inspection and maintenance (I/M) program information

MOVES runs were generated to produce emission rates for each analysis year and each county for an average weekday and weekend for each of 12 months. MOVES outputs include VMT-based and Source

Type Population-based emission lookup databases, which were used to calculate emissions associated with running emissions, and start and soak emissions, respectively.

To estimate direct emissions, the volumes on each link in the network by source type were applied to the corresponding emission rates from the MOVES lookup database. The Post-MOVES module of PPSUITE was used to summarize emission output data and estimate annual totals. The grouping of data by source type and road type data were maintained in the Post-MOVES processes and data summaries.

After the annual total link emissions were estimated by Post-MOVES, they were further aggregated to the level of the corresponding municipality with the data indexed on source type.

Consumption-Based Emissions

Consumption-based emissions were estimated by municipality of origin for each of the four analysis years (2006, 2020, 2035, and 2050). Unlike the direct emissions described above, which were computed for individual highway links and allocated to the municipality in which the link was located, consumption-based emissions were calculated for each origin-to-destination trip in the region, then allocated to the origins and destinations which produced and attracted those trips.

To estimate consumption-based VMT and speeds for the analysis years, first PPSUITE was run with the NJRTME network to generate congested time of day speeds for every link in the network. These speeds were then converted into automobile and truck congested travel times for each link. These PPSUITE-generated travel times were then imported onto the input NJRTME network, and the highway path builder was used to skim travel distance and time by road type and vehicle type for every origin-destination zone pair in the system. As PPSUITE only generates congested travel times for those links within the thirteen counties of NJTPA region, only distances and times within the region were accumulated. VMT associated with travel outside the NJTPA region (say from Connecticut to Maryland) was discarded.

Travel times generated by PPSUITE, and distances traveled over each road type, were accumulated separately for auto and truck trips for each origin-destination pair. Truck trips were then split into three truck classes as defined by the NJRTME—commercial, light and heavy. The percentage of total truck trips assigned to each of the truck classes was determined from factors developed during the trip generation stage of the NJRTME. These factors are listed in Table 2.2.1-6. From the accumulated data, total VMT and vehicle hours of travel (VHT) for each origin-destination pair were calculated by road type and vehicle class.

Table A.3.1-6. Truck Class Factors by Time of Day

Class	AM Peak	Midday	PM Peak	Night
Heavy Trucks	17%	42%	17%	24%
Light Trucks	20%	34%	24%	22%
Commercial Trucks	6.2%	56.2%	28.2%	9.4%

This procedure was conducted for the analysis years 2020, 2035 and 2050, using travel model outputs provided by NJTPA. To determine consumption-based VMT for the 2006 base year (for which no model runs were available), 2010 input files were used, and county-level factors were developed from HPMS data to convert the 2010 auto and truck trip tables to 2006 levels. These factors were applied to the 2010 trip data on both the origin and destination ends to create 2006 trip tables which were used to compute the necessary data aggregations.

For each origin-destination pair (there are 6.5 million such pairs in the NJRTME), VHT and speed, vehicle type, road type and time of day were applied against the MOVES emission rate lookup table (with MOVES emission rates calculated as described in the direct emissions section), multiplied by the appropriate VMT, and emissions calculated for that origin-destination movement. VMT and emissions were then split, 50 percent to the origin traffic analysis zone (TAZ) and 50 percent to the destination TAZ. Finally, TAZ emission and VMT totals were aggregated to the municipality and county levels.

Energy-cycle Emissions

Energy-cycle GHG emissions within the on-road sector are associated with the production, refining, and transport of motor vehicle fuels. Argonne National Laboratory's GHG, Regulated Emissions and Energy use in Transport (GREET) model is used to estimate the energy-cycle emissions of both gasoline and diesel fuels in this analysis. The GREET model allows analysis for any year between 1990 and 2020. The percentage increase from consumption emissions to energy cycle emissions was held constant throughout the analysis period, because no information is available on any change in energy cycle emissions over the forecast period.

Energy-cycle GHG emission estimates were developed for on-road vehicles using an estimation of the portion of the fuel consumption for each vehicle type by fuel type. The fuel type is needed because the energy cycle emission rates for gasoline, diesel, and ethanol all vary. Emissions were not tracked by fuel type in the direct or consumption-based emissions analyses. Therefore, a rough method for estimating the portion of fuel consumption by fuel type was developed from the consumption emissions analysis. A MOVES run using default data for Bergen County in 2006 were developed to obtain the output of energy consumption by fuel type and source type. From the output of this MOVES run, the breakdown of energy consumption by fuel type and vehicle type was estimated, as shown in Table A.3.1-7.

Table A.3.1-7. Energy Consumption Percentage by Fuel and Source Type

Source Type	Gasoline Percentage	Diesel Percentage
Motorcycle	100.0%	0.0%
Passenger Car	99.8%	0.2%
Passenger Truck	97.9%	2.1%
Light Commercial Truck	84.7%	15.3%
Intercity Bus	0.0%	100.0%
Transit Bus	0.9%	99.1%
School Bus	12.5%	87.5%
Refuse Truck	3.9%	96.1%
Single Unit Short-Haul Truck	32.3%	67.7%
Single Unit Long-Haul Truck	30.6%	69.4%
Motor Home	69.9%	30.1%
Combination Short-Haul Truck	0.2%	99.8%
Combination Long-Haul Truck	0.0%	100.0%

This fuel type breakdown was applied in all analysis years and to the entire NJTPA region, because there is very little difference between the 2006 and 2050 breakdown of energy consumption by fuel type and source type in MOVES.

When comparing emissions from fuel combustion (from The Climate Registry's General Reporting Protocol) with energy cycle emissions (from the GREET Model), energy cycle emissions for gasoline are 23.0 percent higher than direct emissions (assuming that gasoline includes 10 percent corn ethanol by volume), while diesel energy cycle emissions are 10.8 percent higher than direct emissions. Based on these assumptions, an energy cycle multiplier was estimated for all source types. For example, light commercial trucks use 84.7% gasoline * 23.0% increase + 15.3% diesel * 10.8% increase. This results in an estimated increase in energy cycle emissions for all light duty commercial trucks of 21.2 percent. The results for all vehicle types are shown in Table A.3.1-8. These percentages were then applied to the consumption-based emissions to estimate energy cycle emissions from on-road vehicles.

Table A.3.1-8. Percentage Increase from Consumption Emissions to Energy Cycle Emissions by Source Type

Source Type	Estimated Increase from Consumption to Energy Cycle Emissions
Motorcycle	23.0%
Passenger Car	23.0%
Passenger Truck	22.8%
Light Commercial Truck	21.2%
Intercity Bus	10.8%
Transit Bus	10.9%
School Bus	12.3%
Refuse Truck	11.3%
Single Unit Short-Haul Truck	14.8%
Single Unit Long-Haul Truck	14.6%
Motor Home	19.4%
Combination Short-Haul Truck	10.8%
Combination Long-Haul Truck	10.8%

There is significant uncertainty in using this method to estimate energy cycle emissions. It is possible that the fuel mix in 2050 will be significantly different than that seen in 2006. Depending on the adoption of various technologies, such as electric vehicles, biofuels, etc, the emissions impacts will be different.

A.3.1.3 Inventory Allocation Method

As discussed above, emissions were estimated at the link level and then were aggregated to the MCD and county level.

A.3.1.4 Forecast Method

The on-road transportation activity data (VMT) were forecasted within the NJRTME model and PPSUITE. As discussed in Section A.3.1.2 and shown in Table A.3.1-5, VMT were forecasted for the years 2020, 2035, and 2050. Emission rates applicable to each year were obtained from MOVES, as discussed above for the base year. All emission calculation methodologies were the same for these forecast years as for the base year. Emissions for all other years were estimated by linear interpolation between these years.

A.3.1.5 Inventory & Forecast Update Methods

Based on the contributions of the on-road sector to NJTPA regional, county, and MCD emissions, future updates to the NJDEP state I&F and in particular to any updates to base or forecasted VMT should be used as the basis for updating the inventory and forecast estimates.

Also, in future updates, VMT, fuel consumption, and emissions should be tracked not just by source type, but also by fuel type. This would improve the energy-cycle emissions estimate, as well as provide additional information on the potential of fuel based initiatives to reduce emissions.

A.3.1.6 Inventory & Forecast Results

Direct and consumption based approaches employ different methodologies in order to estimate emissions. Energy cycle estimates add additional emissions to the consumption based estimate. Because energy cycle emissions were calculated by applying a percentage increase to the consumption-based emission estimates, energy cycle emissions will always be higher than consumption-based emissions, but not necessarily direct emissions estimates. The difference between the three methodologies can be seen in Table A.3.1-9. See the body of this report for summary data at the regional level and additional summary results at the end of this section.

Table A.3.1-9. Summary of Direct, Consumption and Energy Cycle Estimates in North Jersey ($MMtCO_2e$)

	2006	2020	2035	2050
Direct Emissions Total	21.8	23.1	32.5	30.8
Consumption Emissions Total	17.0	21.2	29.1	26.6
Energy Cycle Emissions Total	20.8	25.9	35.5	32.4
Direct VMT (Billion Miles)	53.9	62.7	69.9	76.6

The growth in emissions can be seen in Table A.3.1-9 and also in Figure A.3.1-1. Emissions are forecasted to peak in 2035, and decline slightly in 2050. This trend is not reflected in total VMT, which increases steadily throughout the period. This divergence could be caused by a variety of factors, such as vehicle efficiency improvements.

Figure A.3.1-1. CO_2e Emissions and VMT in North Jersey

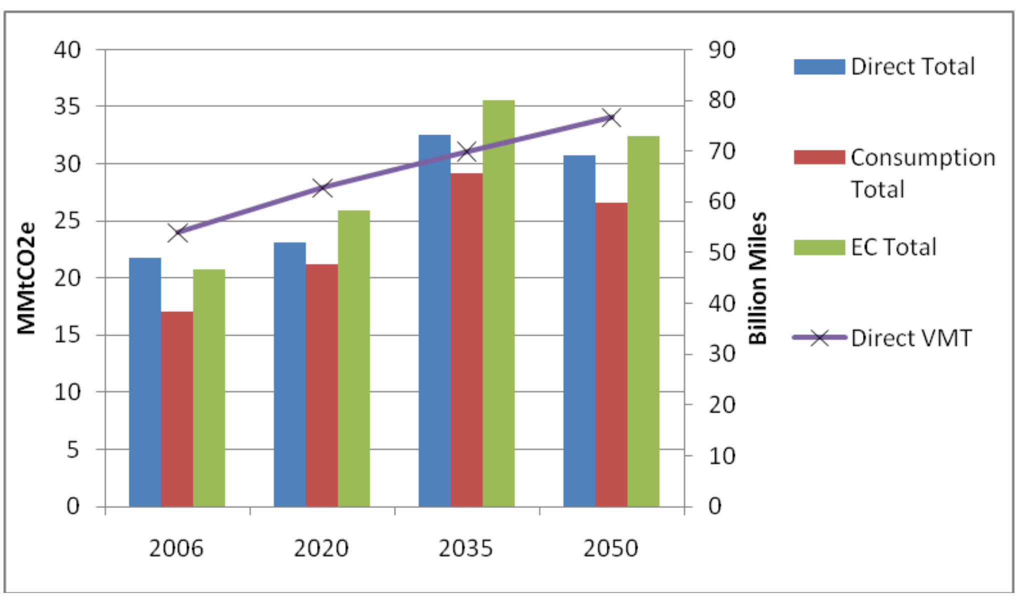
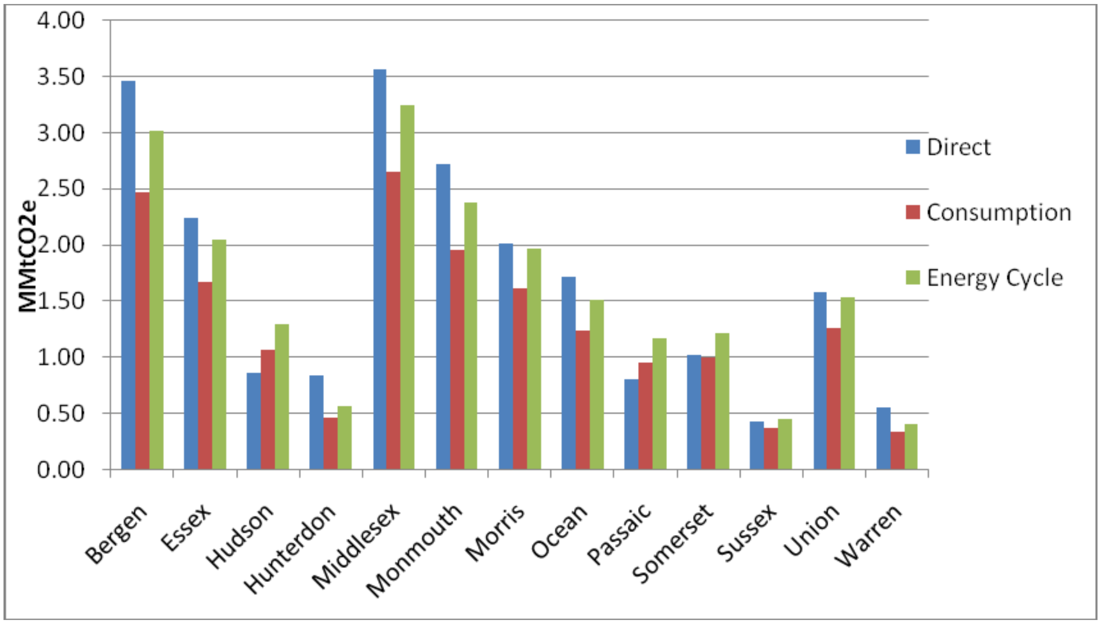


Figure A.3.1-2 shows the difference between direct, consumption, and energy-cycle emissions in all NJTPA counties in 2006. In general, counties with higher total emissions (Middlesex, Bergen, Monmouth, and Essex) are estimated to have higher direct emissions than consumption or energy cycle emissions. Counties with smaller populations and fewer emissions may have lower direct than energy cycle emissions, such as in Hudson, Passaic and Sussex counties. This trend is most likely occurring because direct emissions estimates include through traffic. Counties with larger populations are likely to have more and larger highways going through them, which increases emissions from through traffic.

Figure A.3.1-2. Direct, Consumption and Full-Energy Cycle Emissions by County in 2006



Note: in this figure, "Energy-Cycle" refers to the full energy cycle emissions (consumption + upstream energy cycle component)

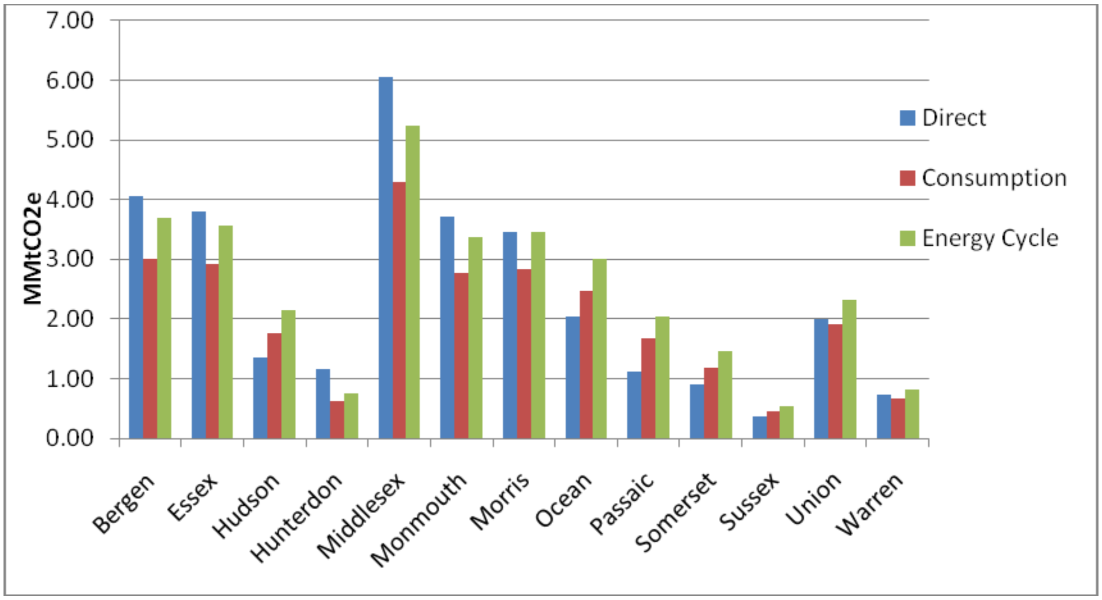
The breakdown of emissions estimates by county is also shown in Table A.3.1-10.

Table A.3.1-10. Direct, Consumption and Full Energy Cycle Emissions by County in 2006 ($MMtCO_2e$)

County	Direct	Consumption	Full Energy-Cycle
Bergen	3.46	2.47	3.01
Essex	2.24	1.67	2.04
Hudson	0.86	1.06	1.29
Hunterdon	0.84	0.46	0.56
Middlesex	3.57	2.65	3.23
Monmouth	2.71	1.95	2.38
Morris	2.01	1.61	1.97
Ocean	1.71	1.24	1.52
Passaic	0.80	0.95	1.16
Somerset	1.02	0.99	1.21
Sussex	0.43	0.37	0.45
Union	1.58	1.26	1.53
Warren	0.55	0.33	0.40
Total	**21.8**	**17.0**	**20.8**

As can be seen in Figure A.3.1-3, when comparing direct and energy cycle emissions estimates in 2050, larger counties continue to show higher direct than energy cycle emissions, whereas smaller counties typically do not. The five counties with the highest emissions in 2050 all have direct emissions greater than energy cycle emissions. In the four counties with the lowest emissions reported, energy cycle emissions are estimated to be higher than direct.

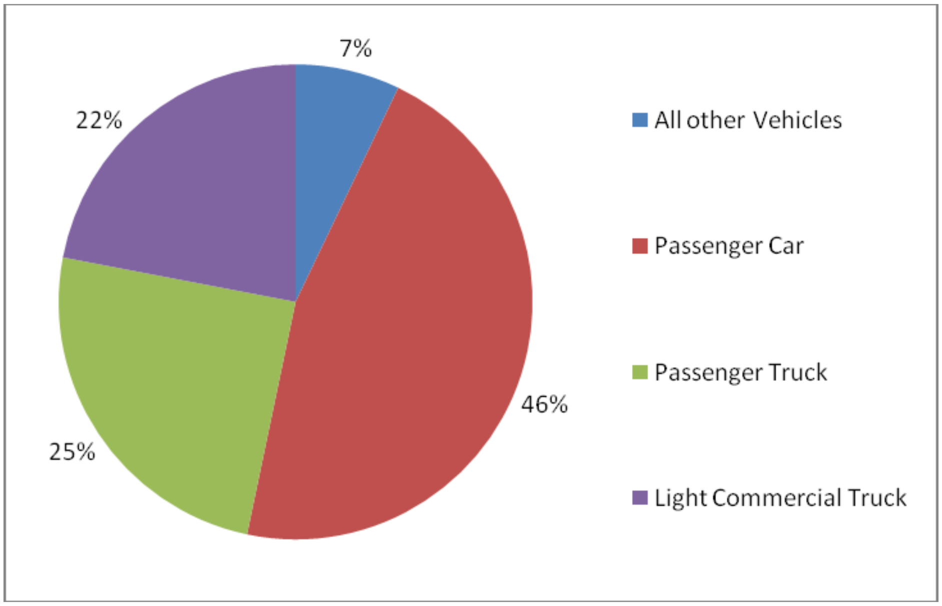
Figure A.3.1-3. Direct, Consumption and Full Energy Cycle Emissions by County in 2050



Note: in this figure, “Energy-Cycle” refers to the full energy cycle emissions (consumption + upstream energy cycle component)

Direct CO_2e emissions are estimated based on the aggregate of emissions from all vehicle types. Three vehicles types (passenger cars, passenger trucks and light duty commercial trucks) accounted for the vast majority of emissions. The other ten vehicle types only accounted for 7.1 percent of on-road emissions in 2006, with the majority of those coming from short haul trucks. The breakdown of emissions by vehicle type for the entire NJTPA area is shown in Figure A.3.1-4.

Figure A.3.1-4. 2006 Direct CO_2e Emissions by Vehicle Type ($MMtCO_2e$)



A.3.1.7 Recommendations for Future Improvement – SOMETHING NEEDS TO BE ADDED

The trend in onroad emissions, with emissions growth significantly exceeding VMT growth from 2020 to 2035 and then with decreasing emissions from 2035 to 2050 while VMT continues to increase, needs to be further explored. It is believed that these trends are an artifact of the MOVES2010 model and the way it was applied as opposed to real changes (increases or decreases) in the base CO2 emission rates. At the time the modeling was performed, the MOVES2010 model version was the latest available and approved by EPA for use. The MOVES2010a model has since been released and may correct these modeling artifacts. Future onroad emission modeling should use this updated version of MOVES. Also, note that the effects of the new Corporate Average Fuel Economy (CAFE) regulations and the new GHG emission standards were not included in the MOVES2010 model used in this analysis but are now factored into the MOVES2010a model. Thus, future modeling with the MOVES2010a model should show reductions in GHG emission over time, unless VMT growth exceeds the reductions from these programs.

A.3.2 Aircraft

A.3.2.1 Source Description

Direct Emissions

The geographic boundary for this analysis includes all public use airports within the NJTPA area. There is one military airport in the North Jersey area (Naval Air Engineering Station Lakehurst), but it was not included because information for military flights is not available. The organizational boundary includes all aircraft operations up to 3000 feet. Airport emissions include aircraft engines plus airport ground support equipment, although only aircraft emissions are included in this section.

Aircraft emission estimates were developed based on estimates from two different sources: the PANYNJ GHG emission inventory for calendar year 2006 (for Newark and Teterboro airports), and EPA 2008 National Emissions Inventory (NEI) landing-takeoff (LTO) data (for all other applicable airports). All estimates are based on the fuel combusted during an LTO cycle (emissions occurring below 3,000 feet during landing and takeoff). This method is also consistent with how criteria and toxic air pollutant inventories are prepared. This method requires data on aircraft/engine type for all LTOs at an airport, which is not available for most of the smaller airports at this time. LTO data for these 24 airports were then retrieved from the EPA NEI airport facilities database[39]. This LTO data were not used in all cases, but provides a reference point for all emissions estimates.

The Airport Cooperative Research Program (ACRP) just released a Guidebook on Preparing Airport GHG Emissions Inventories. This guidebook is designed for airport operators and others to prepare airport-specific GHG emission inventories. For estimating aircraft emissions, the ACRP report recommended methods closely follow those in the IPCC guidelines, which Pechan followed in estimating GHG emissions in 2006 for the PANYNJ-operated airports in North Jersey.

A recent Rutgers University study, "GHG Inventory and Allocation for Small New Jersey Airports"[40], was able to collect aviation fuel sales information for the Morristown Municipal airport, Essex County airport, and Central Jersey Regional airport. However, this fuel sales information is not readily comparable to the CO_2 emissions estimates used for other airports, because this data include all fuel consumption, rather than just fuel used in the LTO cycle. Because of this discrepancy, estimates for these three airports used the NEI LTO figures to estimate overall CO_2 emissions.

[39] http://www.epa.gov/ttnchie1/net/2008inventory.html "Airport Facility Detail and Landing and Takeoff Data" Accessed 4/8/10.

[40] "Greenhouse Gas Inventory and Allocation for Small New Jersey Airports" Task IV.

Consumption-Based & Energy-cycle Emissions

Consumption-Based Accounting

It would be possible to make a consumption based estimate of aircraft fuel consumption. This method was not used due to the difficulty in differentiating between consumption that occurs in the LTO cycle as opposed to consumption that occurs en route.

Energy-cycle Emissions

Argonne National Laboratory's GHG, Regulated Emissions and Energy use in Transport (GREET) model is used to estimate the full energy-cycle emissions of various aviation fuels in this analysis. The GREET model allows analysis for any year between 1990 and 2020. Aircraft use either aviation gas or jet fuel, depending on the aircraft type.

A.3.2.2 General Inventory Approach

Direct Emissions

Aviation emission estimates were developed based on estimates from two different sources: the PANYNJ GHG emission inventory for calendar year 2006 (for Newark and Teterboro airports), and EPA 2008 National Emissions Inventory (NEI) landing-takeoff (LTO) data (for all other applicable airports). Information from PANYNJ was used for Teterboro and Newark airports because it included aircraft type information for all flights taking place. These aircraft types were then assigned emission rates based on their engine types, which allows a more exact allocation of emission factors to aircraft types than an estimate based on average emissions per LTO.

Emissions estimates for all non-Port Authority operated airports were based on the aircraft activity data used in the EPA 2008 NEI. This data source provides 2008 LTO data for all 24 airports in North Jersey The 2008 NEI uses Bureau of Transportation Statistics (BTS)-100 estimates of commercial aircraft LTOs. For general aviation and air taxis, the 2008 NEI uses Federal Aviation Administration LTO data from the terminal area forecasts and EPA Office of Transportation and Air Quality provided activity estimates derived from FAA 5010 master plans. Of the North Jersey smaller airports, less than 1 percent have aircraft/engine information reported in the NEI. Where this information was reported, emissions were estimated based on FAA Emissions and Dispersion Modeling System (EDMS) data. Where no aircraft/engine information is available, emissions were based on a representative aircraft. The NEI LTO data are broken down into four categories, as shown in Table A.3.2-1.

Table A.3.2-1. Emissions Factors used for Various NEI LTO Categories

NEI Category	CO_2 Emissions (kg/LTO)	Representative Aircraft
General Aviation, Piston	0.23436	Beech King Air
General Aviation, Turbine	1.08623	Cessna
Air Taxi, Piston	0.23436	Beech King Air
Air Taxi, Turbine	1.08623	Cessna

The representative aircraft were selected based on their similarity with respect to the NEI emissions rates for other pollutants (CO, VOC, NO_x, SO_2). CO_2 emissions for these representative aircraft come from the 2006 IPCC Guidelines[41].

The emissions breakdown used in this analysis is shown in Table A.3.2-2 below.

Table A.3.2-2. Source Classification Codes Used in this Analysis

County	County FIPS	SCC	SCC Level 1	SCC Level 2	SCC Level 3	SCC Level 4
Sussex	34037	22750XXXXX	Point	Mobile Sources	Aircraft	SUSSEX
Warren	34041	22750XXXXX	Point	Mobile Sources	Aircraft	HACKETTSTOWN
Sussex	34037	22750XXXXX	Point	Mobile Sources	Aircraft	AEROFLEX-ANDOVER
Passaic	34031	22750XXXXX	Point	Mobile Sources	Aircraft	GREENWOOD LAKE
Bergen	34003	22750XXXXX	Point	Mobile Sources	Aircraft	TETERBORO
Warren	34041	22750XXXXX	Point	Mobile Sources	Aircraft	BLAIRSTOWN
Morris	34027	22750XXXXX	Point	Mobile Sources	Aircraft	MORRISTOWN MUNI
Morris	34027	22750XXXXX	Point	Mobile Sources	Aircraft	LINCOLN PARK
Essex	34013	22750XXXXX	Point	Mobile Sources	Aircraft	ESSEX COUNTY
Essex	34013	22750XXXXX	Point	Mobile Sources	Aircraft	NEWARK LIBERTY INTL

[41] IPCC Guidelines for National Greenhouse gas Inventories. Chapter 3 – Mobile Combustion. Table 3.6.9 "LTO Emission Factors for Typical Aircraft".

County	County FIPS	SCC	SCC Level 1	SCC Level 2	SCC Level 3	SCC Level 4
Hunterdon	34019	22750XXXXX	Point	Mobile Sources	Aircraft	SOLBERG-HUNTERDON
Hunterdon	34019	22750XXXXX	Point	Mobile Sources	Aircraft	SKY MANOR
Hunterdon	34019	22750XXXXX	Point	Mobile Sources	Aircraft	ALEXANDRIA
Somerset	34035	22750XXXXX	Point	Mobile Sources	Aircraft	PRINCETON
Somerset	34035	22750XXXXX	Point	Mobile Sources	Aircraft	SOMERSET
Somerset	34035	22750XXXXX	Point	Mobile Sources	Aircraft	CENTRAL JERSEY RGNL
Union	34039	22750XXXXX	Point	Mobile Sources	Aircraft	LINDEN
Middlesex	34023	22750XXXXX	Point	Mobile Sources	Aircraft	OLD BRIDGE
Monmouth	34025	22750XXXXX	Point	Mobile Sources	Aircraft	MONMOUTH EXECUTIVE
Ocean	34029	22750XXXXX	Point	Mobile Sources	Aircraft	ROBERT J. MILLER AIR PARK
Ocean	34029	22750XXXXX	Point	Mobile Sources	Aircraft	LAKEWOOD
Ocean	34029	22750XXXXX	Point	Mobile Sources	Aircraft	EAGLES NEST
Sussex	34037	22750XXXXX	Point	Mobile Sources	Aircraft	TRINCA
Sussex	34037	22750XXXXX	Point	Mobile Sources	Aircraft	NEWTON

Using the emissions factors listed above for airports where only LTO data were available provided an estimate of CO_2 emissions for all 24 North Jersey public airports. These emissions are summarized in Table A.3.2-3 below.

Table A.3.2-3. LTOs and CO_2 Emissions and North Jersey Airports

FAA Airport Name	LTOs	Percentage of North Jersey LTOs	2006 CO_2e Emissions	Source
SUSSEX	17,067	1.7%	8,071	LTO Based Estimate
HACKETTSTOWN	9500	1.0%	4,492	LTO Based Estimate

FAA Airport Name	LTOs	Percentage of North Jersey LTOs	2006 CO_2e Emissions	Source
AEROFLEX-ANDOVER	12413	1.2%	5,870	LTO Based Estimate
GREENWOOD LAKE	14,762	1.5%	6,981	LTO Based Estimate
TETERBORO	93,895	9.4%	120,198	PANYNJ Estimate
BLAIRSTOWN	11,632	1.2%	5,501	LTO Based Estimate
MORRISTOWN MUNI	68,943	6.9%	30,956	LTO Based Estimate
LINCOLN PARK	29,000	2.9%	13,714	LTO Based Estimate
ESSEX COUNTY	45,881	4.6%	21,642	LTO Based Estimate
NEWARK LIBERTY INTL	481,529	48.2%	595,538	PANYNJ Estimate
SOLBERG-HUNTERDON	18,641	1.9%	8,815	LTO Based Estimate
SKY MANOR	17,356	1.7%	8,207	LTO Based Estimate
ALEXANDRIA	14,932	1.5%	7,061	LTO Based Estimate
PRINCETON	24,850	2.5%	11,699	LTO Based Estimate
SOMERSET	20,382	2.0%	9,638	LTO Based Estimate
CENTRAL JERSEY RGNL	18,743	1.9%	8,863	LTO Based Estimate
LINDEN	21,213	2.1%	10,031	LTO Based Estimate
OLD BRIDGE	12,146	1.2%	5,744	LTO Based Estimate
MONMOUTH EXECUTIVE	28,712	2.9%	12,406	LTO Based Estimate
ROBERT J. MILLER AIR PARK	17,635	1.8%	7,616	LTO Based Estimate
LAKEWOOD	7,882	0.8%	3,727	LTO Based Estimate
EAGLES NEST	150	0.0%	71	LTO Based Estimate
TRINCA	6,101	0.6%	2,885	LTO Based Estimate
NEWTON	5,348	0.5%	2,529	LTO Based Estimate
Total	**998,713**		**912,255**	

This emissions estimate of 912,000 metric tons of CO_2e appears to be consistent with the emissions estimate of 1 million metric tons that was made for the state of New Jersey Inventory and Forecast. While this analysis only covers Northern New Jersey, the two largest airports in the state are located in this area, so it is likely that the majority of emissions would be captured in this analysis.

There are significant uncertainties associated with this type of emissions estimate. If the default airplanes used do not represent the aircraft taking off at smaller airports in NJ, then the emissions estimate will not be accurate. In addition, there are uncertainties associated with the Port Authority estimate for CO_2 emissions. Our estimate for the PANYNJ uses default time in mode assumptions. If we used actual estimates of time in mode for Newark, CO_2e emission estimates would be higher.

Consumption-Based & Energy-cycle Emissions

Consumption-Based Accounting

A separate consumption-based accounting of emissions from the aircraft sector was not developed for this project. Consumption-based emissions are considered to be the same as direct emissions in this project.

Energy-cycle Emissions

To determine the energy-cycle emissions for aviation fuel consumption, the GREET model was used. Energy-cycle emissions factors from GREET were compared with direct emissions factors from The Climate Registry. The GREET model does not have an energy-cycle emissions estimate specifically for aviation fuels, so diesel fuel was used as a surrogate. This revealed a 24.8 percent increase in emissions when energy-cycle emissions are added to those developed for the direct and consumption based inventories. These emissions are presented below in Table A.3.3-4.

Table A.3.2-4. Full Energy-cycle CO_2 Emissions at North Jersey Airports

SCC Level 1	SCC Level 2	SCC Level 3	SCC Level 4	GHG	2006 Energy Cycle Emissions (tCO_2e/yr)
Point	Mobile Sources	Aircraft	SUSSEX	CO_2	10,074
Point	Mobile Sources	Aircraft	HACKETTSTOWN	CO_2	5,607
Point	Mobile Sources	Aircraft	AEROFLEX-ANDOVER	CO_2	7,327
Point	Mobile Sources	Aircraft	GREENWOOD LAKE	CO_2	8,713
Point	Mobile Sources	Aircraft	TETERBORO	CO_2	150,033

SCC Level 1	SCC Level 2	SCC Level 3	SCC Level 4	GHG	2006 Energy Cycle Emissions (tCO_2e/yr)
Point	Mobile Sources	Aircraft	BLAIRSTOWN	CO_2	6,866
Point	Mobile Sources	Aircraft	MORRISTOWN MUNI	CO_2	38,640
Point	Mobile Sources	Aircraft	LINCOLN PARK	CO_2	17,118
Point	Mobile Sources	Aircraft	ESSEX COUNTY	CO_2	27,013
Point	Mobile Sources	Aircraft	NEWARK LIBERTY INTL	CO_2	743,360
Point	Mobile Sources	Aircraft	SOLBERG-HUNTERDON	CO_2	11,003
Point	Mobile Sources	Aircraft	SKY MANOR	CO_2	10,245
Point	Mobile Sources	Aircraft	ALEXANDRIA	CO_2	8,814
Point	Mobile Sources	Aircraft	PRINCETON	CO_2	14,603
Point	Mobile Sources	Aircraft	SOMERSET	CO_2	12,031
Point	Mobile Sources	Aircraft	CENTRAL JERSEY RGNL	CO_2	11,063
Point	Mobile Sources	Aircraft	LINDEN	CO_2	12,521
Point	Mobile Sources	Aircraft	OLD BRIDGE	CO_2	7,169
Point	Mobile Sources	Aircraft	MONMOUTH EXECUTIVE	CO_2	15,486
Point	Mobile Sources	Aircraft	ROBERT J. MILLER AIR PARK	CO_2	9,506
Point	Mobile Sources	Aircraft	LAKEWOOD	CO_2	4,652
Point	Mobile Sources	Aircraft	EAGLES NEST	CO_2	89
Point	Mobile Sources	Aircraft	TRINCA	CO_2	3,601
Point	Mobile Sources	Aircraft	NEWTON	CO_2	3,156

A.3.2.3 Inventory Allocation Method

Covered under the discussion above (Section A.3.2.2)

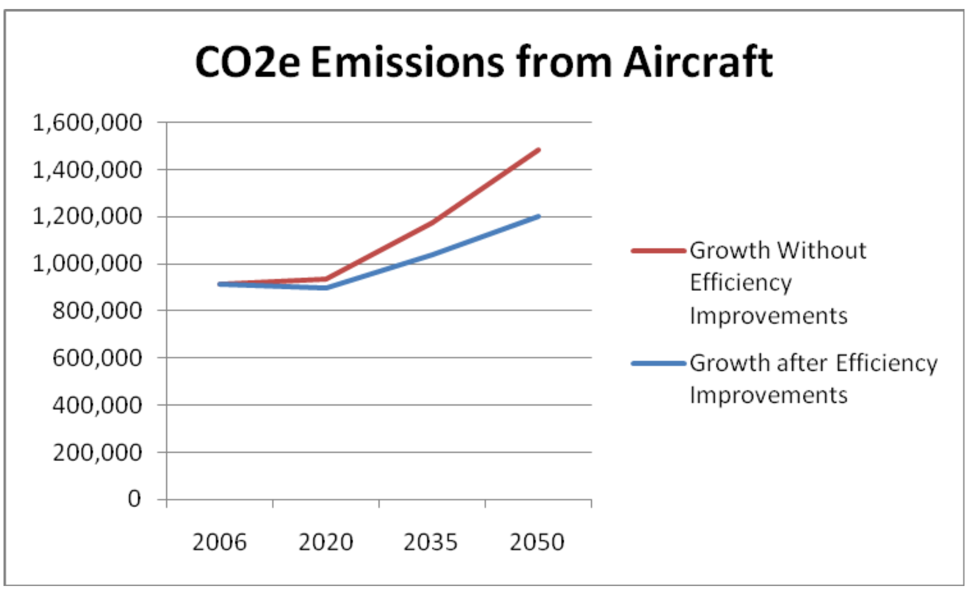
A.3.2.4 Forecast Method and Results

Direct Emissions

See the body of this report for results at the regional level and the end of this Transportation section for additional results. Aviation emissions were projected from 2006 through 2030 using general aviation and commercial aircraft operations projections data from the Federal Aviation Administration's Terminal Area Forecast System[42]. Since all of the LTO based emissions estimates are for 2008, these emissions were adjusted using these growth factors back to 2006 levels. In the case of the airports considered in the PANYNJ inventory, these estimates were already for the year 2006, so no adjustment was made.

Forecast year estimates were adjusted to reflect the projected increase in national aircraft fuel efficiency (indicated by increased number of seat miles per gallon) as reported in AEO 2010[43]. The impact of this efficiency adjustment is shown in Figure A.3.2-1, below.

Figure A.3.2-1. CO_2e Emissions Growth Adjusted for Fuel Efficiency Improvements



[42] Federal Aviation Administration, Terminal Area Forecast data, accessed 4/19/10. http://aspm.faa.gov/main/taf.asp

[43] US DOE. Annual Energy Outlook 2010, transportation supplement. http://www.eia.doe.gov/oiaf/aeo/supplement/index.html retrieved 4/19/10.

TAF data were only available for 15 of the 24 airports in North Jersey (typically the airports with higher annual LTOs have TAF data available). Where TAF data were not available, emissions estimates were grown according to an average of the growth expected in other North Jersey airports. Because airports with higher annual LTOs have TAF data available, this TAF average growth estimate was only used on 9 percent of overall North Jersey flights. For all airport forecasts, estimated emissions growth rates for 2025-2030 were held constant for years 2030-2050.

Table A.3.2-5. Airport Emissions Annual Growth Rates

SCC Level 4	Annual Growth Rate (2006-2020)	Annual Growth Rate (2020-2035)	Annual Growth Rate (2035-2050)
SUSSEX	-0.31%	-0.54%	-0.57%
HACKETTSTOWN	-0.35%	-0.09%	-0.12%
AEROFLEX-ANDOVER	-0.35%	-0.09%	-0.12%
GREENWOOD LAKE	-0.31%	-0.54%	-0.57%
TETERBORO	-1.85%	0.98%	0.96%
BLAIRSTOWN	-0.35%	-0.09%	-0.12%
MORRISTOWN MUNI	-1.68%	0.96%	0.92%
LINCOLN PARK	-0.31%	-0.54%	-0.57%
ESSEX COUNTY	-0.53%	0.84%	0.81%
NEWARK LIBERTY INTL	0.62%	1.22%	1.19%
SOLBERG-HUNTERDON	-0.35%	-0.09%	-0.12%
SKY MANOR	-0.35%	-0.09%	-0.12%
ALEXANDRIA	-0.35%	-0.09%	-0.12%
PRINCETON	1.25%	0.09%	0.05%
SOMERSET	-0.31%	-0.54%	-0.57%
CENTRAL JERSEY RGNL	-0.31%	-0.54%	-0.57%
LINDEN	-0.31%	-0.54%	-0.57%
OLD BRIDGE	-0.35%	-0.09%	-0.12%
MONMOUTH EXECUTIVE	-0.31%	-0.54%	-0.57%
ROBERT J. MILLER AIR PARK	-0.31%	-0.54%	-0.57%
LAKEWOOD	-0.56%	-0.54%	-0.57%

SCC Level 4	Annual Growth Rate (2006-2020)	Annual Growth Rate (2020-2035)	Annual Growth Rate (2035-2050)
EAGLES NEST	-0.35%	-0.09%	-0.12%
TRINCA	-0.35%	-0.09%	-0.12%
NEWTON	-0.35%	-0.09%	-0.12%

See Table A.3.2-6 for emissions in forecast years. These emissions apply the growth rates shown in Table A.3.2-5 above.

Table A.3.2-6. Forecast Direct Emissions at North Jersey Airports

Airport	2006	2020	2035	2050
SUSSEX	8,071	7,724	7,123	6,534
HACKETTSTOWN	4,492	4,275	4,220	4,144
AEROFLEX-ANDOVER	5,870	5,586	5,514	5,415
GREENWOOD LAKE	6,981	6,681	6,161	5,651
TETERBORO	120,198	92,492	107,026	123,465
BLAIRSTOWN	5,501	5,235	5,167	5,075
MORRISTOWN MUNI	30,956	24,418	28,160	32,302
LINCOLN PARK	13,714	13,125	12,104	11,102
ESSEX COUNTY	21,642	20,077	22,751	25,696
NEWARK LIBERTY INTL	595,538	649,649	779,816	931,154
SOLBERG-HUNTERDON	8,815	8,389	8,281	8,132
SKY MANOR	8,207	7,811	7,710	7,572
ALEXANDRIA	7,061	6,720	6,633	6,514
PRINCETON	11,699	13,924	14,112	14,226
SOMERSET	9,638	9,225	8,507	7,803

Airport	2006	2020	2035	2050
CENTRAL JERSEY RGNL	8,863	8,483	7,823	7,175
LINDEN	10,031	9,601	8,854	8,121
OLD BRIDGE	5,744	5,466	5,396	5,299
MONMOUTH EXECUTIVE	12,406	11,874	10,950	10,043
ROBERT J. MILLER AIR PARK	7,616	7,289	6,722	6,165
LAKEWOOD	3,727	3,445	3,177	2,914
EAGLES NEST	71	68	67	65
TRINCA	2,885	2,746	2,710	2,662
NEWTON	2,529	2,407	2,376	2,333
Total	**912,255**	**926,710**	**1,071,361**	**1,239,562**

Note that EPA is not developing 2008 estimates of military aircraft emissions, so no default activity data will be available for military airports. Emission estimates for military airports like Lakehurst Naval Air Station will have to rely on those facilities providing activity information (or fuel use estimates). Pechan will need support from NJTPA or TAC members if these emissions are to be included in the NJTPA inventory.

Consumption-Based Accounting

A separate consumption-based accounting of emissions from the aircraft sector was not developed for this project.

Energy-cycle Emissions

Energy-cycle emissions were projected into the future using the same methods and growth factors described in the direct emissions forecast. The full energy cycle emissions (consumption + energy cycle component) are displayed in Table A.3.2-7.

Table A.3.2-7. Full Energy-cycle Forecast Emissions at North Jersey Airports

County	GHG	2006 (tCO_2e/yr)	2020 (tCO_2e/yr)	2035 (tCO_2e/yr)	2050 (tCO_2e/yr)
SUSSEX	CO_2e	10,074	9,642	8,892	8,155
HACKETTSTOWN	CO_2e	5,607	5,337	5,268	5,173
AEROFLEX-ANDOVER	CO_2e	7,327	6,973	6,883	6,759
GREENWOOD LAKE	CO_2e	8,713	8,339	7,691	7,054
TETERBORO	CO_2e	150,033	115,450	133,591	154,111
BLAIRSTOWN	CO_2e	6,866	6,534	6,450	6,334
MORRISTOWN MUNI	CO_2e	38,640	30,479	35,150	40,320
LINCOLN PARK	CO_2e	17,118	16,383	15,108	13,858
ESSEX COUNTY	CO_2e	27,013	25,061	28,398	32,074
NEWARK LIBERTY INTL	CO_2e	743,360	810,902	973,379	1,162,281
SOLBERG-HUNTERDON	CO_2e	11,003	10,472	10,337	10,151
SKY MANOR	CO_2e	10,245	9,750	9,624	9,451
ALEXANDRIA	CO_2e	8,814	8,388	8,280	8,131
PRINCETON	CO_2e	14,603	17,380	17,614	17,757
SOMERSET	CO_2e	12,031	11,514	10,619	9,739
CENTRAL JERSEY RGNL	CO_2e	11,063	10,588	9,765	8,956
LINDEN	CO_2e	12,521	11,984	11,052	10,137
OLD BRIDGE	CO_2e	7,169	6,823	6,735	6,614
MONMOUTH EXECUTIVE	CO_2e	15,486	14,821	13,668	12,536
ROBERT J. MILLER AIR PARK	CO_2e	9,506	9,098	8,390	7,696
LAKEWOOD	CO_2e	4,652	4,300	3,966	3,638

EAGLES NEST	CO_2e	89	84	83	82
TRINCA	CO_2e	3,601	3,427	3,383	3,322
NEWTON	CO_2e	3,156	3,004	2,965	2,912
Total	**CO_2e**	**1,138,691**	**1,156,734**	**1,337,290**	**1,547,242**

A.3.2.5 Recommendations for Future Improvement

A more realistic and potentially useful consumption-based inventory would be based on the air travel services used by NJTPA region residents. The Team is unaware of any such data specific to the region that would not also capture travelers from other areas using the local airports or just passing through. Without conducting surveys to gather this type of information, the next best thing might be to rely on national air travel estimates and allocate these to the NJTPA region based on population. Energy-cycle emissions based entirely on aviation fuel, rather than diesel fuel would reduce the uncertainty associated with energy-cycle estimates. At the moment, no comprehensive energy-cycle emissions factor could be found for the aviation sector.

A.3.3 Commercial Marine Vessels

A.3.3.1 Source Description

Direct Emissions

The emissions associated with Commercial Marine Vessels (CMV) cover all the major marine emissions categories, including Ocean Going Vessels (OGVs), harbor boats, towboats, dredging boats, ferry boats, excursion vessels and government boats. Small, privately owned vessels are not included in the commercial category. Only emissions occurring within the three-mile demarcation line of the shore are included in this analysis. This is consistent with the boundary used for the ozone nonattainment area State Implementation Plan (SIP) emission inventory and the PANYNJ GHG inventory. Emissions come from fuel combusted in these vessels, both in the main engines for propulsion and in the secondary engines for electrical power and other onboard services. This fuel combustion results in emissions of CO_2, CH_4 and N_2O, primarily from the combustion of diesel fuel. Other fuels, such as residual oil, are used on occasion in some types of OGVs, but our information indicates that diesel fuel is the primary fuel used at North Jersey terminals.

Table A.3.3-1 below provides the source classification codes employed for the CMV sector.

Table A.3.3-1. Source Categories for the Commercial Marine Vessels Sector

Subsector	SCC	SCC Level 1	SCC Level 2	SCC Level 3	SCC Level 4
Direct Emissions					
Ocean Going Vessels	2280002010	Nonroad	Mobile Sources	Marine Vessels, Commercial	Diesel - Ocean Going Vessels
Harbor Vessels	2280002020	Nonroad	Mobile Sources	Marine Vessels, Commercial	Diesel - Harbor Vessels
Harbor Vessels	228000202X	Nonroad	Mobile Sources	Marine Vessels, Commercial	Diesel - Towboats
Harbor Vessels	228000202X	Nonroad	Mobile Sources	Marine Vessels, Commercial	Diesel - Dredging Boats
Harbor Vessels	228000202X	Nonroad	Mobile Sources	Marine Vessels, Commercial	Diesel - Ferry/Excursion Boats
Harbor Vessels	228000202X	Nonroad	Mobile Sources	Marine Vessels, Commercial	Diesel - Govt Boats
Consumption-Based Emissions					
Same as those listed above for direct emissions.					
Energy-cycle ***Emissions***					
Same as those listed above for direct emissions.					

Consumption-Based & Energy-cycle Emissions

Consumption-Based Accounting

Full consumption-based accounting for the CMV sector involves estimating the GHGs that occur as a result of CMV activity in the North Jersey area. This data were readily available based on an inventory of CMV emissions conducted in 2003. This served as the primary data source to assess CMV emissions in the North Jersey area.

Energy-cycle Emissions

Energy-cycle GHG emissions within the CMV sector are associated with the production, refining and transport of diesel fuel and residual oil. Argonne National Laboratory's GHG, Regulated Emissions and Energy use in Transport (GREET) model is used to estimate the full Energy-cycle emissions of the two primary marine fuels in this analysis. The GREET model allows analysis for any year between 1990 and 2020.

A.3.3.2 General Inventory Approach

Direct Emissions

The majority of CMV activity data were obtained from the appendices to the Starcrest report *The New York, Northern New Jersey, Long Island Non-attainment Area Commercial Marine Vessel Emissions Inventory.*[44] The appendices to the Starcrest report provided activity data for the 2000 calendar year in kilowatt hours (kWh) and horsepower hours (hp-hr) for main and auxiliary engines, and metric tons of fuel for boilers for the entire ozone non-attainment area. Starcrest's 2000 activity data were extrapolated to 2006 for each vessel type using historical port-wide ship call data. Activity data corresponding to towboat activity over the period were not available and were based on advice provided by the PANYNJ. It was assumed that there was zero growth in towboat activity across the period[45]. 2006 calendar year dredging data (in cubic yards) were obtained from the U.S. Army Corps of Engineers (USACE) Waterborne Commerce section[46]. The best source of information on CMV emissions in North Jersey is from the Port Authority Commercial Marine Vessel Inventory conducted by Starcrest

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[44] Starcrest, 2003a: Starcrest Consulting Group, LLC, "New York, Northern New Jersey, Long Island Non-attainment Area Commercial Marine Vessel Emissions Inventory," prepared for The Port Authority of New York and New Jersey and the United States Army Corps of Engineers – New York District, 2003.

[45] Towboat activity to/from PANYNJ facilities for 2000 was not available. 2006 towboat activity attributed to PANYNJ facilities was determined to be 4,237 trips (based on analysis of towboat trips to Port Authority Marine Facilities. 2006 activity data were provided by Robert Beard, Port Commerce Division).

[46] USACE, 2007: United States Army Corps of Engineers - Waterborne Commerce section, Personal Communications, December 6, 2007.

Consulting in 2003 for the year 2000. This was the most complete estimate of all CMV sources made in the past ten years. Estimates were made based on estimated total OGVs, harbor boats, towboats and dredging boats. Ferries, excursion vessels and government boats were a much smaller number of vessels, and these were estimated based on their individual activity data and horsepower. All emissions estimates were then grown to 2006 levels based on estimated growth in the Starcrest report for port-wide ship calls by vessel type. Total emissions by category are shown in Table 2.2.4-2. These emissions are then allocated across the different counties.

Table A.3.3-2. Carbon Dioxide Equivalent Emissions in North Jersey CMVs

SCC	Descriptions	2006 CO_2e Emissions
2280002010	OGVs	145,531
2280002020	Harborboats	60,071
228000202X	Towboats	5,206
228000202X	Dredging Boats	12,059
228000202X	Ferry/Excursion	51,726
228000202X	Govt Boats	1,236

In the case of OGVs, emissions were allocated by county based on the terminal they would eventually use. All other vessels were allocated to counties according to the percentage of time spent in that county, as estimated in the Starcrest report. Table A.3.3-3 shows the county percentage breakdown of emissions by category.

Table A.3.3-3. County-level Allocation Data for CMV Sector

County	OGVs	Harbor boats	Towboats	Dredging Boats	Ferry/Excursion	Govt Boats
Hudson	21.9%	87.8%	69.7%	87.8%	92.1%	57.5%
Monmouth	0.0%	0.1%	0.0%	0.1%	5.8%	10.6%
Union	60.1%	2.1%	11.4%	2.1%	0.0%	10.6%
Essex	11.9%	6.0%	2.7%	6.0%	0.0%	10.6%
Middlesex	6.1%	4.1%	0.0%	4.1%	0.0%	10.6%
Bergen	0.0%	0.0%	16.3%	0.0%	2.1%	0.0%

Consumption-Based Accounting

A separate consumption-based accounting of emissions for CMVs was not developed for this project. Consumption-based emissions are considered to be the same as direct emissions.

Energy-cycle Emissions

Energy-cycle GHG estimates were developed for commercial marine vessels by adding the upstream GHG emissions associated with fuel extraction, processing and transport for the diesel fuel consumed by CMVs. This estimate comes from the GREET model's estimate of full energy-cycle emissions for diesel fuel. This resulted in a 24.8 percent increase in total CO_2e when energy-cycle emissions are considered. Accurately estimating the upstream GHG emissions associated with fuel extraction, processing and transport can be difficult for the CMV sector, because little information is available on the energy-cycle emissions associated with diesel for marine use. In this analysis, energy-cycle emission estimates for on-road diesel fuel is used as a surrogate, until a better estimate can be found. Full energy-cycle emissions (consumption + energy-cycle component) by SCC are included in Table A.3.3-4 below.

Table A.3.3-4. Full Energy-cycle Carbon Dioxide Equivalent Emissions in North Jersey CMVs

SCC	Description	2006 Energy-Cycle Emissions (t CO_2e)
2280002010	OGVs	181,294
2280002020	Harborboats	74,847
228000202X	Towboats	6,486
228000202X	Dredging Boats	15,025
228000202X	Ferry/Excursion	64,449
228000202X	Govt Boats	1,540

A.3.3.3 Inventory Allocation Method

Covered under the discussion above (Section A.3.3.2).

A.3.3.4 Forecast Method and Results

Direct Emissions

CMV emissions were forecast through 2050 using information from the Annual Energy Outlook 2010 (AEO). The AEO has a forecast for total commercial shipping in the United States, which is expected to decline at an annual rate of 0.3 percent between 2006 and 2020. In the longer term, fuel consumption in shipping is predicted to increase 0.2 percent between 2020 and 2035. The AEO does not estimate emissions beyond 2035, so the growth factor for 2020-2035 was held constant through 2050. Estimated emissions are shown in Table A.3.3-5. Emissions were allocated to counties at the same rate shown in the base year estimate.

Table A.3.3-5. Forecast CO_2e Emissions from CMVs in North Jersey

SCC	Descriptions	2006	2020	2035	2050
2280002010	OGVs	145,531	138,837	142,328	145,908
2280002020	Harbor boats	60,071	57,308	58,749	60,227
228000202X	Towboats	5,206	4,966	5,091	5,219
228000202X	Dredging Boats	12,059	11,504	11,793	12,090
228000202X	Ferry/Excursion	51,726	49,347	50,588	51,860
228000202X	Govt Boats	1,236	1,179	1,209	1,239
	Totals	**275,829**	**263,141**	**269,758**	**276,543**

Consumption-Based Accounting

A separate consumption-based accounting of emissions for CMVs sector was not developed for this project. Consumption-based emissions are considered to be the same as direct emissions.

Energy-cycle Emissions

Energy-cycle emissions were projected into the future using the same methods and growth factors described in the direct emissions forecast. The emissions for the full energy-cycle (consumption-based + energy-cycle component) are displayed in Table A.3.3-6.

Table A.3.3-6. Forecast Full Energy-cycle CO_2e Emissions from CMVs in North Jersey

SCC	Descriptions	2006	2020	2035	2050
2280002010	OGVs	181,294	172,955	177,304	181,764
2280002020	Harbor boats	74,847	71,404	74,224	76,091
228000202X	Towboats	6,486	6,188	5,319	5,453
228000202X	Dredging Boats	15,025	14,333	15,980	16,382
228000202X	Ferry/Excursion	64,449	61,485	61,745	63,298
228000202X	Govt Boats	1,540	1,469	1,506	1,544
Totals		**343,641**	**327,834**	**336,078**	**344,532**

A.3.3.5 Recommendations for Future Improvement

The Energy-cycle emissions rate would be more accurate if it were based on diesel fuel for CMVs rather than on-road diesel fuel. The primary data source for this analysis was an assessment of CMV emissions conducted for the year 2000. A more recent inventory of emissions would have less uncertainty than growing the 2000 estimate to 2006 levels. Growth factors currently used are based on a national average of growth in CMV fuel consumption from the Annual Energy Outlook. It is possible that growth seen at PANYNJ will be significantly different if expansions or other changes to the port are planned.

A.3.4 Railway

A.3.4.1 Source Description

The railway sector covers emissions associated with the operation of both passenger rail and freight rail locomotives. The GHGs involved are CO_2, CH_4, and N_2O, primarily from the combustion of diesel fuel and the consumption of electricity.

Direct emissions include only diesel emissions. Consumption based emissions include both diesel and electric. In the NJTPA region, this sector includes the following components:

- NJTransit: electric and diesel rail and electric light rail.
- PATH: electric service only.
- Amtrak: electric service only.
- Heavy freight rail.

A.3.4.2 General Inventory Approach

Passenger Rail

Passenger rail includes inter-city rail (Amtrak), NJ TRANSIT (commuter lines, Hudson-Bergen Light Rail, and Newark Subway), and PATH. NJ TRANSIT and PATH annual electricity and fuel consumption data for baselines years were obtained through NJ TRANSIT's 2007 carbon footprint assessment and PATH's 2008 electric traction summary.[47]

GHG Emissions for the entire NJTPA region were calculated based on the fuel and electricity consumption data using the electricity, fuel, and incremental energy-cycle emission rates commonly applied to all sectors of this inventory. These total emissions were applied to the consumption based approach, whereas the direct emissions were calculated using only the diesel sources.

Freight Rail

Freight is transported in New Jersey by 14 short line railroads, two regional railroads and three national railroads. Collecting detailed data for all freight rail would require a significant effort and not all detailed data are available. However, for the consumption-based inventory, the tonnage of freight associated with each county in the NJTPA was available.[48] Total ton-miles were estimated by multiplying the tonnage by the average distance traveled for freight with an origin or destination of the New York-Newark-Bridgeport, NY-NJ-CT-PA area from the U.S. Census *Commodity Flow Survey*,.[49] Consumption-based emissions for the region were then estimated using a national average energy factor per ton-mile transported of 302 BTU/ton-mile.[50] However, since these only represent total quantities to and from the region, and don't identify through traffic and specific routes, direct emissions were calculated separately.

Average freight rail traffic densities (ton-miles per mile) for individual lines from the NJ freight plan[51] were used to estimate total ton-miles transported within each county. Because this data set only includes densities for the year 2000, growth factors were used to estimate 2006 base year emissions. This is discussed below, in Section A.3.4.4.

A.3.4.3 Inventory Allocation Method

Passenger Rail

Direct emissions were allocated to the MCD level based on the fraction of train-trip miles along NJ TRANSIT's commuter rail line for the trips within the NJTPA region (diesel emissions only). 2007 train

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[47] NJ TRANSIT, Assessment of NJ TRANSIT's Carbon Footprint, 2008

[48] Provided by NJTPA, May 2010.

[49] US Census, 2009, Commodity Flow Survey, US Census, 2007

[50] USDOE, 2010, Transportation Energy Data Book, Ed. 29, 2008 data, Table 9.8: Summary Statistics for Class I Freight Railroads (national data)

[51] NJDOT, 2007, The New Jersey Comprehensive Statewide Freight Plan, 2000 data, Figure 7-5: Freight Rail System Traffic Density (Estimates) - 2000

schedules were used to estimate trip miles traveled within each area. Emissions were then allocated between areas based on the amount of train-trip miles that were allocated to them.

The consumption-based and energy-cycle approaches allocated the additional emissions associated with the system's electric consumption and reallocated the direct emissions based on ridership origin and destination, allocating 50 percent to each origin and destination. NJ TRANSIT ridership data (commuter lines, Hudson-Bergen Light Rail, Newark Subway) were obtained from NJ TRANSIT. This included daily on/off passenger counts for each station. At each station, calculations were done to determine the number of passengers onboard from previous stations. The number of passengers exiting the train at a station was assumed to be allocated by origin in the same proportions as those on the train. Passenger boarding counts were then added to the train and allocated to the current station, resulting in an estimate of trips by origin and destination. Passenger-miles traveled were then calculated by origin and destination stations. The passenger-miles were divided evenly between the corresponding origin and destination stations. Commuter rail stations were further divided between miles traveled on diesel- and electric-powered trains. Emissions were then allocated to the MCD level based on the amount of passenger-miles allocated to each station and its location.

PATH ridership data included 2007 station entry counts along with passenger destination mixes by origin station. Passenger-miles traveled by origin and destination were then calculated. PATH emissions were allocated to the MCD level in a similar manner to the procedure described above for the NJ TRANSIT systems.

Freight Rail

Freight rail emissions were not allocated to the MCD level. This was due to data availability limitations, the very high effort involved in producing such detailed estimated, and the limited utility of providing MCD level results (decisions regarding freight rail are not generally made at the MCD level). Emissions were calculated for each county separately, as described above in Section A.3.4.2.

A.3.4.4 Forecast Method

Passenger Rail

Growth rates for individual lines within the NJ TRANSIT systems were based on estimates obtained from NJ TRANSIT shown in Table A.3.4-1. These growth rates represent various changes in future service and demand, including changes associated with the operation of the Access to the Region's Core (ARC) Tunnel.[52] Most of the growth would occur on the commuter lines that are projected to have new access to New York City. Due to the dependence on the ARC project, growth would not take effect until 2018. Therefore, total emissions were assumed to remain constant until 2018. Emissions were assumed to grow linearly between 2018 and 2030. Additionally, it was assumed that emissions will remain constant past 2030.

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[52] At the time of completion of this inventory, there is some uncertainty about the future of the Access to the Region's Core (ARC) project. Given this uncertainty and the limited data for other scenarios, all analyses in this inventory include the ARC project in future estimates. Allocation and growth may both differ significantly if ARC is not constructed.

Table A.3.4-1. Annual Growth Factors Applied to Direct Freight Rail Base Year Emissions

NJ TRANSIT Commuter Line	Growth Rate 2018-2030
Bergen	59.50%
Main	31.79%
Montclair-Boonton	8.94%
Morris-Essex	0.85%
Northeast Corridor	11.68%
New Jersey Coast Line	10.73%
Pascack Valley	22.87%
Raritan Valley	48.16%
Port Jervis	38.07%

In the long term, NJ TRANSIT rail emissions are expected to grow in proportion to the forecasted ridership growth on the commuter lines. However, ridership growth would occur prior to the expansion of lines related to the ARC tunnel in 2018. The passenger-mile distribution is projected to change between 2007 and 2018 because of the differing growth rates between rail lines (reflecting demographic shifts, not changes in the rail system). This resulted in shifts in the projected allocation of consumption-based emissions at the MCD level while the total number of trains (and therefore total emissions) did not grow.

Emissions forecasts for NJ TRANSIT's light rail system were based on ridership forecasts produced for the ARC project FEIS.[53] An annual growth factor was calculated for the years between the 2000 base year and the 2030 build year, resulting in an annual growth rate of 5.7 percent. This was assumed to represent the growth of the light rail system's emissions due to the system's small size and large growth rate. A long term emissions forecast assumed that annual growth remained constant for future years beyond 2030.

Ridership data for 2008, 2009, and 2010 for the PATH system were provided by Port Authority of New York and New Jersey. This was used along with projected annual growth factors provided. This growth was assumed to represent the growth in the PATH system's emissions due to the system capacity. A long term emissions forecast assumed a constant average annual growth for future years. These growth rates are seen in Table A.3.4-2.

Table A.3.4-2. Annual Growth Factors Applied to PATH Base Year Emissions

Years	Annual Growth Rate
2010-2011	0.31%
2011-2012	3.50%
2012-2013	3.02%

[53] NJ TRANSIT, Access to the Region's Core FEIS, Table 3.1-13: Daily Total and Trans-Hudson Trips by Primary Mode (Linked Trips): Build Alternative - 2030

Years	Annual Growth Rate
2010-2011	0.31%
2013-2014	2.81%
2014-2015	2.53%
2015-2016	9.83%
2016-2017	8.46%
2017-2018	7.59%
2018-2019	6.90%
2019-2020	6.67%
2020-2021	-0.08%
2021-2022	-0.05%
2022-2023	-0.02%
2023-2024	0.36%
2024-2025	0.05%
2010-2025	3.40%

Freight Rail

Forecasts for direct emissions associated with freight were based on growth in commodity tonnage shipped to and from the NJTPA region projected by FHWA[54] between 2002 and 2035. It was assumed that the growth between 2000 (the base year for the freight data) and 2002 was the same as that projected for 2002-2010. Table A.3.4-3 shows the annual growth rates used for the various time periods between 2000 and 2035. Future long-term estimates assumed a constant annual growth rate. However, the consumption and energy-cycle approaches used growth rates based on growth in

Table A.3.4-3. Annual Growth Factors Applied to Direct Freight Rail Base Year Emissions

Years	Annual Growth Rate
2000-2002	1.96%
2002-2010	2.42%
2010-2015	1.42%
2015-2020	1.28%
2020-2025	1.60%
2025-2030	1.66%
2030-2035	1.56%

A.3.4.5 Inventory & Forecast Update Methods

Since the passenger rail emissions analysis is closely tied to the ARC project, updates for this sector should include updates of all passenger rail data affected by ARC if there are changes in that project. Of specific interest to the freight rail sector is the Cross Harbor Freight Movement project, which would

[54] USDOT, 2006, Freight Analysis Framework (FAF) Version 2.2

significantly increase freight rail movement in northern New Jersey and southern NY, potentially including construction of a tunnel under the New York Harbor (and/or other alternatives being examined) and other capacity improvements. If this project is approved (some actions may be approved as early as 2011, the project as a whole potentially by 2013), the assessment should be updated to reflect changes as early as 2017 when the project may be operational. Other updates could include updated NJ freight plan data, newer FAF data, and updates to the freight tonnage data if available.

A.3.4.6 Inventory & Forecast Results

Direct Emissions

See the body of the report for results at the regional level. Figure A.3.4-1 and Figure A.3.4-2 provide a summary of the consumption-based and direct 2006 base year emissions from the railway sector.

Figure A.3.4-1. Consumption-Based Rail Emissions by County (tCO_2e)

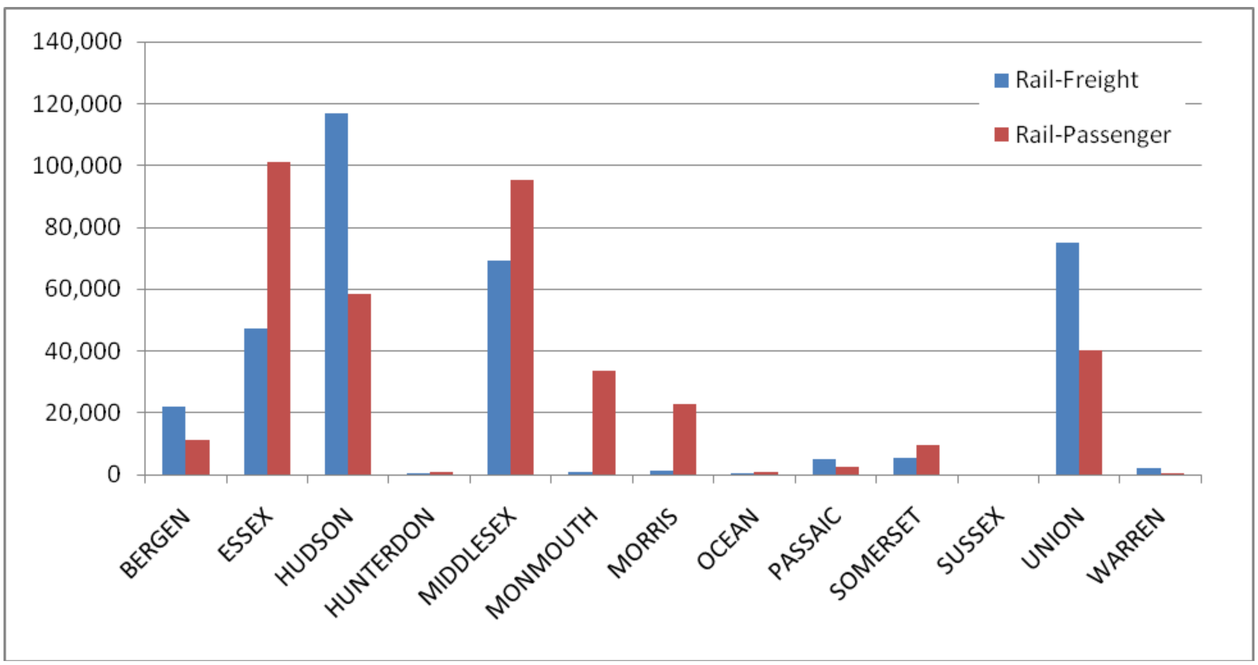
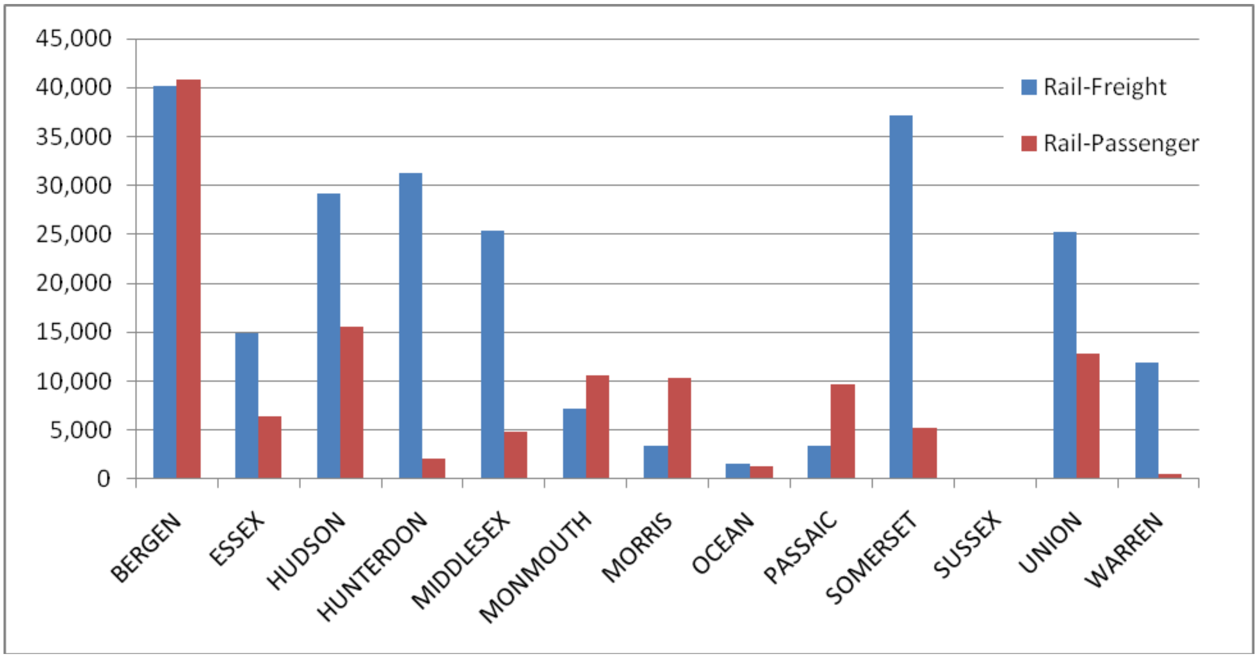


Figure A.3.4-2. Direct Rail Emissions by County (tCO_2e)



A.3.4.7 Recommendations for Future Improvement

Given the increasing interest in rail as a preferred mode for both passenger and freight transport, future improvements in the detailed data and in the consistency of rail and on-road data could prove useful to future analysis of mitigation policy options. Examples could include the inclusion of out-of-state truck freight data, and close tracking of fuel, electricity, passenger ridership (origin-destination data and capacity data), and peak versus off-peak ridership and growth projections.

A.3.4.8 Nonroad Engine Emissions

Nonroad engines are used in many sectors for various tasks. Inventory sectors with nonroad engines in the NJTPA region include agriculture; forestry; residential, commercial, and industrial; off-road transportation; air transportation; railway transportation; and marine transportation. The general methods described in this section for nonroad engines apply to all sectors.

A.3.4.9 Source Description

Nonroad engines include mobile vehicles and engines (including non-vehicle engines such as movable generators). As mentioned above, the emissions from these engines are included in various sectors or sub-sectors. The detailed discussion of sources is included in each section as appropriate. Engine categories included for nonroad recreational engines (land based transportation engines) are listed in Table A.3.4-1. Since the emissions are all local, the consumption-based and the direct emissions from these sources is the same.

Table A.3.4-1. Source Categories for Nonroad Recreational Engines

SCC	SCC Level 1	SCC Level 2	SCC Level 3	SCC Level 4
2260001010	Mobile Sources	Off-highway Vehicle Gasoline, 2-Stroke	Recreational Equipment	Motorcycles: Off-road
2260001020	Mobile Sources	Off-highway Vehicle Gasoline, 2-Stroke	Recreational Equipment	Snowmobiles
2260001030	Mobile Sources	Off-highway Vehicle Gasoline, 2-Stroke	Recreational Equipment	All Terrain Vehicles
2260001060	Mobile Sources	Off-highway Vehicle Gasoline, 2-Stroke	Recreational Equipment	Specialty Vehicles/Carts
2265001010	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Recreational Equipment	Motorcycles: Off-road
2265001030	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Recreational Equipment	All Terrain Vehicles
2265001050	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Recreational Equipment	Golf Carts
2265001060	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Recreational Equipment	Specialty Vehicles/Carts
2267001060	Mobile Sources	LPG	Recreational Equipment	Specialty Vehicles/Carts
2270001060	Mobile Sources	Off-highway Vehicle Diesel	Recreational Equipment	Specialty Vehicles/Carts

A.3.5 General Inventory Approach

County-level CO_2 emissions from nonroad equipment in these sectors were calculated from fuel consumption obtained from running the EPA NONROAD2008 Emission Model, which is based on source inventory data accumulated for specific categories of nonroad equipment. Since nonroad engines are a minor source of emissions in these sectors, and since CH_4 and N_2O emissions are a very minor component of those emissions, CH_4 and N_2O and were not included. The model includes estimates of all equipment used, load factors, and hours of operation for the various equipment and fuel types, which are gasoline, diesel, liquefied petroleum gas (LPG), and compressed natural gas (CNG), for all applicable sectors.

Direct Emissions

The model was run for the 2006 base year at the county level for all equipment in the inventory. The resulting for fuel consumption estimates were subsequently summed by source classification code. For each type of equipment (specified by its source classification code), fuel-specific CO_2 emissions factors obtained from The Climate Registry's General Reporting Protocol[55] were applied based on the type of

[55] The Climate Registry, January 2010, General Reporting Protocol, Table 13.1

fuel used to obtain direct emissions for the base year (see Section 2.0 for more details on emission factors).

To account for the effect of the Renewable Fuel Standard (RFS2) beginning in 2008, direct or consumption-based emissions based on these fuel consumption estimates were reduced by the fraction of ethanol that is in the gasoline/ethanol fuel types and by the fraction of advanced biodiesel that is in the diesel/biodiesel fuel types. Note that this approach does not include emissions from biofuel combustion since the emissions are based on CO_2 originally sequestered by plants. The energy-cycle, consistent with this approach, does not include sequestration of this same carbon (but does include other emissions associated with fuel production), and thus adding the direct or the consumption based emissions to the energy cycle emissions will produce the total net emissions.

Energy-cycle Emissions

Upstream emissions were calculated based on fuel consumption for the energy-cycle GHG estimates. For the 2006 base year and 2007, well-to-pump emissions factors were obtained from the GREET model[56] and applied to the fuel consumption estimates based on fuel type. For 2008 and all future years beyond 2008, year-specific average emissions factors were applied to estimate energy-cycle emissions with the impact of the RFS2. For a full discussion of the fuel energy cycle emission factors see Section 2.0, "Cross Sector Approach, Data, and Methods".

A.3.5.1 Inventory Allocation Method

Emissions were produced at the sub-region (county) level directly by the NONROAD model, as discussed in Section A.2.5.2 above.

A.3.5.2 Forecast Method

The growth rates used in the emissions forecast were specific to each sector. For sectors without specific growth assumptions, EPA's assumptions regarding engine technologies and fuels as well as economic and engine population growth assumptions provided with the NONROAD Model were applied. Differences in growth rates between each fuel type were neglected, and sector-wide, county-specific growth rates were applied to the base year results to forecast emissions through 2050; the only exception is in agricultural engines, where EPA predicts CNG engines to be phased out by 2010. The analysis assumes that all CNG equipment in the base year would be replaced by diesel engines.

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[56] Gasoline: GREET 1.8c, Wheel to Pump Emissions for mix of 50% RFG and 50% conventional Gasoline
Diesel: GREET 1.8c, Wheel to Pump Emissions for Low Sulfur Diesel
CNG: GREET 1.8c, Wheel to Pump Emissions for CNG
LPG: GREET Fleet Footprint Calculator. CO2-equivalent Emissions and Petroleum Use (Upstream GHGs) for LPG (100% Petrol)

The growth rates applied are as follows:

Agriculture. Growth rates based on NJDEP State Inventory and Forecast for crop residues were used for nonroad sources associated with agriculture, consistent with the growth assumed for other emissions in the agriculture sector. These rates are shown in Table A.6-3 in Chapter A.6, "Agriculture."

Forestry. The default growth rates for logging in the NONROAD model were used for nonroad sources associated with logging. These rates are 2.55 percent annual growth from 2006-2020, 1.86 percent from 2020-2035, and 1.46 percent from 2035 to 2050.

Residential Fuel Combustion. Nonroad emissions in this subsector consist of lawn and garden equipment. The Plan 2035 demographic forecasts for households within the NJTPA region were used for nonroad sources associated with residential uses. These rates are discussed further in Section A.2, "Residential, Commercial and Industrial Fuel Use".

Commercial Fuel Combustion. The Plan 2035 demographic forecasts for employment within the NJTPA region were used for nonroad sources associated with commercial uses, consistent with the growth assumed for other emissions in the commercial sector. These rates are discussed further in Section A.2, "Residential, Commercial and Industrial Fuel Use".

Industrial Fuel Combustion. The Plan 2035 demographic forecasts for employment within the NJTPA region were used for nonroad sources associated with industrial uses in the region, which include subsectors construction, industrial, and oil field. These rates are discussed in Section A.2, "Residential, Commercial and Industrial Fuel Use".

Transportation—Nonroad. Nonroad equipment in the transportation sector consists mostly of off-road recreational vehicles. The default growth rates for recreational vehicles in the NONROAD model were used for nonroad sources associated with off-road recreational vehicles or equipment. These rates are 0.75 percent annual growth from 2006-2020, 0.68 percent from 2020-2035, and 0.61 percent from 2035 to 2050.

Transportation—Air. Growth rates developed from terminal area forecast data for airports in North Jersey in conjunction with 2010 Annual Energy Outlook (AEO) average airplane fuel efficiency were used for nonroad sources associated with airport ground support equipment. For discussion of the development of these rates, see Section A.3.2, "Aircraft".

Transportation—Marine. The default growth rates for recreational marine equipment in the NONROAD model were used for nonroad sources associated with recreational marine equipment. These rates are 0.71 percent annual growth from 2006-2020, 0.65 percent from 2020-2035, and 0.59 percent from 2035 to 2050.

Transportation—Railway. The default growth rates for railway support equipment in the NONROAD model were used for nonroad sources associated with railway support equipment. These rates are

1.76 percent annual growth from 2006-2020, 1.40 percent from 2020-2035, and 1.16 percent from 2035 to 2050.

As described above, all resulting emissions were adjusted to account for effects of the RFS2. Base year and forecast results based on the assumptions described above are provided in their respective chapters.

A.3.5.3 Inventory & Forecast Results

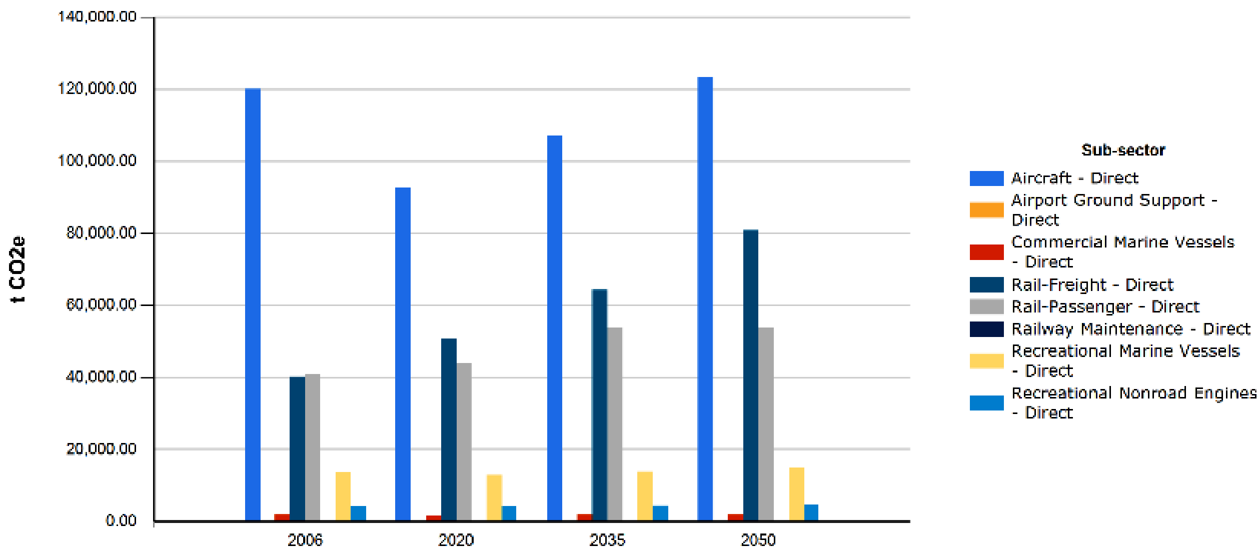
See the body of the report for results at the regional level and the end of this Transportation section for additional summary results.

A.3.6 Additional Transportation Sector Results

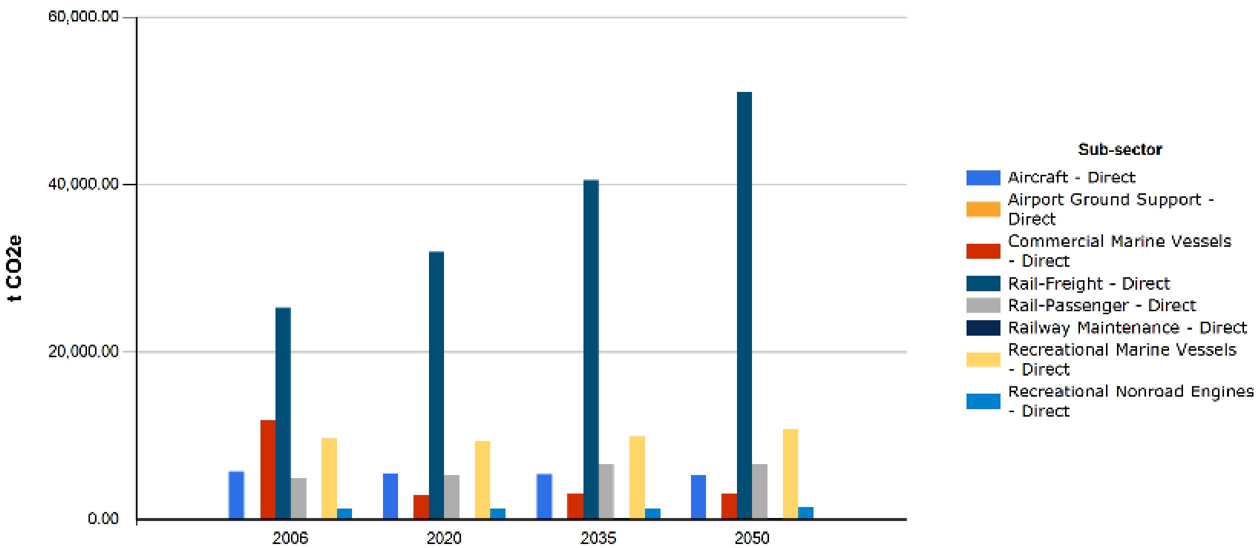
Additional sub-regional I&F results for a sample of counties are shown below. Figures A.3.6-1 and A.3.6-2 provide county-level summaries for the transportation sector, except onroad vehicles (due to the differences in scale of emissions, it is easier to see the results for subsectors other than highway vehicles when they are graphed on a separate chart).

Figure A.3.6-1 Select County-level Summaries for Other Transportation Subsectors, Direct tCO_2e

Bergen County



Middlesex County



Passaic County

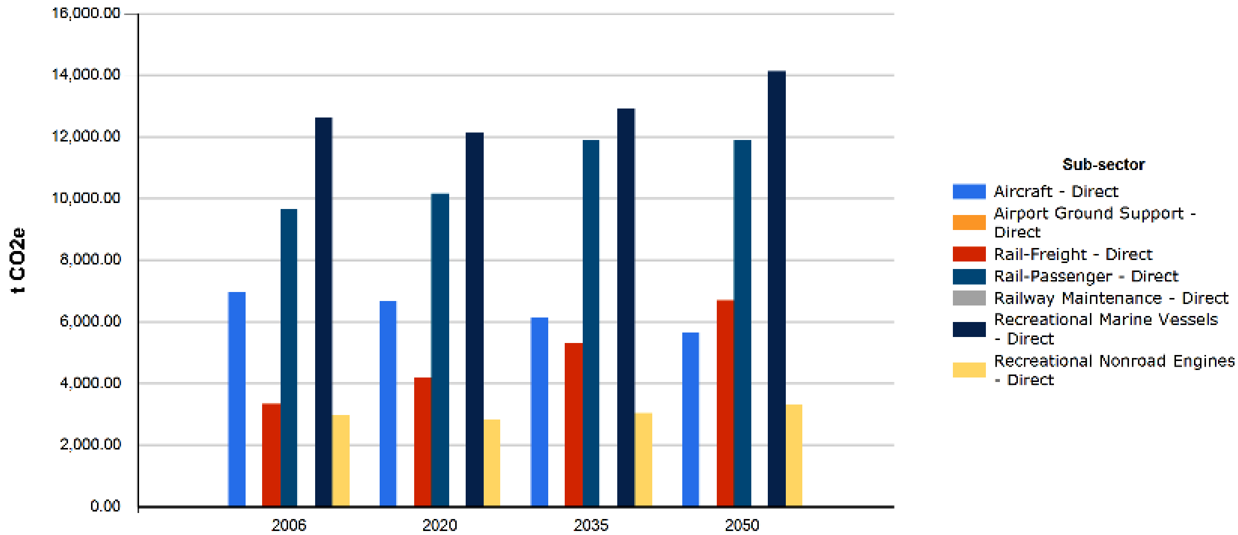
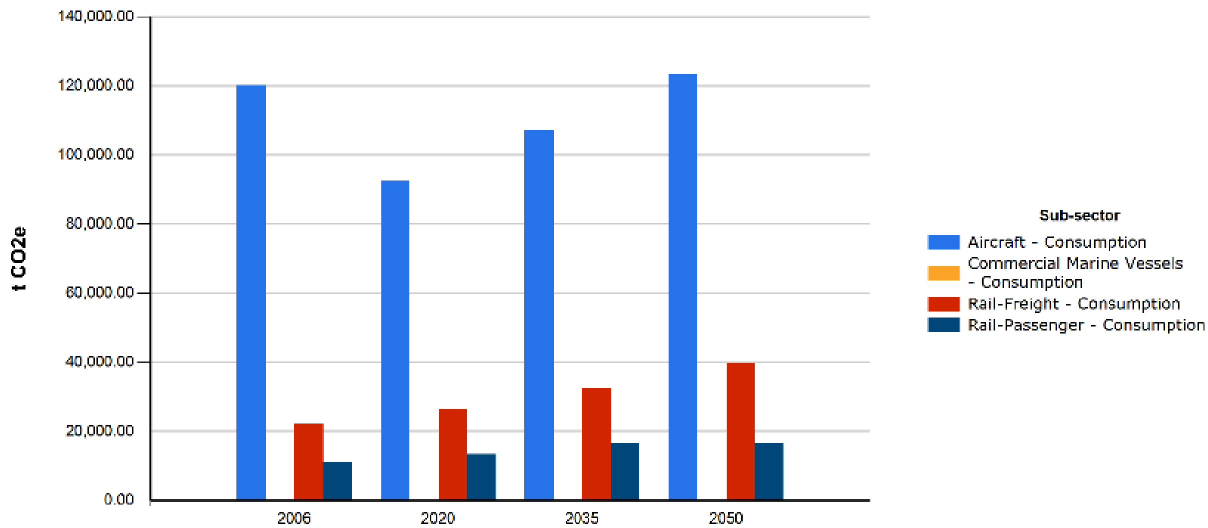
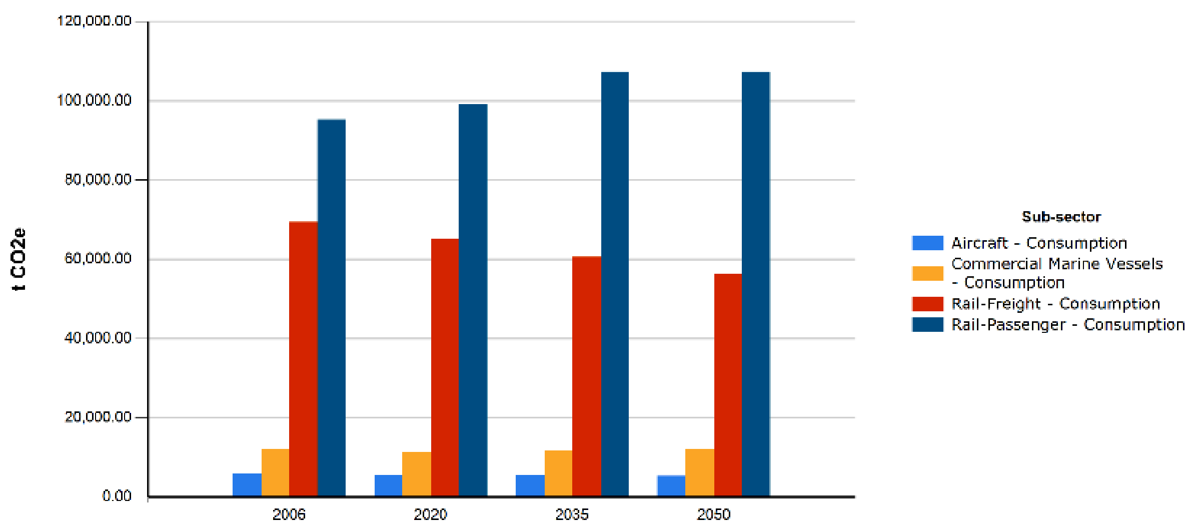


Figure A.3.6-2 County-level Summaries for Other Transportation Subsectors, Consumption tCO_2e

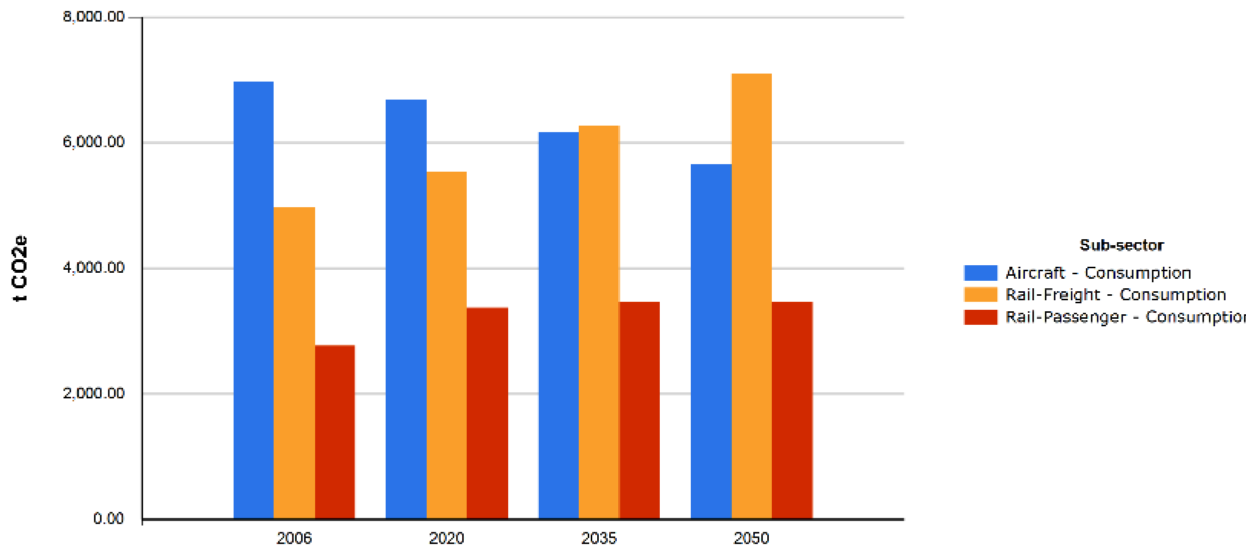
Bergen County



Middlesex County



Passaic County



A.4. Industrial Processes

A.4.1 Source Description

Direct Emissions

Industrial Process emissions include CO_2, CH_4, SF_6, HFCs, PFCs, and N_2O released as by-products from industrial activities, excluding combustion of fuels and electricity use (which are included in other sectors), and from the use of refrigerants and SF_6.

The Industrial Process sector in the US EPA National Inventory, prepared based on IPCC guidance, includes iron and steel production, cement production, lime production, ammonia production and urea consumption, limestone and dolomite use (e.g., flux stone, flue gas desulfurization, and glass manufacturing), soda ash production and use, aluminum production, titanium dioxide production, CO_2 consumption, ferroalloy production, phosphoric acid production, zinc production, lead production, petrochemical production, silicon carbide production and consumption, nitric acid production, and adipic acid production. Also included are the use and release of fluorinated compounds from the use of ozone depleting substance (ODS) substitutes for cooling and refrigeration equipment and from industries such as aluminum production, HCFC-22 production, semiconductor manufacture, electric power transmission and distribution, and magnesium metal production and processing.

This sector comprised approximately two percent of the New Jersey State GHG emissions in 2000, and about 5.0 percent of New Jersey's gross GHG emissions projected for 2020. Many of the above mentioned sources, including some larger ones such as cement, iron, and steel production, are not found in New Jersey. The sources identified in the New Jersey I&F are consumption of limestone and soda ash, nitric acid production, the use of ODS substitutes, semiconductor manufacturing, and electric power transmission and distribution.

Consumption-Based & Energy-Cycle Emissions

Note that some industrial process emissions may be part of a consumption-based analysis, not included in the analysis of this sector. For example, the purchase and use of computers is associated with upstream emissions from the production of semiconductors, some of which may occur in the NJTPA region and much of which would occur outside of New Jersey. In most cases, these are small contributions and often cannot be addressed by local mitigation efforts.

For this inventory, consumption-based emissions associated with cement and steel production were included since this is a sector that can be addressed locally, and since these emissions are substantial. Reducing the amount of cement and steel used or substituting these materials with low-carbon alternatives can reduce the associated emissions.

A.4.2 General Inventory Approach

Direct Emissions

Detailed data regarding the manufacturing output and usage of all of the substances included in this sector within the NJTPA region are not available, and the level of effort required to produce such data would be well beyond the scope of this proposal. Furthermore, this sector is expected to have a relatively small footprint overall, and it is unlikely that actions to mitigate these emissions can be taken at the local level. Therefore, the approach for all sources was to allocate the emissions of this sector from the New Jersey I&F, based on the methodology provided by the *Draft Regional Inventory Guidance* (EPA 2009). In cases where the New Jersey I&F was used, and where the New Jersey I&F was based on the National Inventory, the data were updated as necessary based on the latest national inventory (April 2009) and the latest demographic data, in consultation with NJDEP.

The detailed emission inventory sources and allocation to the NJTPA region are presented in Table A.4-1 below. See Section A.4.3 below for more details regarding allocation metrics.

Table A.4-1. 2006 Source Inventory Data and Allocation Metrics

Subsector	GHG	NJ State-Wide Emissions		Metric of Allocation to NJTPA Region
		Emissions (MMt/yr)	Emissions ($MMtCO_2e$/yr)	
Limestone Use	CO_2	0.0051	0.0051	Manufacturing Employment
Soda Ash Production and Use	CO_2	0.0755	0.0755	Manufacturing Employment
Nitric Acid Production	N_2O	3.4E-06	0.0011	Manufacturing

		NJ State-Wide Emissions		Metric of
				Employment
Semiconductor Manufacture	HFC, PFC, SF_6	NA	0.0255	Manufacturing Employment
Fluorinated Compounds (ODS substitutes) for Cooling and Refrigeration Equipment	HFC/PFC	NA	2.74	Population
Fluorinated Compounds (ODS substitutes) for aerosols, foams, solvent, fire protection	HFC/PFC	NA	0.301	Population
Electric Power Transmission and Distribution (SF6)	SF_6	1.3E-05	0.305	Electricity Consumption

NA—Not Available

* Based on methane emissions from NJDEP report, with CO_2e corrected to use the global warming potential factors used for this study (IPCC 2006).

Consumption-Based & Energy-Cycle Emissions

For industrial process emissions, in most cases, consumption-based mitigation is not available on a local or regional scale. Given the small portion of the overall inventory these emissions represent, and given the limited utility in providing this data and the high level of effort involved in obtaining specific baseline and consumption data for each product, consumption-based emissions were not calculated for most of the industrial process sector.

The analysis focused instead on two central products, cement and metals (iron and steel), which represent a relatively large portion of the national GHG inventory and for which consumption-based mitigation options are available. The analysis was prepared using a top-down approach.

For cement consumption, the analysis was based on allocating the amount of Portland cement shipped to NJ, as reported by the Portland Cement Association,[57] to the NJTPA region. The allocation from state-wide to the NJTPA region was based on EPA's estimates of construction activity by county used for the NONROAD model. This quantity was then multiplied by energy-cycle emission factors of 927 kg CO_2 and 0.0395 kg of methane per metric ton of cement produced.[58]

For iron and steel consumption, the analysis was based on allocating the amount of base metals shipped to the NJ portion of the New York-Newark-Bridgeport region, as reported by the Federal Highway Administration,[59] to the NJTPA region. It was assumed that the fraction of metals used for construction and for manufacturing in the NJTPA region was similar to the national fraction, reported by the United

[57] Portland Cement Association, Long-Term Cement Consumption Outlook, May 30, 2006, cement.org.

[58] Portland Cement Association, Life Cycle Inventory of Portland Cement Manufacture, 2006

[59] FHWA, Freight Analysis Framework (FAF2.2), November 2006, http://ops.fhwa.dot.gov/freight/freight_analysis/faf/index.htm, accessed September 2010.

States Geological Service,[60] estimated at 29 percent for construction and 71 percent for manufacturing (this excludes shipments to service centers and distributors). The quantities shipped for each end-use to the NJ portion of the New York-Newark-Bridgeport region were then allocated to the NJTPA counties (subtracting Mercer County shipments and adding shipments to Warren County), by construction activity (as described above for cement) and by manufacturing employment (see below for more details). This quantity was then multiplied by energy-cycle emission factors of 1.83 metric tons per metric ton of metal produced.[61]

Note that the factors used for cement and for iron and steel are energy-cycle factors, but include both energy and process emissions associated with production and transport of materials (not including delivery), and therefore the consumption-based data include energy components (unlike direct emissions in this sector).

Not all details of the iron and steel and the cement energy-cycle factor development were available, but it is assumed that upstream emissions associated with fuel production were included, and therefore no emissions specific to the upstream energy-cycle component are presented.

A.4.3 Inventory Allocation Method

Direct Emissions

For ODS substitutes, the vast majority of the emissions are associated with the use of refrigerants, and therefore their geographic distribution can be estimated to be correlated with population, based on the *Plan 2035* demographic data. This method was used to allocate the state-wide emissions down to the region and subregion levels, and to forecast future emission levels.

The release of SF_6 from electric power transmission and distribution was allocated to the NJTPA region from the NJ State-wide emissions, and then further allocated down to the subregion level based on the proportion of the electric power consumption in each area relative to the State of New Jersey. The electricity consumption by county is presented in Table A.4-2.

As for the rest of the compounds, since emissions are generally associated with the process rather than the distribution or consumption, allocation was based on manufacturing employment.[62] These emissions were not further allocated down to the MCD level due to the limited information regarding facility distribution and the output of facilities in each area. In the future, local action regarding specific facilities should be considered based on detailed local information where available, whereas region-wide actions

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[60] USGS, 2008 Minerals Yearbook: Iron and Steel (advance release), March 2010.

[61] Worrell, Martin, and Price, Energy Efficiency and Carbon Dioxide Emissions Reduction Opportunities in the U.S. Iron and Steel Sector, Ernest Orlando Lawrence Berkeley National Laboratory, 1999.

[62] NJ Department of Labor and Workforce Development, Industry Employment Projections, http://lwd.state.nj.us/, accessed May 2010.

can address the larger sources without specific allocation data. The 2006 manufacturing employment data are presented in Table A.4-2.

Table A.4-2. Manufacturing Employment (2006)

NJ State-wide	323,900
Bergen	41,950
Essex	25,000
Hudson	11,300
Hunterdon	3,450
Middlesex	42,800
Monmouth	10,250
Morris	27,500
Ocean	5,850
Passaic	22,650
Somerset	18,950
Sussex	1,500
Union	33,650
Warren	5,650
NJTPA Total	*250,500*

Source: NJ Department of Labor and Workforce Development

Consumption-Based & Energy-Cycle Emissions

Allocation of the consumption-based emissions to the county level was based on the same metrics used for allocation from state- or area-wide emissions to the NJTPA region, described in Section A.4.2 above.

A.4.4 Forecast Method

As discussed above, ODS substitutes, were allocated by population. Therefore, forecasting future emissions were based on the population growth estimates. The population projections from the NJTPA *Plan 2035* were used for that purpose.

The forecast of the release of SF_6 from electric power transmission and distribution was correlated to the forecast of electric power in each county, as described above for allocation.

Since projections were not available for manufacturing employment, emissions of other compounds was forecast based on the general employment growth rates from *Plan 2035*.

A.4.5 Inventory & Forecast Update Methods

Since this analysis is closely tied to the New Jersey I&F, future updates should include any updated information from the state-wide inventory process for this sector. As with many sectors, both growth and allocation were tied to *Plan 2035* demographic data, so any update in growth assumptions for the region should also be accounted for in future updates. If base-year emissions are being adjusted to a different year, manufacturing employment should be updated to reflect the new base year.

A.4.6 Inventory & Forecast Results

See the body of the report for a summary of emissions at the regional level. Total emissions from the IP sector by county, including both direct and consumption-based emissions, are presented in Figure A.4-1 Although direct and consumption-based emissions are not normally to be combined, in this instance, since there is no overlap in the sources, this combination give a good sense of the importance of this sector. It should be noted that although not calculated in detail for the current effort, the direct emissions are mostly also consumption-based; for example, ODS emissions from refrigeration units, the largest sub-sector in the direct analysis, occur mostly at the consumption end. The consumption-based emissions in this case, cement and iron & steel production, include energy related emissions in the manufacturing process, which is much more of a true lifecycle analysis in this instance. A similar analysis of other goods would reveal increased emission for the production of those goods, similar to the data presented in the solid waste sector. Since cement and iron/steel manufacturing are known as large sources, this data were included here for use in mitigation planning.

Similar to the data presented in Figure A.4-1, Figure A.4-2 shows the breakdown of total emissions by sub-sector and by year. This figure highlight the dominance of cement and iron/steel consumption within the sector, and that significant growth in their consumption is expected in future years.

Figure A.4-1. Combined IP Emissions by County tCO_2e)

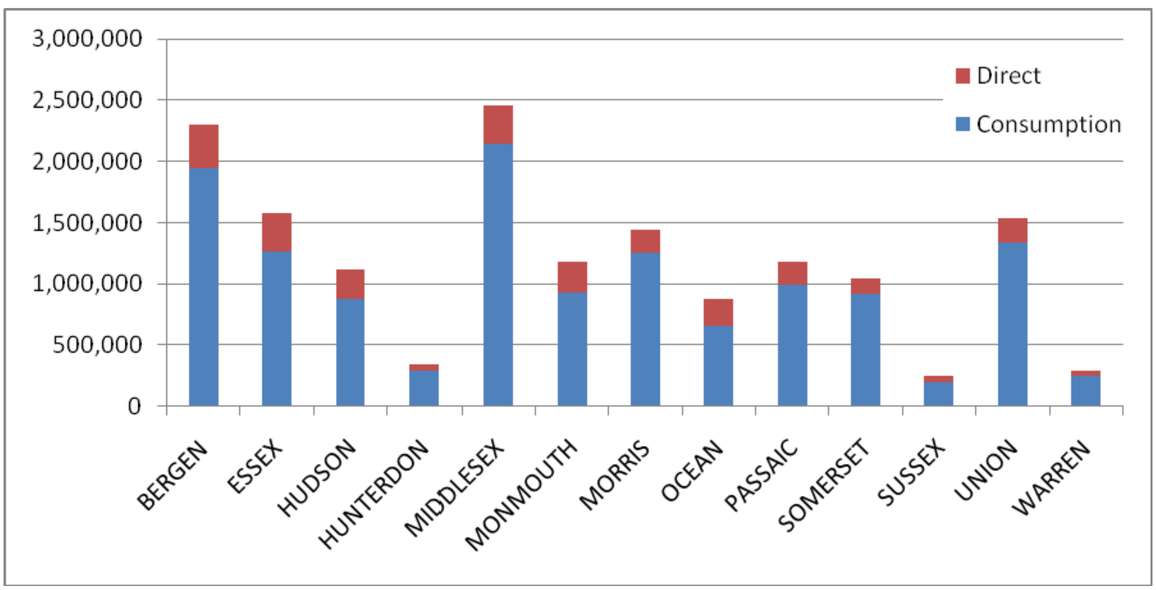
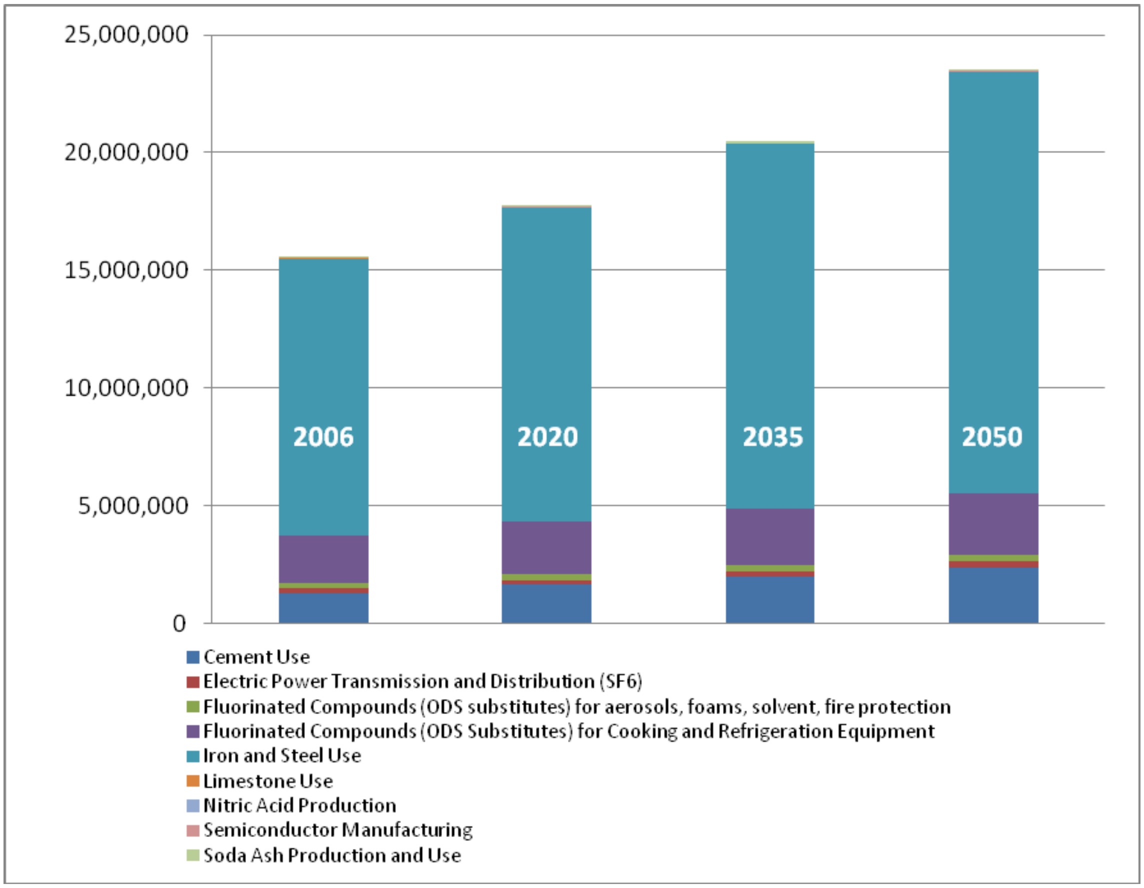


Figure A.4-2. Combined IP Emissions by Year and Sub-Sector (tCO_2e)



A.4.7 Recommendations for Future Improvement

As mitigation options are developed, it is possible that focus on certain sources may become more important. In that instance, more detailed data from specific industries may be required. This could include more detailed data sources regarding industries and materials consumption, enabling better quantification and allocation to the MCD level.

A.5. Fossil Fuel Industry

A.5.1 Source Description

Crude oil refining and natural gas distribution losses represent the only significant sources of GHG emissions associated with the fossil fuel industry in the NJTPA region. Note that the sector represents emissions associated with the processing and distribution of the fuels—not combustion, which is represented in other sectors. Both sources are presented as direct emissions only.

CH_4 emissions from crude oil refining processes and systems are released to the atmosphere as fugitive emissions, vented emissions, emissions from operational upsets, and emissions from fuel combustion. These emissions account for slightly less than two percent of total CH_4 emissions from the oil industry because most of the CH_4 in crude oil is removed or escapes before the crude oil is delivered to the refineries. There is an insignificant amount of CH_4 in all refined products. Within refineries, vented emissions account for about 87 percent of the emissions, while fugitive and combustion emissions account for approximately six and seven percent, respectively. Refinery system blowdowns for maintenance and the process of asphalt blowing—with air, to harden the asphalt—are the primary venting contributors. Most of the fugitive CH_4 emissions from refineries are from leaks in the fuel gas system. Refinery combustion emissions include small amounts of unburned CH_4 in process heater stack emissions and unburned CH_4 in engine exhausts and flares.

There is only one refinery operating in the NJTPA region, in Linden (Union County), with an operating capacity of 238,000 barrels per day, representing 1.4 percent of the total capacity in the US.

Also included in this sector are CH_4 emissions released from the distribution of natural gas. These include vented and fugitive emissions associated with system leaks.

These emissions are presented as direct only. Overall, refinery and natural gas distribution emissions are a portion of the upstream emissions for fuel consumption wherever it may occur (within NJ or elsewhere), and emissions from this sector (in NJ and elsewhere) are included in the energy-cycle emissions presented for fuel consumption.

A.5.2 General Inventory Approach

Crude oil refining emissions were not found in NJDEP's state inventory, and were therefore developed based on the EPA national inventory, using an emission factor, from EPA's State Inventory Tool, of 4.96 kg CH_4 per 1,000 barrels produced. As reported by EIA,[63] 238,000 barrels of atmospheric crude were produced in the NJTPA region (in Linden, Union county) per calendar day in 2006. This number has remained constant through 2009.

Similar to the method described above for the industrial process sector (Section 3.4), natural gas transmission and distribution losses of methane were estimated by allocating the emissions from this sector in the New Jersey I&F, based on the the consumption of natural gas (from the Fuel Use sector, Section 3.2). State-wide natural gas transmission and distribution methane losses from the latest updates of the NJDEP inventory were 0.104 Mmt. Total natural gas consumption in New Jersey in 2006 was 547,206 million cubic feet.[64] The natural gas consumption in the NJTPA region is presented in Table A.5-1.

[63] EIA, Refinery Capacity Report, http://www.eia.doe.gov/oil_gas/petroleum/data_publications/refinery_capacity_data/refcapacity.html, accessed May 2010.

[64] EIA, Natural Gas Consumption by End Use 2006, http://tonto.eia.doe.gov/dnav/ng/ng_cons_sum_dcu_SNJ_a.htm, accessed May 2010.

Table A.5-1. Projected Natural Gas Consumption (million cubic feet delivered)

County	2006	2020	2035	2050
Bergen	79,919	82,702	86,978	90,665
Essex	45,960	48,545	51,507	53,874
Hudson	27,026	30,966	34,875	38,340
Hunterdon	5,545	6,329	7,165	7,703
Middlesex	81,299	89,672	99,650	107,853
Monmouth	25,713	28,165	30,650	32,654
Morris	21,921	23,561	25,943	25,943
Ocean	22,483	25,537	29,858	33,379
Passaic	20,311	22,453	25,147	27,075
Somerset	18,147	20,703	23,447	25,630
Sussex	2,468	2,986	3,570	4,173
Union	97,489	100,211	103,175	105,428
Warren	5,060	5,402	5,656	5,888
Grand Total	**453,342**	**487,231**	**527,620**	**558,602**

Source: AKRF, based on utility data and forecast metrics.
Notes: Includes all natural gas used in the residential, commercial, and industrial sectors, including power generation. For more information see Section 3.1 and 3.2.

A.5.3 Inventory Allocation Method

There is only one refinery operating in the NJTPA region, in Linden (Union County); therefore, no allocation was necessary.

Natural gas distribution losses were allocated based on the allocation of natural gas consumption emissions (see above). Although this method could be used to further allocate emissions down to the MCD level, since the actual release is associated with specific transmission facilities, this would not likely produce an accurate allocation at that level. Furthermore, the utility of that information at the MCD level would be limited since the expected emissions would be a very small component of the inventory and actions to reduce these emissions are not likely to be taken at the municipal level. Note that since this is based on consumption, the direct natural gas distribution loss emissions also represent consumption based-emissions.

A.5.4 Forecast Method

There are currently no known plans for expansion of oil refining in the NJTPA region. Given the past trend, it is assumed that emissions associated with oil refining will remain constant in future years.

The forecast of natural gas distribution loss emissions was correlated to the forecast of natural gas usage (see above).

A.5.5 Inventory & Forecast Update Methods

Future updates in the oil refining sub-sector could include changes in refining output, if any such changes are expected.

Natural gas distribution losses should be updated in the future based on any updates to that sector in the NJDEP state-wide inventory.

A.5.6 Inventory & Forecast Results

See the body of the report for results at the regional level. Note that crude oil refining is very limited in the NJTPA region, although as a single source, it is not insignificant. However, natural gas transmission losses are much more substantial on the regional level, and can be mitigated with efforts to improve leak detection and other systems and technology improvements.

A.5.7 Recommendations for Future Improvement

If mitigation efforts are focused on the oil refining sub-sector, detailed inventory information may be developed for the Linden facility. The current estimate is not-facility specific, and it is possible that operations or measures specific to this facility result in a different emission rate than the industry-wide average.

The natural gas distribution loss can be improved with detailed facility-level data, if necessary, to refine both the emissions and their allocation.

In general, since EPA now requires GHG reporting for facilities in this sector, detailed emissions may become available, providing better estimates of current emissions for use in baseline estimates.

A.6 Agriculture

A.6.1 Source Description

Direct Emissions

In typical municipal to state accounting of direct emissions, the agriculture sector covers non-fuel combustion emissions associated with production of crops and livestock management. Emissions from fuel combustion within the agriculture sector are typically included with industrial fuel combustion emissions. Also, aside from soil carbon management related emissions, emissions associated with changes in land use are covered under Land Use, Land Use Change & Forestry (LULUCF), in Section 3.7. In consultation with the TAC, the Team allocated the emissions from nonroad engines in the agriculture sector to this sector (see the discussion of nonroad engines modeling in the Transportation chapter above for more details on the development of those emissions based on EPA's NONROAD model).

The non-fuel combustion GHGs involved are primarily N_2O and CH_4. N_2O emissions result from the application of synthetic and organic nitrogen additions to soils and during manure management. Methane emissions are produced during manure management and from enteric fermentation within ruminant animals (primarily cattle). Some CO_2 emissions also occur as a result of soil carbon losses during cultivation and application of limestone/dolomite and urea; however, data for those sources are lacking and additional effort was not made in this project to capture them due to the likely contribution to regional or municipal GHG emissions. Overall, the non-fuel combustion emissions in the agricultural sector contribute very little to the state-wide total GHG emissions (~0.5 $MMtCO_2e$ in 2005, which is less than 0.5 percent of the New Jersey total).[65] Of this amount, about 80 percent is contributed by crop soils.

Additional agricultural sources include CO_2 emissions from urea application (emitted as urea breaks down in soil). These are in addition to the N_2O emissions associated with fertilizer application. Soil liming (with limestone or dolomite) is also a possible source of CO_2; however, the NJ state I&F indicate that little, if any, soil liming occurs in the state. Finally, soil carbon flux from changes in crop management practices also produces net emissions or a sink for CO_2. The state I&F estimates are based on modeling for a single year (1997) and show this to be essentially a net neutral source/sink in NJ (-0.07 $MMtCO_2e$/yr).[66] Due to the relative lack of importance and available data, they were left out of this NJTPA inventory and forecast.

[65] New Jersey GHG I&F, http://www.nj.gov/globalwarming/home/documents/pdf/20081031inventory-report.pdf. Note that these estimates do not include CO_2 emissions from the application of limestone/dolomite and urea.

[66] New 2008 estimates were recently released by EPA. The overall net change in agricultural soil carbon stocks is fairly unchanged from 1997 at -0.08 $MMtCO_2e$/yr.

For nonroad engines, the GHGs involved are CO_2, CH_4, and N_2O, primarily from the combustion of diesel fuel and small amounts of other fossil fuels (gasoline, liquefied petroleum gas, and compressed natural gas).

Consumption-Based & Energy-cycle Emissions

Consumption-Based Accounting

Full consumption-based accounting for the agriculture sector would involve estimating the GHGs embedded within the agricultural products consumed by NJTPA residents and food service establishments. This type of analysis was beyond the scope of this project; however, it would have obvious benefits in mitigation planning (e.g., sourcing of locally produced agricultural products). In the I&F data files, emissions are listed as "n/a", for "not applicable". When a consumption-based inventory is developed, there will likely be a need to develop a different source classification scheme than used in this project for direct and energy-cycle GHG estimates (i.e., one based on consumption of different fresh and packaged agricultural products).

Energy-cycle Emissions

Important energy-cycle GHG emissions within the agriculture sector are associated with the production and transport of synthetic fertilizers. One of the common GHG mitigation options in the crop production sector is nutrient management programs, where reductions in applied nitrogen lead to reductions in direct emissions of N_2O. Since usage of fertilizer is reduced, energy-cycle GHG emissions occurring from the production and transport of nutrients are reduced, as well. In this project, since nonroad engine fuel combustion is included in this sector, then the upstream GHG emissions associated with fuel extraction, processing and transport are also included.

Table A.6-1 below provides the source classification employed for the agriculture sector. In a region with higher GHG contributions in the agriculture sector, further work to disaggregate the livestock and crop production emissions might be useful (e.g., by specific crop or livestock type). As shown in the table below, MCD-level nonroad engine emissions are estimated at the 4-digit SCC level for gasoline, LPG, and CNG. Since most agricultural nonroad engines use diesel fuel, emissions were estimated at the 10-digit SCC-level detail for that fuel.

Table A.6-1. Source Categories for the Agriculture Sector

Subsector	SCC	SCC Level 1	SCC Level 2	SCC Level 3	SCC Level 4
Direct Emissions					
Enteric Fermentation	2805060xxx	Misc. Area Sources	Agriculture Production - Livestock	Unspecified Livestock	Enteric Fermentation
Manure Management	28050xxxxx	Misc. Area Sources	Agriculture Production - Livestock	Unspecified Livestock	Manure Management
Agricultural Burning	28015001xx	Misc. Area Sources	Agriculture Production - Crops	Agricultural Field Burning	Crop Not Specified
Fertilizer	280170000x	Misc. Area	Agriculture	Fertilizer	Fertilizer Not

Subsector	SCC	SCC Level 1	SCC Level 2	SCC Level 3	SCC Level 4
Application		Sources	Production - Crops	Application	Specified
	280200000x	Misc. Area Sources	Agriculture Production - Crops	Fertilizer Application	Fertilizer Not Specified - Indirect N2O (N Re-Deposition)
	280210000x	Misc. Area Sources	Agriculture Production - Crops	Fertilizer Application	Fertilizer Not Specified - Indirect N2O (Runoff/Leaching)
	2801700004	Miscellaneous Area Sources	Agricultural Production - Crops	Fertilizer Application - Synthetic	Urea
Manure Application[a]	2805080xxx	Misc. Area Sources	Agriculture Production - Livestock	Unspecified Livestock – manure spreading	Direct Emissions
	28050081xx	Misc. Area Sources	Agriculture Production - Livestock	Unspecified Livestock – manure spreading	Indirect Emissions (N-Redeposition)
	28050082xx	Misc. Area Sources	Agriculture Production - Livestock	Unspecified Livestock – manure spreading	Indirect Emissions (Runoff/Leaching)
Crop Soils	280110000x	Misc. Area Sources	Agriculture Production - Crops	Crop Residues	Crop Not Specified
	280120000x	Misc. Area Sources	Agriculture Production - Crops	N-Fixing Crops	Crop Not Specified
	280130000x	Misc. Area Sources	Agriculture Production - Crops	Soil Management	High Organic Soils (Histosols)
Residue Burning	28015001xx	Misc. Area Sources	Agriculture Production - Crops	Agriculture Field Burning	Crop Not Specified
Nonroad Engines	2260005035	Mobile Sources	Off-highway Vehicle Gasoline, 2-Stroke	Agricultural Equipment	Sprayers
	2265xxxxxx	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Agricultural Equipment	Total
	2287xxxxxx	Mobile Sources	LPG	Agricultural Equipment	Total
	2268xxxxxx	Mobile Sources	CNG	Agricultural Equipment	Total
	2270005010	Mobile Sources	Off-highway Vehicle Diesel	Agricultural Equipment	2-Wheel Tractors
	2270005015	Mobile Sources	Off-highway Vehicle Diesel	Agricultural Equipment	Agricultural Tractors

Subsector	SCC	SCC Level 1	SCC Level 2	SCC Level 3	SCC Level 4
	2270005020	Mobile Sources	Off-highway Vehicle Diesel	Agricultural Equipment	Combines
	2270005025	Mobile Sources	Off-highway Vehicle Diesel	Agricultural Equipment	Balers
	2270005030	Mobile Sources	Off-highway Vehicle Diesel	Agricultural Equipment	Agricultural Mowers
	2270005035	Mobile Sources	Off-highway Vehicle Diesel	Agricultural Equipment	Sprayers
	2270005040	Mobile Sources	Off-highway Vehicle Diesel	Agricultural Equipment	Tillers > 6 HP
	2270005045	Mobile Sources	Off-highway Vehicle Diesel	Agricultural Equipment	Swathers
	2270005055	Mobile Sources	Off-highway Vehicle Diesel	Agricultural Equipment	Other Agricultural Equipment
	2270005060	Mobile Sources	Off-highway Vehicle Diesel	Agricultural Equipment	Irrigation Sets
	2270005098	Mobile Sources	Off-highway Vehicle Diesel	Agricultural Equipment with equivalent diesel emissions converted from CNG (2268xxxxxx)	Mobile Sources
Consumption-Based Emissions					
Not developed for the Agriculture Sector					
Energy-Cycle Emissions					
Same as those listed above for direct emissions, where applicable.					

[a] Same as the “Ag Soils – Animals” sector in EPA’s SIT Module which was used for the NJDEP state I&F.

A.6.2 General Inventory Approach

Direct Emissions

Given the relatively small contributions from the agricultural sector, the Team’s approach was to use the New Jersey I&F estimates as a starting point for non-combustion agricultural sources. These were developed using the latest version of EPA's State Inventory Tool (SIT) agriculture module.[67] For the livestock sector, 2007 county-level data on animal populations by type from the US Department of Agriculture's (USDA's) 2007 Census of Agriculture (COA) were used to allocate the 2006 state-level base year emissions down to the county-level. Table A.6-2 provides a summary of the county-level allocation data. For livestock, the allocation took into account the contribution of livestock type to total statewide emissions. For example, within the SIT module, cattle produce 70 percent of CH_4 emissions from the livestock sector (remaining 30 percent from "other" livestock; so, the allocation to the county-level took that into account). For allocation to the municipal scale, the Team used data on the total number of livestock operations by zip code, also obtained from the USDA's COA.[68]

Table A.6-2. County-level Allocation Data for Agriculture Sector

County	Total Crops		Cattle		Poultry		Other Livestock	
	acres	% of State	head	% of State	head	% of State	head	% of State
NJ Total	**242,827**	**100%**	**38,198**	**100%**	**124,2803**	**100%**	**79,022**	**100%**
Bergen	242	0.10%	0	0.00%	4,307	0.35%	336	0.43%
Essex	20	0.01%	0	0.00%	137	0.01%	0	0.00%
Hudson	0	0.00%	0	0.00%	0	0.00%	0	0.00%
Hunterdon	16,981	6.99%	5,358	14.03%	7,849	0.63%	40,373	51.09%
Middlesex	9,477	3.90%	0	0.00%	815	0.07%	1,532	1.94%
Monmouth	13,628	5.61%	0	0.00%	0	0.00%	8,496	10.75%
Morris	2,237	0.92%	387	1.01%	1,850	0.15%	2,418	3.06%
Ocean	1,706	0.70%	0	0.00%	2,521	0.20%	962	1.22%
Passaic	184	0.08%	0	0.00%	849	0.07%	554	0.70%
Somerset	4,902	2.02%	0	0.00%	6,864	0.55%	0	0.00%
Sussex	184	0.08%	0	0.00%	849	0.07%	554	0.70%
Union	50	0.02%	0	0.00%	0	0.00%	0	0.00%
Warren	27,201	11.20%	8,009	20.97%	0	0.00%	1,887	2.39%

For the crop production sources, the 2006 state-level emissions were allocated to the county based on total crop acres in the 2007 COA. County to MCD-level allocation of emissions was performed based on each MCD's fraction of agricultural land use.[69]

For nonroad engines, the county-level estimates from the NONROAD model were allocated to the MCD-level using each MCD's fraction of agricultural land use. The nonroad emission estimates are housed in a

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[67] Direct emission factors and other emission estimation inputs are contained within the EPA SIT Ag Module available from: http://www.epa.gov/statelocalclimate/resources/tool.html.

[68] http://www.agcensus.usda.gov/Publications/2007/Online_Highlights/County_Profiles/New_Jersey/index.asp.

[69] 2002 land cover/land use data provided by NJTPA.

separate data file from the rest of the agricultural emissions in order to keep the size of the data files manageable.

Consumption-Based & Energy-cycle Emissions

Consumption-Based Accounting

A separate consumption-based accounting of emissions from the agriculture sector was not developed for this project.

Energy-cycle Emissions

Since a consumption-based inventory was not developed for agriculture, energy-cycle emissions are not applicable. However, the Team did produce some information that might be of value during future mitigation planning. Upstream GHG estimates were developed for the manufacture and transport of the synthetic fertilizers applied within the NJTPA region. This was done by allocating state-wide fertilizer consumption (in kilograms of nitrogen) from the New Jersey I&F to each county, as was done for the direct crop-related emission estimates above. An upstream GHG estimate for each source category was then developed for each county using the total synthetic nitrogen applied and an upstream emission factor from the scientific literature (0.858 kg CO_2e/kg N).[70] Upstream emission estimates were also developed for fuels consumed in the agriculture sector as described in the section on Transportation – Nonroad Engines.

A.6.3 Inventory Allocation Method

Covered under the discussion above (Section A.6.2).

A.6.4 Forecast Method

The Team used growth rates based on NJDEP's State I&F to forecast emissions in the agriculture sector through 2020. As shown in Table A.6-3 below, most of these show contraction in the agricultural industry during this period (based on recent trends in the sector). Longer term estimates for the agricultural sector were not identified, and the team does not feel that it is reasonable to assume that the same level of forecasted negative growth will continue through 2050. Hence, in the post-2020 time-frame, the forecasted emissions were held constant.

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[70] Sam Wood and Annette Cowie (2004), "A Review of Greenhouse Gas Emission Factors for Fertilizer Production", Research and Development Division, State Forests of New South Wales, Cooperative Research Centre for Greenhouse Accounting. The original study was: T.O. West and G. Marland. "A Synthesis of Carbon Sequestration, Carbon Emissions and Net Carbon Flux in Agriculture: Comparing Tillage Practices in the United States." Agriculture, Ecosystems and Environment September 2002:91(1-3):217-232. Available at: http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6T3Y-46MBDPX-10&_user=10&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=4bf71c930423acddffbcef6d46d763c3.

Nonroad sources were forecasted based on the growth factor for crop residues for all fuels except CNG with the assumption that crop residues are a reasonable proxy for crop production and associated fuel use for cultivation. The NONROAD model predicts a sharp decline in CNG consumption for agricultural nonroad engines; therefore, CNG emissions were adjusted to go to zero by 2010, with the equivalent energy going to a new unspecific diesel SCC (2270005098). The nonroad emissions were also adjusted to account for the effects of the National Renewable Fuel Standards (RFS2), as discussed in the section on Transportation – Nonroad Sector emissions.

Table A.6-3. Annual Growth Factors Applied to Agriculture Sector Base Year Emissions

	Annual Growth Rate		
Subsector	**2006-2020**	**2020-2035**	**2035-2050**
Enteric Fermentation	-4.6%	0.0%	0.0%
Manure Management	-4.6%	0.0%	0.0%
Agricultural Burning	-3.5%	0.0%	0.0%
Fertilizer Application	0.9%	0.0%	0.0%
Ag Soils – Crop Residues	-3.5%	0.0%	0.0%
Ag Soils – N-Fixing Crops	-2.4%	0.0%	0.0%
Ag Soils - High Organic Soils (Histosols)	0.0%	0.0%	0.0%
Manure Application- Direct N2O	-4.6%	0.0%	0.0%
Manure Application - Indirect N20	-5.3%	0.0%	0.0%
Ag Nonroad	-3.5%	0.0%	0.0%

A.6.5 Inventory & Forecast Update Methods

Based on the contributions of the agriculture sector to NJTPA regional, county, and MCD emissions, the Team recommends using future updates to the NJDEP state I&F as the basis for updating the inventory and forecast estimates. These will include updated growth factors, as well as potentially updated base year emission estimation methods or activity data. The allocation methods used here and described above could continue to be used until new USDA COA data become available. The 2010 COA data probably won't be available until 2012 or 2013.

For MCD's where agriculture is a more important contributor to total GHG emissions, the Team recommends developing bottom-up estimates using MCD-specific data on livestock populations and manure management systems, crop production and nutrient application, and fuel use data via surveys of producers and county agricultural extension offices. See additional discussion under Section A.6.7 below.

A.6.6 Inventory & Forecast Results

Direct Emissions

Figure A.6-1 and Table A.6-4 provide a summary of the direct 2006 base year and forecast estimates for the agriculture sector in the NJTPA region. These summaries are provided at the subsector level; however, the Excel workbook developed for the project has estimates for each of the source categories listed under Section A.6.1 above. Table A.6-5 shows total county-level CO_2e emissions by subsector. Figure A.6-2 shows the contribution of each GHG to the total agricultural sector CO_2e emissions for 2006.

Figure A.6-1. Agricultural Sector Direct Emissions by Subsector

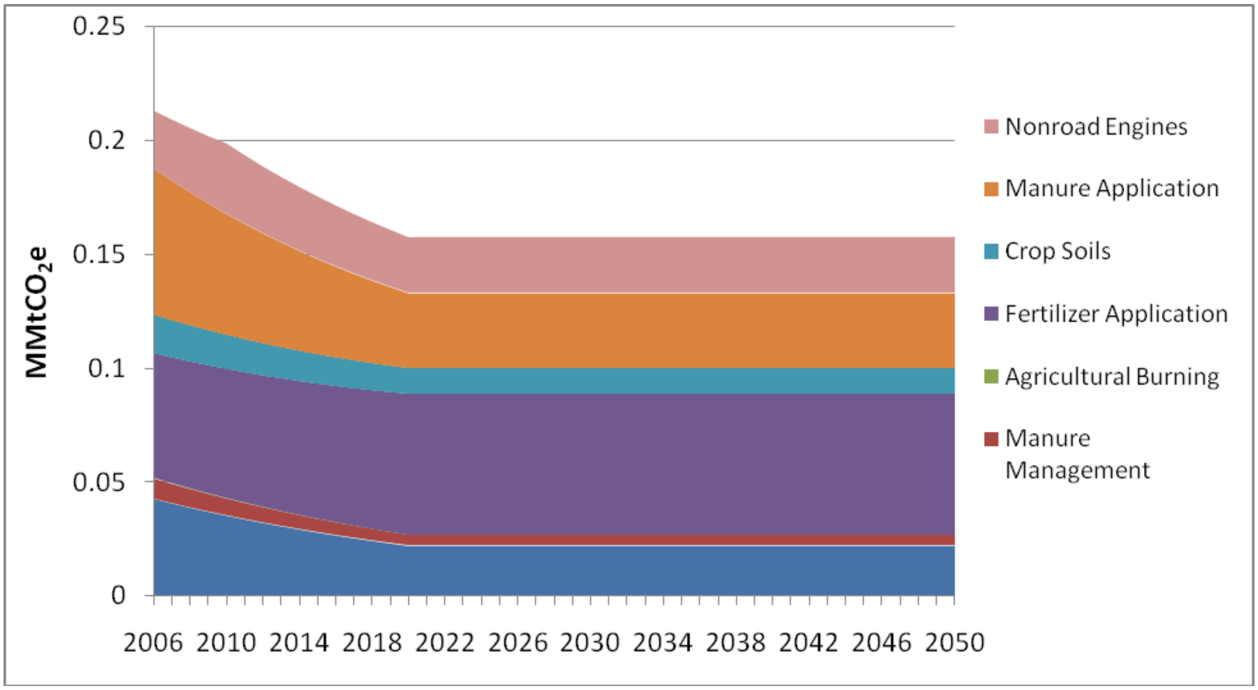


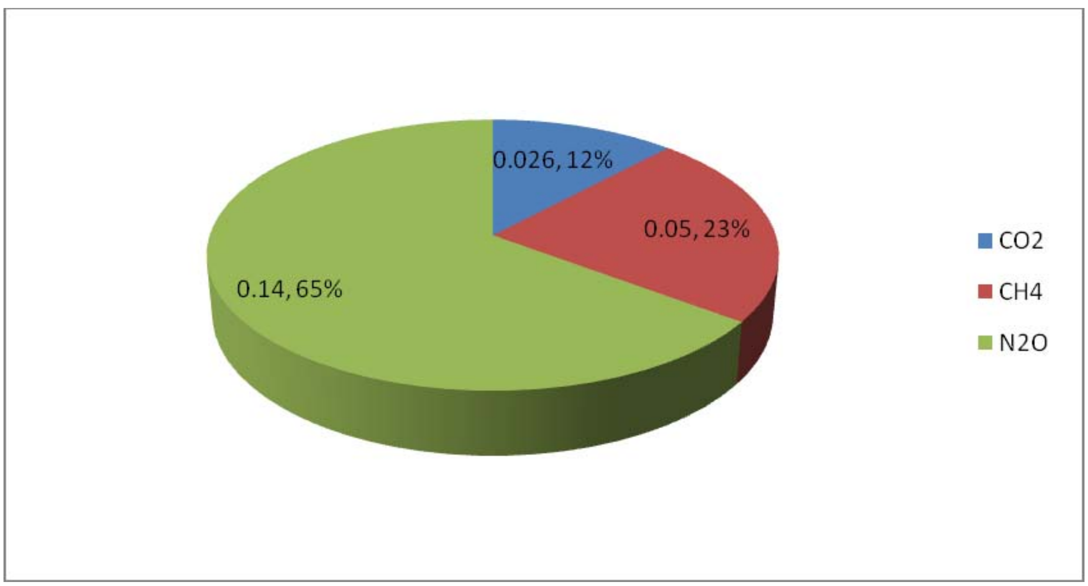
Table A.6-4. Agricultural Sector Direct Emissions by Subsector ($MMtCO_2e$)

Subsector	2006	2010	2015	2020	2030	2040	2050
Enteric Fermentation	0.043	0.036	0.028	0.022	0.022	0.022	0.022
Manure Management	0.009	0.007	0.006	0.005	0.005	0.005	0.005
Agricultural Burning	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Fertilizer Application	0.055	0.057	0.059	0.062	0.062	0.062	0.062
Crop Soils	0.017	0.015	0.013	0.011	0.011	0.011	0.011
Manure Application	0.064	0.053	0.042	0.033	0.033	0.033	0.033
Nonroad Engines	0.025	0.031	0.027	0.024	0.025	0.025	0.025
Total	**0.21**	**0.20**	**0.18**	**0.16**	**0.16**	**0.16**	**0.16**

Table A.6-5. County-level Agricultural Sector Emissions, 2006

County	Direct (tCO_2e)
Bergen	307
Essex	41
Hudson	0
Hunterdon	92,001
Middlesex	12,829
Monmouth	27,281
Morris	7,409
Ocean	3,250
Passaic	928
Somerset	6,776
Sussex	4,487
Union	60
Warren	57,883
Total	**213,251**

Figure A.6-2 Contributions of CO_2, CH_4, and N_2O to Direct 2006 Emissions ($MMtCO_2e$)



Consumption-Based Accounting

As mentioned above, a separate consumption-based accounting for the agriculture sector was beyond the scope of this project.

Energy-Cycle Emissions

As mentioned above, an accounting of energy-cycle emissions was not performed, since a consumption-based inventory was not developed.

A.6.7 Recommendations for Future Improvement

The New Jersey State Department of Agriculture has MCD-level agricultural data based on the New Jersey Division of Taxation's Farmland Assessment.[71] These data include cropland acreage by crop and livestock population by type of animal. The Team became aware of these data after the agriculture inventory had been prepared. Therefore, they are not used in this inventory. However, these data have the potential to be used either as an alternative method for allocation of state-level estimates or as the starting point for developing bottom-up (MCD-level) estimates.

A.7 Land Use, Land Use Change, and Forestry (LULUCF)

A.7.1 Source Description

This sector includes net CO_2 flux from both forested lands and urban forests. Hence, the CO_2 flux in any given area could represent a net source or a net sink, for example due to the amount of clearing and conversion in an area. Also included are emissions of N_2O from non-agricultural fertilizer application (often referred to as emissions associated with "settlement soils").

Direct Emissions

The forestry and land use sector covers a number of GHG sources and sinks, but is primarily devoted to accounting for carbon dioxide sequestration in forested landscapes and urban forests. The current state I&F covers only the forested landscape of New Jersey and estimates that 5.6 $MMtCO_2$ are sequestered every year. These sequestration levels are projected to decline in future years due to losses of forests to development (1.2 percent/yr statewide). Note that CH_4 and N_2O emissions also occur during wildfires or prescribed burns; however, these tend to be ignored, unless the level of wildfire/prescribed burn activity is very large (e.g., some western US states).

Carbon sequestration also occurs in urban forests. Other direct emission sources include long-term carbon sequestration from land-filled food & yard waste[72] and non-farm fertilizer application. Any fuel combustion occurring in this sector (e.g., forest industry) is often captured within the industrial fuel combustion sector; however, for this project, the Team broke out emissions from the use of logging

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[71] New Jersey Department of the Treasury, Division of Taxation, Farmland Assessment, http://www.state.nj.us/treasury/taxation/lpt/farmland.shtml.

[72] Long-term storage of carbon in landfills from forest products (waste paper and wood) are commonly captured within the forest carbon modeling net sequestration totals. For this project, carbon storage in landfills from food and yard waste is addressed within the waste management sector.

equipment from the EPA NONROAD model estimates and added them to this sector (see the Transportation – Nonroad sector section for more details on the EPA NONROAD model data development).

Consumption-Based Emissions

A true consumption-based inventory for the forestry and land use sector was beyond the scope of this project. A consumption-based accounting of the forestry sector should take into account all of the forest products consumed by NJTPA residents and businesses, including wood and paper products. The carbon fluxes associated with the use and disposal of these products would then be modeled. As with the Agricultural sector, there are limited data available on the use and disposal of forest products in the NJTPA region. Because of this and the allocation of resources for the project, this type of modeling was not performed for this study.

For urban forestry, a consumption-based accounting should account in some way for services provided to society of urban trees. In addition, the accounting needs to be done in a way that assists GHG mitigation planners. Hence, while urban trees enhance the aesthetics of an urban area, provide storm water benefits, and other services, it is their ability to reduce building energy consumption through shade and wind protection that is most appropriate for mitigation planning. Therefore, a useful consumption-based inventory would include both the CO_2 emissions from the direct inventory above, along with the associated energy benefits of the urban canopy. This type of an assessment was beyond the resources available to the project.

Energy-Cycle Emissions

With the exception of non-farm fertilizer use and nonroad forestry/logging equipment, there are no other energy-cycle GHG emissions in the forestry and land use sector (i.e., all of the upstream energy use associated with carbon sequestration is renewable solar during photosynthesis). Any forest products industry fuel use is captured in the industrial fuel combustion sector. For non-farm fertilizer use (e.g., lawns, parks, golf courses), there are embedded GHGs associated with the manufacturing and transport of commercial fertilizers, as discussed under the agriculture section above. For nonroad engines, there are upstream GHG emissions associated with fuel extraction, processing and transport.

Source Classification

Table A.7-1 below provides the source classification employed for the forestry and land use sector.

Table A.7-1. Source Categories for the Land Use, Land Use Change & Forestry Sector

Subsector	SCC	SCC Level 1	SCC Level 2	SCC Level 3	SCC Level 4
Direct Emissions					
Forest Land Use Change	2701440000	Natural Sources	Biogenic	Forest Land Use Change	Total
Urban Forest	2701410001	Natural Sources	Biogenic	Urban or Built-Up Land	Carbon Sequestration - Urban Forest

Subsector	SCC	SCC Level 1	SCC Level 2	SCC Level 3	SCC Level 4
Non-farm Fertilizer	2701410002	Natural Sources	Biogenic	Urban or Built-Up Land	Settlement Soils - Fertilizer Usage
Forestry Nonroad Engines Gasoline	2260007005	Mobile Sources	Off-highway Vehicle Gasoline, 2-Stroke	Logging Equipment	Chain Saws > 6 HP
Forestry Nonroad Engines Gasoline	2265007010	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Logging Equipment	Shredders > 6 HP
Forestry Nonroad Engines Gasoline	2265007015	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Logging Equipment	Forest Eqp - Feller/Bunch/Skidder
Forestry Nonroad Engines Gasoline	2270007010	Mobile Sources	Off-highway Vehicle Diesel	Logging Equipment	Shredders > 6 HP
Forestry Nonroad Engines Gasoline	2270007015	Mobile Sources	Off-highway Vehicle Diesel	Logging Equipment	Forest Eqp - Feller/Bunch/Skidder
Consumption-Based Emissions					
Not developed for the Forestry and Land-Use Sector					
Energy-Cycle Emissions					
Same as those listed above for direct emissions. Only applies to Non-farm Fertilizer and Nonroad Engines subsectors.					

A.7.2 General Inventory Approach

Direct Emissions

Forested Landscapes. Here there are two considerations: 1. Forest Carbon Flux, which captures the net annual emission/sequestration of carbon dioxide from the forest land base in an area; and, 2. Emissions/sequestration from Forest Land Use Change, where carbon is either gained or lost depending on whether the forest base is either growing or shrinking. Based on available resources and readily-available data, the Team only developed estimates from Forest Land Use Change.

Additional work should be done in the future to cover the additional carbon flux in forest lands that are not undergoing land use change. Ideally, this would be done by identifying forest carbon density estimates covering at least two periods of time. Combined with forest land use data, the density estimates can be used to determine carbon stocks for each time period and area (e.g., MCD). The net change over time for carbon stocks is then used to calculate CO_2 emission or sequestration. The Team had difficulty in this project identifying carbon density estimates for the region covering more than one period of time.

For this project, the Team developed estimates for Forest Land Use Change using two primary sources of input data:

1. Estimates of forest carbon density for NJTPA at the county-level derived from the US Forest Service (USFS) and National Council for Air and Stream Improvement (NCASI) Carbon On-Line Estimator (COLE);[73] these were based on measurements taken from 2004-2009;
2. Municipal-level estimates of forest acreage and their historical trends available from NJDEP for 1986, 1995, and 2002 (2007 data were not available in time for use in this inventory).

With the above two sources of input data, the Team had carbon density estimates (e.g., metric tons of carbon per hectare of forest) and forested area estimates for the years 1986, 1995 and 2002. Carbon flux due to forest land use change for each municipality was estimated by multiplying the forest area in a given year by the forest carbon density; then the net difference from year to year determined whether there was a net positive or negative flux. This net loss or gain was then multiplied by 3.67 (the ratio of the molecular weight of CO_2 (44) to the molecular weight of carbon (12)) to convert carbon to CO_2.

For nonroad logging equipment, the county-level estimates from the NONROAD model were allocated to the MCD-level using each MCD's fraction of forestry land use.

Urban Forests. The Team developed the urban forest sequestration estimates from the bottom-up using the urban area for each municipality developed above from the NJDEP LULC data (Figure 2.5-3 shows county-level data for urban area growth rates), USFS urban tree canopy cover data,[74] and a region-specific urban forest carbon accumulation rate (0.3 kg C/m^2).[75] Annual sequestration rates are determined by multiplying the municipality's urban area by the percent of canopy cover and then by the carbon sequestration rate.

Emissions of N_2O from non-farm fertilizer application were also estimated. The EPA SIT Land Use, Land Use Change and Forestry module was used to develop a state-level estimate. The state-level estimate was allocated down to each municipality using USFS data on urban area available green space (non-tree canopy green space).

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[73] http://www.nrs.fs.fed.us/carbon/tools/.

[74] New Jersey urban forestry data can be found here: http://www.nrs.fs.fed.us/data/urban/state/?state=NJ.

[75] US Forest Service, Urban and Community Forests of the Mid-Atlantic Region, March 2009, http://nrs.fs.fed.us/pubs/9740.

Another category that tends to be covered in this sector is sequestration via carbon storage of landfilled yard trimmings and food scraps. These are covered within the waste management sector inventory and forecast, as described under Section 3.8.

Consumption-Based & Energy-Cycle Emissions

As described under A.7.1 above, development of a consumption-based inventory for the forestry and land use sector was beyond the scope of this project.

For energy-cycle emissions, the sources to address regarding upstream GHGs are the application of non-farm fertilizers and fuel use in nonroad engines. The Team used the same approach and data sources that were used for on-farm fertilizers to estimate the energy-cycle GHG emissions for non-farm fertilizers (see discussion under the Agriculture sector). The same energy cycle emission factors used for other combustion sources as described under the Transportation Nonroad section were used along with the fuel consumption estimates from EPA's NONROAD model to estimate energy-cycle GHG emissions for nonroad engines.

A.7.3 Inventory Allocation Method

The general inventory methods described above provide municipal-level inventory estimates for the most important sources: forested landscape carbon sequestration; and urban forest sequestration. Therefore, no more allocation was needed for those. Non-farm fertilizer emissions were allocated based on urban land data from the USFS (urban area available green space, which is non-tree canopy green space). For nonroad logging equipment, the county-level estimates from the NONROAD model were allocated to the MCD-level using each MCD's fraction of forestry land use. This simplified allocation method could be improved in the future by gathering geographic information on the location of forest harvests and allocating emissions only to the associated MCD's.

A.7.4 Forecast Method

Forested landscape and urban forestry carbon sequestration/emission estimates were forecasted based on each municipality's observed historic trends of growth/decline in forested landscape or urban area, respectively. A rate of change (growth or reduction) for 1986-2002 in land area for urban areas was used to forecast the urban forest and forested landscape GHG estimates to 2020. Due to concerns that the 1986-2002 growth rates would result in unrealistic estimates when forecasted to 2050 and a lack of other medium to long-term land use forecast data, an assumption of no growth was assumed for the 2021-2050 period. This results in zero emissions/sequestration for forest land use change in the post-2020 period. Also, for forest land use change, in some MCD's very large positive or negative annual growth rates were derived from the 1986-2002 land use data (up to +/- 18%/yr). The Team restricted the growth rates to within the 90^{th} percentile of growth seen across the region in order to minimize the potential for unrealistic forecasts out to 2020. The restricted growth rates kept all growth between -2.5%/yr and +3.4%/yr through 2020.

Note that the forecasting methods are simple in that they do not account for any changes in carbon sequestration rates in the future, which could occur in a changing climate, from changes in harvesting practices, or from increased pests/disease/wildfire activity. In addition, the forecasts are not tied directly with the demographic and economic forecasts used elsewhere in the GHG I&F. This was beyond the scope of this project, but should be considered by the NJTPA in the future (see discussion below).

For non-farm fertilizer application, historic (1990-2006) estimates from the EPA SIT module were linearly projected to 2050 to estimate a growth rate for all MCDs in the region. For nonroad engines, the default growth rates in the NONROAD model, shown in Table 2.5-4, were used. Forecast nonroad engine emissions were also adjusted to account for effects of the National Renewable Fuel Standards (RFS2), which are further described under the Transportation Nonroad section.

Table A.7-2. County-level Growth Rates for Forested Landscapes[a]

County	Annual Growth Rate (2006-2020)
BERGEN	-0.08%
ESSEX	0.45%
HUDSON	-1.23%
HUNTERDON	0.49%
MIDDLESEX	0.10%
MONMOUTH	0.01%
MORRIS	-0.22%
OCEAN	-0.31%
PASSAIC	-0.15%
SOMERSET	0.01%
SUSSEX	0.17%
UNION	0.44%
WARREN	0.23%
NJTPA Region	0.06%

[a] County-level estimates provided for context only; MCD level growth rates were used to forecast emissions/sequestration.

Table A.7-3. County-level Growth Rates for Urban Forestry[a]

County	Annual Growth Rate (2006-2020)
BERGEN	-0.05%
ESSEX	-0.14%
HUDSON	0.10%

HUNTERDON	1.47%
MIDDLESEX	0.78%
MONMOUTH	1.08%
MORRIS	0.56%
OCEAN	1.55%
PASSAIC	0.10%
SOMERSET	1.49%
SUSSEX	1.51%
UNION	-0.09%
WARREN	1.48%
NJTPA Region	0.96%

[a] County-level estimates provided for context only; MCD-level growth rates were used to forecast emissions/sequestration.

Table A.7-4. Growth Rates for Logging Equipment Nonroad Engines [a]

County	County FIPS	MCD	MCD Code	Annual Growth Rate (2006-2020)	Annual Growth Rate (2020-2035)	Annual Growth Rate (2035-2050)
BERGEN	*34003*	*All*	*All*	2.6%	1.9%	1.5%
ESSEX	*34013*	*All*	*All*	2.6%	1.9%	1.5%
HUDSON	*34017*	*All*	*All*	2.6%	1.9%	1.5%
HUNTERDON	*34019*	*All*	*All*	2.6%	1.9%	1.5%
MIDDLESEX	*34023*	*All*	*All*	2.6%	1.9%	1.5%
MONMOUTH	*34025*	*All*	*All*	2.6%	1.9%	1.5%
MORRIS	*34027*	*All*	*All*	2.6%	1.9%	1.5%
OCEAN	*34029*	*All*	*All*	2.6%	1.9%	1.5%
PASSAIC	*34031*	*All*	*All*	2.6%	1.9%	1.5%
SOMERSET	*34035*	*All*	*All*	2.6%	1.9%	1.5%
SUSSEX	*34037*	*All*	*All*	2.6%	1.9%	1.5%
UNION	*34039*	*All*	*All*	2.6%	1.9%	1.5%
WARREN	*34041*	*All*	*All*	2.6%	1.9%	1.5%

[a] Logging nonroad emissions forecasted based on county-level growth rates.

A.7.5 Inventory & Forecast Update Methods

The LULC data used to estimate sequestration/emissions for forestland and urban forestry, are currently updated by the state (historically NJDEP) about every five years. The 2007 data were released in the Summer of 2010; however, not in time for use in this project. During the next update cycle, these data should be used to update the emission estimates and near-term growth factors. The USFS Forest Inventory & Analysis (FIA) data upon which the COLE estimates are derived also get updated; hence, a revision to the carbon density estimates should also be performed approximately every 3 years.

A.7.6 Inventory & Forecast Results

Direct Emissions

See the body of the report for a summary of regional results. Figure 3.7-1 shows results for Hackensack, while Figure 3.7-2 shows results for West Paterson. Both of these are primarily urban areas, so the size of the forest subsector sink is small compared to the urban forest estimate. In both cases, emissions sources were very small relative to the sinks. The forested landscape sector is shown in the figure as the "Forest Land Use Change" subsector (this is equivalent to the "Forests Remaining Forests" in the US National Inventory and the forestry sector of the state inventory).

Consumption-Based Accounting

As mentioned above, consumption based accounting would apply to durable wood products; however, data and resources were not available to estimate emissions for this subsector.

Energy-Cycle Emissions

Since no consumption-based inventory was developed, an accounting of energy-cycle emissions was not performed for this sector.

A.7.7 Recommendations for Future Improvement

Additional work on the forestry sector should include consideration of a change in approach. As described above, ideally the inventory would capture both the sequestration/emission of CO_2 for the forest land base as well as any loss or gain from changes in that land base. This is best done by developing carbon stock estimates for two different periods of time. To accomplish that two defensible estimates of carbon density are needed (one for each time period). Additional discussion with the appropriate USFS or state forestry personnel could prove useful in this regard. In addition, the forecasts for both forestland and urban forestry could be tied more closely with NJTPA's demographic and economic forecasting efforts.

Land use data are updated approximately every five years and should be used to update the inventory. In addition, the forecasts should be refined when any mid- to long-term projections of land use become available. For any counties with a significant forest products industry, an effort should be made to collect data on wood harvest, in order to better allocate nonroad emissions and to develop estimates of carbon stored in durable wood products. In addition, the forecasts for both forestland and urban forestry could be tied more closely with NJTPA's demographic and economic forecasting efforts.

A.8 Solid Waste Management

A.8.1 Source Description

The waste management sector is divided into solid waste management and wastewater treatment. The inventory and forecast methods for the solid waste management sector are documented in this section, while the wastewater sector emissions are documented in Section A.9 of this appendix.

The Team's experience indicates that up to 90 percent of the GHG reduction benefits of mitigation options such as source reduction or recycling can be attributed to upstream GHGs associated with the manufacturing and transport of products and packaging that become components of the waste stream. In particular, for certain components of the waste stream, such as steel and other metals, glass, and cement, a significant amount of energy is used and emissions generated during raw material extraction, processing, and transport. When waste is reduced at the source or recycled, significant GHG reductions are achieved. This is because the energy needed to produce a product or packaging is avoided (source reduction or re-use) or the net energy needed to recycle a product is lower than making it out of raw materials (e.g., recycling an aluminum can).

The nature of GHG emissions is such that the physical location of the emission or the activity which begets the emission does not differentially impact the overall global concentration of GHGs. In a manner of speaking, a ton of CO_2e emitted in New Mexico is the same as a ton emitted in New Jersey. The concept of consumption and energy-cycle emissions accounting is applied to the solid waste management sector by allocating the emissions that result from a given waste management activity to the geographic location of where the waste was generated. Upstream emissions associated with the production and transport of the waste material can also be added in to get a full perspective of the GHG emissions associated with waste generation and management. In contrast, direct emissions from solid waste management only account for the emissions associated with the waste management activity (e.g., landfilling, waste combustion, composting).

Figure A.8-1 portrays a conceptual model of the direct, consumption, and energy-cycle emissions from the solid waste management sector:

- *Energy-Cycle* emissions take place at the most upstream point in the process, resulting from raw materials acquisition, manufacturing process energy and non-energy inputs, and transportation of materials and finished products;[76]

- *Consumption-Based* emissions result from the processes of collecting and transporting the waste (if necessary) and treatment of the waste, regardless of where that treatment takes

[76] The EPA Waste Reduction Model – the source for energy-cycle emission factors – only considers transportation emissions for the transport of raw materials to the manufacturing facility. Therefore, the transportation component of the energy-cycle emissions calculated in this study do not include transportation of material from the manufacturing facility to the retail location, or from the retail location to the point of use and waste generation.

place.[77] For example, if a ton of waste is generated in County X, then County X is responsible for the consumption-based emissions related to the transport and landfilling or composting of its waste; and

- *Direct* emissions are only the emissions that take place within the geographic boundaries of the jurisdiction in question. Therefore, if County X generates a large amount of waste that is disposed of in a landfill that is located in Pennsylvania (because County X does not have an open landfill), then the direct landfill emissions from the landfill disposal of that waste will be zero and the consumption-based emissions will represent the landfill emissions resulting from County X's landfill disposal. As the generator of the waste, County X is also responsible for the energy-cycle emissions related to the landfill disposal of that ton of waste, regardless of where the waste is disposed.

Direct Emissions Accounting

The direct emission sources for the solid waste sector are solid waste landfills, waste combustion, and composting operations. Emissions include: CH_4 from solid waste landfills; CO_2, CH_4 and N_2O from waste combustion;[78] and CH_4 and N_2O from composting operations. Composting operations also represent a carbon sink. The composting process forms stable carbon compounds, such as humic substances or aggregates.[79] Therefore, while composting is listed as a "source" of CO_2 in this report, composting actually creates a net carbon "sink," resulting in negative values for composting CO_2 emissions, even after consideration of the CH_4/N_2O emissions.[80] While it is possible that some of the waste generated in a municipality or county could be recycled within that same municipality/county, the Team has assumed that this does not occur in the NJTPA region; hence, no direct emissions associated with recycling have been developed.[81]

Consumption-Based Accounting

There are consumption-based emissions related to solid waste landfill disposal, composting, waste transportation, and waste combustion.[82] Consumption-based emissions in the solid waste sector

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[77] There are emissions related to all forms of waste management; landfill disposal, composting, and recycling. Emissions from recycling processes, however, are classified as industrial emissions and would be counted within the Residential, Commercial, and Industrial Inventory and Forecast.

[78] Emissions from waste combustion for energy purposes (e.g., waste to energy plants) will be captured in the applicable fuel use sector (e.g., electricity production). Where energy from waste combustion is not captured for use, those emissions would be addressed here (e.g., backyard burn barrels). Note: according to the New Jersey I&F, there is no waste combustion occurring in the state other than waste to energy plants.

[79] USEPA. 2006. "Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks, 3rd Edition." Chapter 4: Composting. Available at: http://epa.gov/climatechange/wycd/waste/SWMGHGreport.html.

[80] See additional discussion below on composting emission factors. It is possible that composting operations with much higher CH_4 or N_2O emissions could significantly impact composting's ability to act as a net negative GHG source.

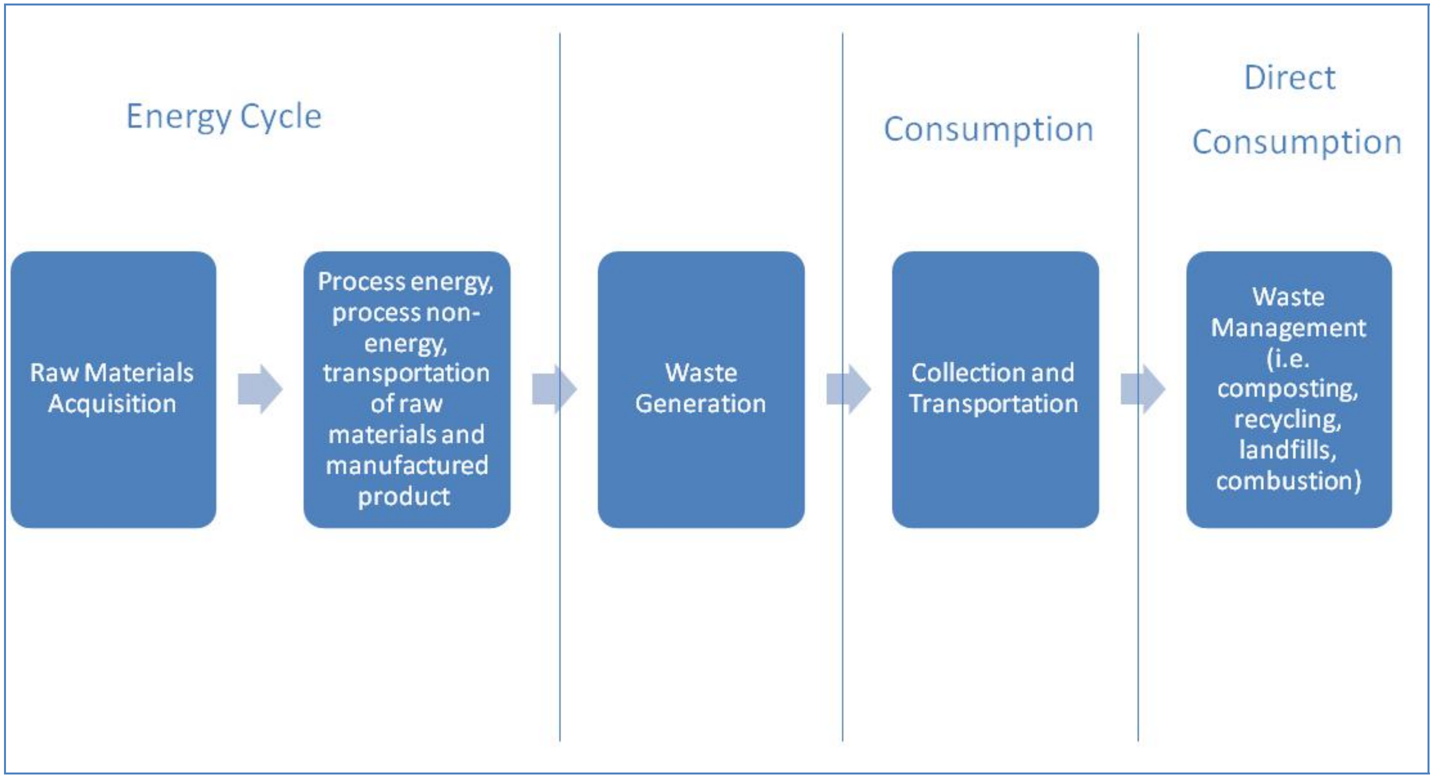
[81] Note that fuel combustion emissions associated with any NJTPA material recovery facilities or industrial processes conducting recycling operations will be captured within the top-down estimates of the RCI sector. Detailed information to allow for its incorporation in this sector (if these emissions occur) was not available for this study.

[82] There are no known waste combustion units that do not utilize the heat for energy. Combustion units that do utilize the heat for energy are included in the Electricity Supply Sector. The waste combustion emissions that are counted in the solid waste subsector inventory and forecast are due to residential open burning.

include: CH_4 from landfill disposal, CO_2e from transportation of waste to landfills, CO_2, CH_4, and N_2O emissions from composting,[83] CO_2e from transportation of waste to composting facilities, CO_2e from transportation of waste to recycling facilities, and CO_2, CH_4, and N_2O from waste combustion (residential open burning). It is assumed that the direct and consumption-based emissions for each jurisdiction are equal for residential open burning.

[83] Composting is a carbon sink. Therefore, the CO_2 emissions from composting are negative.

Figure A.8-1. Conceptual Model of Solid Waste Management Emissions Accounting



Energy-Cycle Emissions

All energy-cycle emissions are expressed in terms of CO_2e. The sources of energy-cycle emissions are landfill disposal, recycling, composting, and waste combustion. The energy-cycle emissions represent the embedded energy in the waste that is managed:

- *Landfill Disposal energy-cycle emissions:* include the embedded energy of the waste disposed at landfills, based on the current mix of recycled and virgin materials that comprise the waste stream;

- *Recycling energy-cycle emissions*: these are based on the embedded energy of the current mix of the waste stream, less the virgin input portion of the embedded emissions due to the fact that the materials that are being recycled will be replacing the necessary extraction of virgin materials. Therefore, the net embedded emissions from recycling are equal to the process energy and non-energy and upstream material transportation emissions that result from the recycling process;

- *Composting energy-cycle emissions:* there are no composting energy-cycle emissions accounted for in this study, as there has been no literature identified by the Team which provides factors for the embedded energy of yard and food waste (e.g., that occurring during lawn/garden maintenance or food production); and

- *Waste Combustion energy-cycle emissions:* the embedded emissions of waste combustion (residential open burning in NJTPA) represent the current input mix of embedded emissions in the portion of the residential waste combusted that is not yard or food waste.

This study does not attempt to assess the downstream GHG benefits that result from landfill gas utilization for energy generation, and the application of compost to soils that increases soil carbon retention and replaces fossil-based fertilizers as soil nutrients. Also, the energy-cycle embedded energy in transportation fuels used to transport raw materials to manufacturing facilities, or to transport the generated waste to the landfill, recycling, or composting site.

Table 3.8-1 below provides the source classification employed for the solid waste sector. New SCCs have been developed to represent the consumption-based and energy-cycle emission sources. The key change to these SCCs is applied at SCC Level 2. As there are no existing SCC level 4 codes to represent MSW recycling, 8-digit SCCs are used for recycling sources.

Table A.8-1. Source Categories for the Solid Waste Sector

Subsector	SCC	SCC Level 1	SCC Level 2	SCC Level 3	SCC Level 4
Direct Emissions					
Open Burning	2610000100	Waste Disposal, Treatment, and Recovery	Open Burning	All Categories	Yard Waste - Leaf Species Unspecified
	2610000400	Waste Disposal, Treatment, and Recovery	Open Burning	All Categories	Yard Waste - Brush Species Unspecified
	2610030000	Waste Disposal, Treatment, and Recovery	Open Burning	Residential	Household Waste
MSW Landfill	2620030000	Waste Disposal, Treatment, and Recovery	Landfills	Municipal	Total
Composting	2680003000	Waste Disposal, Treatment, and Recovery	Composting	100% Green Waste (e.g., residential or municipal yard wastes)	All Processes
Consumption-Based Emissions					
Open Burning	2611000100	Waste Disposal, Treatment, and Recovery	Open Burning - Consumption	All Categories	Yard Waste - Leaf Species Unspecified
	2611000400	Waste Disposal, Treatment, and Recovery	Open Burning - Consumption	All Categories	Yard Waste - Brush Species Unspecified
	2611030000	Waste Disposal, Treatment, and Recovery	Open Burning - Consumption	Residential	Household Waste
MSW Landfill	2621030000	Waste Disposal, Treatment, and Recovery	Landfills - Consumption	Municipal	Total
	2621030000	Waste Disposal, Treatment, and Recovery	Landfills - Consumption	Municipal	Total

Subsector	SCC	SCC Level 1	SCC Level 2	SCC Level 3	SCC Level 4
Recycling	26530000XX	Waste Disposal, Treatment, and Recovery	Scrap and Waste Materials - Transportation	Scrap and Waste Materials	Recycling - MSW
Composting	2681003000	Waste Disposal, Treatment, and Recovery	Composting - Consumption	100% Green Waste (e.g., residential or municipal yard wastes)	All Processes
	2683003000	Waste Disposal, Treatment, and Recovery	Composting - Transportation	100% Green Waste (e.g., residential or municipal yard wastes)	All Processes
			Energy-Cycle Emissions		
Open Burning	2612030000	Waste Disposal, Treatment, and Recovery	Open Burning - Embedded Energy	All Categories	Yard Waste - Brush Species Unspecified
MSW Landfill	2622030000	Waste Disposal, Treatment, and Recovery	Landfills - Embedded Energy	Municipal	Total
Recycling	26520000XX	Waste Disposal, Treatment, and Recovery	Scrap and Waste Materials - Embedded Energy	Scrap and Waste Materials	Recycling - MSW
Composting	2682003000	Waste Disposal, Treatment, and Recovery	Composting - Embedded energy	100% Green Waste (e.g., residential or municipal yard wastes)	All Processes

A.8.2 General Inventory Approach

Direct Emissions

MSW Landfills. NJDEP provided a list of the mid-size and large landfills in New Jersey, including the estimated CH_4 emissions, as predicted by the first-order decay (FOD) equation. The FOD equation is a universally-accepted method for predicting CH_4 emissions from the anaerobic decomposition of organic matter. For landfills with landfill gas (LFG) collection, a collection efficiency of 75 percent is assumed, which is a standard assumption used by the US EPA. The assumed oxidation rate of CH_4 in surface soils is 10 percent (also a standard EPA assumption).

It is also known that there are over 300 small landfills in New Jersey. However, there is very little information available on these landfills and no information available on the web for these facilities. All of these landfills are closed and waste emplacement data are nonexistent for many. Based on the NJ DEP estimated emissions from the small landfills, they represent less than 5 percent of all landfill emissions in New Jersey. Additionally, considering that these are old landfills that are no longer accepting waste, LFG emissions at these landfills will continue to decrease throughout the forecast period. Hence, emissions from these sites have not been included in this study.

Composting. NJDEP provided the Team with a list of composting facilities in New Jersey, including the location of each facility and the type of feedstock composted. The amount of feedstock was multiplied by the emission factors for CO_2, CH_4, and N_2O to yield the emission estimates for each facility. The CO_2 emission factor is -0.169 tCO_2 per ton of compost feedstock.[84] The CH_4 emission factor is 7.89×10^{-4} tCH_4 per ton of compost feedstock.[85] The N_2O emission factor is 4.74×10^{-5} tN_2O per ton of compost feedstock.[86]

Waste Combustion. Waste combustion emissions accounted for in the solid waste sector result from residential open burning.[87] The quantity of waste burned is based on a per-capita burning rate for brush waste, leaf waste, and MSW biomass and the 2006 population for each county. The per-capita open burning rates are county-specific, as reported by an open burning study completed for the Mid-Atlantic / Northeast Visibility Union.[88] The CO_2 emissions from leaf and brush open burning are assumed to be biogenic and thus not counted in the inventory estimates. The CO_2 emission factor for household waste open burning is dependent on the fraction of paper and cardboard waste to clothing, carpet and other waste that could be burned (the latter materials having fossil based carbon). The emission factor is calculated for each county based on 2006 IPCC guidance and represents the non-biogenic component of household waste (i.e., the coating on cereal boxes, or synthetic portions of clothing).[89]

The CH_4 emission factor for leaf and brush waste is 5.44×10^{-3} tCH_4 per ton of waste burned.[90] The CH_4 emission factor for household waste is 5.90×10^{-3} tCH_4 per ton of waste burned.[91] The N_2O emission

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[84] USEPA. 2006. "Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks, 3rd Edition." Chapter 4: Composting. Available at: http://epa.gov/climatechange/wycd/waste/SWMGHGreport.html.

[85] Roe *et al.* 2004. "Estimating Ammonia Emissions from Anthropogenic Nonagricultural Sources." Available at: http://www.epa.gov/ttnchie1/eiip/techreport/volume03/eiip_areasourcesnh3.pdf.

[86] UNFCCC. 2005. "Approved Baseline Methodology AM0025; Avoided emissions from organic waste composting at landfill sites." Available at: http://cdm.unfccc.int/EB/021/eb21repan15.pdf.

[87] The Team discussed the inclusion of residential open burning emissions with NJ DEP. While open burning emissions are not included in the statewide GHG inventory and extensive burning bans across the state, NJ DEP stated that it may be possible for some burning to occur in more rural areas.

[88] E.H. Pechan and Associates. 2004. "Open Burning in Residential Areas, Emission Inventory Development Report." Available at: http://www.marama.org/visibility/OpenBurn/OB_FnlReport_Jan31_04.pdf.

[89] 2006 IPCC Guidelines for National GHG Inventories Volume 5, Chapters 2 and 5. Available at: http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html.

[90] EPA WebFIRE database. Available at: http://cfpub.epa.gov/webfire/index.cfm?action=fire.main&CFID=9769977&CFTOKEN=96275224&jsessionid=5a303f44554a4cd7a39c3d213b736716172d.

factor for leaf and brush waste is 9.07 x 10^{-5} tN_2O per ton of waste burned.[92] The N_2O emission factor for household waste is 3.99 x 10^{-5} tN_2O per ton of waste burned.[93]

Consumption-Based & Energy-Cycle Emissions

In order to prepare the base-year inventory and reference case projection for the solid waste sector consumption-based and energy-cycle emissions, it was necessary to complete a historical and projected municipal solid waste (MSW) management profile. The profile uses existing data as a basis to identify the amount of waste generated, landfilled, combusted, recycled, and composted in each year from 1990 through 2050. The forecast waste management profile is based on the average annual growth in per-capita waste generation from 1995 to 2006 and the most recent rates of landfill disposal, combustion, recycling, and composting.

The Team sent a survey to each county waste management director in order to improve data already available on the NJDEP Recycling Statistics page.[94] The counties were asked to supply the amount of waste generated that was disposed of in-county and exported outside the county to landfills and/or waste combustion units, the amount of waste collected that was eventually recycled and composted, and the composition of waste generated, disposed, or diverted within the county. The counties were asked to supply data for each year available, but were informed that 2006 was the most vital year for this project. The counties which provided data were Hudson, Middlesex, Morris, Monmouth, Ocean, Somerset, and Warren. For all other counties, the NJDEP data for waste disposed and diverted were used to create the waste management profile. For these counties, it was assumed that if there is an active landfill in a given county, that the county disposes all waste in-county. For counties without a landfill, it was assumed that all waste is exported for landfill emplacement. The composition of materials recycled in New Jersey for 2006 was used to determine the fraction of diversion that is recycled and the fraction that is composted, with the exception of those counties that provided diversion composition data.[95]

Consumption-Based Accounting - MSW Landfills. The annual estimates for waste generated within a county that was disposed at landfills in the years 1990 to 2050 – regardless of the geographic location of those landfills – was entered into the EPA LandGEM model, which applies the FOD equation.[96] The 75 percent collection efficiency and 10 percent oxidation factors were applied to the CH_4 emissions predicted by LandGEM. It is reasonable to assume that all of the landfills that receive waste from New Jersey counties practice LFG collection.[97]

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[91] EPA AP-42 Guidance. Section 2.5: Open Burning. Available at: http://www.epa.gov/ttnchie1/ap42/ch02/final/c02s05.pdf.

[92] USEPA. 2006. "Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks, 3rd Edition." Available at: http://epa.gov/climatechange/wycd/waste/SWMGHGreport.html.

[93] Ibid.

[94] http://www.state.nj.us/dep/dshw/recycling/stats.htm.

[95] The counties that provided diversion composition data were Hudson, Middlesex, Monmouth, and Warren.

[96] EPA Landfill Gas Emissions Model (LandGEM) Manual: http://www.epa.gov/ttn/catc/dir1/landgem-v302-guide.pdf.

[97] According to NJDEP data, all landfills in NJ that are still open practice LFG collection. It is reasonable to assume that the large out-of-state landfills accepting waste from NJ do the same. Also, from previous work completed by Pechan, it is known that

The Team used Morris County as the example for emissions due to out-of-county landfill disposal. Morris County provided the Team with the amounts of waste disposed at landfills in Pennsylvania. The distances were calculated using Google Maps and a weighted average ton-miles distance was calculated. WARM provides an emission factor for tCO_2e per ton-mile, which was multiplied by the weighted average from Morris County (average ton-miles per ton of waste). The resulting emissions factor is 9.28 x 10^{-3} tCO_2e per ton of waste transported. This was the emission factor used for exported waste in each county.[98] The WARM default assumption (based on 20 ton-miles) is used as the emission factor for transportation to in-county landfills (2.81 x 10^{-3} tCO_2e per ton of waste transported).

Recycling. The amount of waste recycled in each year that was predicted in the waste management profile for each county was multiplied by the default emission factor from WARM for waste transportation; 2.81 x 10^{-3} tCO_2e per ton of waste transported.

Composting. The same emission factors for CO_2, CH_4, and N_2O applied in the Direct Emissions analysis were applied for the consumption-based accounting. However, the consumption-based accounting practice multiplies the tons of compost feedstock generated in each county (as predicted by the waste management profile), regardless of where the feedstock is actually composted.

To estimate emissions from transportation of compost feedstock, the amount of waste composted in each year that was predicted in the waste management profile for each county was multiplied by the default emission factor from WARM for waste transportation; 2.81 x 10^{-3} tCO_2e per ton of waste transported.

Waste Combustion. The method for calculating waste combustion emissions, for which the sole source is residential open burning, is the same as for the direct emissions inventory.

Energy-Cycle Emissions

MSW Landfills. The emission factor for the emissions resulting from the embedded energy contained within landfilled waste is dependent on the waste composition data provided. For some counties, waste composition data were provided.[99] For the others, the New Jersey statewide composition data were used. The current mix (U.S. average mix of virgin and recycled materials in each material waste stream) embedded energy emission factors from WARM, which are based on process energy, non-energy process emissions, and emissions from the transportation of raw materials and manufactured goods, are applied to the relevant composition of waste generated in the county that is disposed in landfills. The

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most landfills in PA accepting waste from out-of-state practice LFG collection. Based on this experience, the Team felt that it is reasonable to assume that all landfills accepting waste generated in New Jersey practice LFG collection.

[98] While this assumption may be overstating the transportation emissions for exported waste generated in counties closer to PA and understating the transportation emissions for exported waste that is shipped further away, calculating precise emissions from the transportation of exported waste for each county or MCD would be more time consuming that this project allows. Also, it is expected that the difference in emissions for each county using more precise county or MCD level export transportation emission factors would be minimal.

[99] Counties providing composition data are Hudson, Middlesex, Monmouth, Ocean, and Warren.

quantity of waste disposed is based on predictions from the waste management profile (see Appendix B).

Recycling. The emission factor for the embedded emissions within materials that are recycled is also drawn from WARM. The quantity of waste recycled is based on predictions from the waste management profile (see Appendix B). The embedded emissions are based on the embedded energy and non-energy emissions within materials that are made from 100 percent recycled inputs. This assumption was made in order to show the benefit of returning a 100 percent recycled material to the market, as opposed to a material composed of the current mix of recycled and virgin inputs. In the cases where the counties provided recycling composition data, these data were used to generate the per-ton energy-cycle emission factor. In cases where county-specific recycling composition data were not available, the New Jersey statewide composition data were used.

Table A.8-2. Energy-cycle emissions factors from WARM[100]

MSW Category	Virgin Input (tCE/ton)	Recycled Input (tCE/ton)	Percent Recycled Inputs	Current Mix (tCE/ton)
Aluminum Containers	4.27	0.30	51%	2.25
Brush/Tree Parts				
Corrugated	0.23	0.25	35%	0.24
Food Waste				
Glass Containers	0.18	0.09	23%	0.14
Grass Clippings				
Leaves				
Mixed Office Paper	0.28	0.37	4%	0.32
Newspaper	0.58	0.34	23%	0.48
Other Paper/Mag/JunkMail	0.46	0.46	4%	0.46
Other Plastic	0.59	0.05	6%	0.37
Plastic Containers	0.54	0.05	10%	0.34
Steel Containers	1.01	0.51	28%	0.81
Textiles	1.09	1.09	0%	-
Other/Mixed	0.92	0.35	18%	0.69

Composting. While it is believed that food and yard waste do retain embedded energy (such as energy to remove yard waste or process food that results in residuals), there are no sufficient studies available to the Team at the time of this report's publication. Therefore, the energy-cycle emissions attributed to composting are zero. Note that the down-stream emissions associated with fuel combustion at composting facilities, as well as for landfill operations equipment, are captured in the top-down industrial fuel combustion emission estimates (however, they cannot be broken out separately based on available data).

[100] Results converted to tCO_2e based on conversion factor of 44 tCO_2e / 12 tCe.

Waste Combustion. The team applied the available waste composition data (disposal composition from either county data or New Jersey statewide composition) to the portion of the residential open burning waste stream that is classified as MSW. The energy-cycle emission factors used for residential open burning are based on the "current mix" factors from WARM. The current mix factors are based on the average share of materials inputs between recycled and virgin inputs. The current mix embedded emission factors from WARM were applied only to the MSW portion of the residential open burning stream to estimate embedded emissions from waste that is combusted.

A.8.3 Inventory Allocation Method

Direct Emissions

The direct emissions were allocated based on where the emissions take place. MSW landfill and composting emissions were allocated by the physical location of each facility. Waste combustion emissions (residential open burning) were allocated based on each MCD's share of the total county population.

Consumption-based Accounting

The consumption-based emissions (for all sources) are generally allocated based on each MCD's share of the total county population. The only exceptions are in cases where the county provided the amount of waste collected, disposed, and/or recycled for each MCD.[101] In those cases, the emissions were allocated based on each MCD's share of the county's total waste collected, disposed, and/or recycled. However, the waste combustion emissions are always allocated according to population.

Energy-cycle Emissions

Energy-cycle emissions were allocated in the same manner as the consumption-based accounting emissions.

A.8.4 Forecast Method

Direct Emissions

The forecast MSW landfill emissions are based on the application of the FOD equation to the waste emplacement data for each landfill provided by NJDEP. This method assumes constant annual waste disposal at open landfills until the year they are anticipated to close. The composting emissions forecast is based on the average annual growth in waste composted between 2000 and 2006 in the state of New Jersey. This growth rate is 1.47% and is applied for each composting facility through 2050. The waste combustion (residential open burning) emissions are based on population growth projections through 2050 for each MCD.

[101] Counties providing composition data are Hudson, Middlesex, Monmouth, Ocean, and Warren.

Consumption-based Accounting

The forecast for consumption-based emissions resulting from landfill disposal, recycling, and composting are based on the waste management profile. The projections within the profile were based on each county's average annual per-capita generation growth rate for 1995-2006. A key assumption is that the disposal, recycling, and composting rates for the most recent data year available were applied throughout the forecast period (i.e., meaning no change in solid waste management under business as usual conditions through 2050). The waste combustion (residential open burning) emissions were based on population growth projections through 2050 for each MCD.

Energy-cycle Emissions

Energy-cycle emissions were forecasted in the same manner as the consumption-based accounting emissions.

A.8.5 Inventory & Forecast Update Methods

Based on the contributions of the solid waste sector to NJTPA regional, county, and MCD emissions, the Team recommends using future data updates from NJDEP as the basis for updating the direct inventory and forecast estimates. These updates could include updated waste emplacement rates at NJ landfills, composting activity data, open burning activity data, and possibly information on emerging waste management methods (e.g., other organics management, such as anaerobic digestion). Updates to the landfill emplacement data would require re-running the FOD equation to update the current and future year methane emissions.

For consumption-based emissions, the completion of a waste management profile at the most detailed level possible will allow local, county, and state waste management planners to gauge the impact of their waste diversion strategies, potentially increasing the cost-effectiveness of their diversion efforts, as they relate to GHG mitigation. The county-level waste management profiles developed in this project could be updated in the future to drive revised emission estimates; however, for some of the larger NJTPA MCD's a more refined MCD-specific waste management profile would provide more accurate estimates for that MC. As mentioned above, other important refinements and updates should include refining the BAU assumptions in each county's waste management profile as to the amounts of waste landfilled, recycled, composted, open burned, or managed in another way. The current estimates assume no change from current practice.

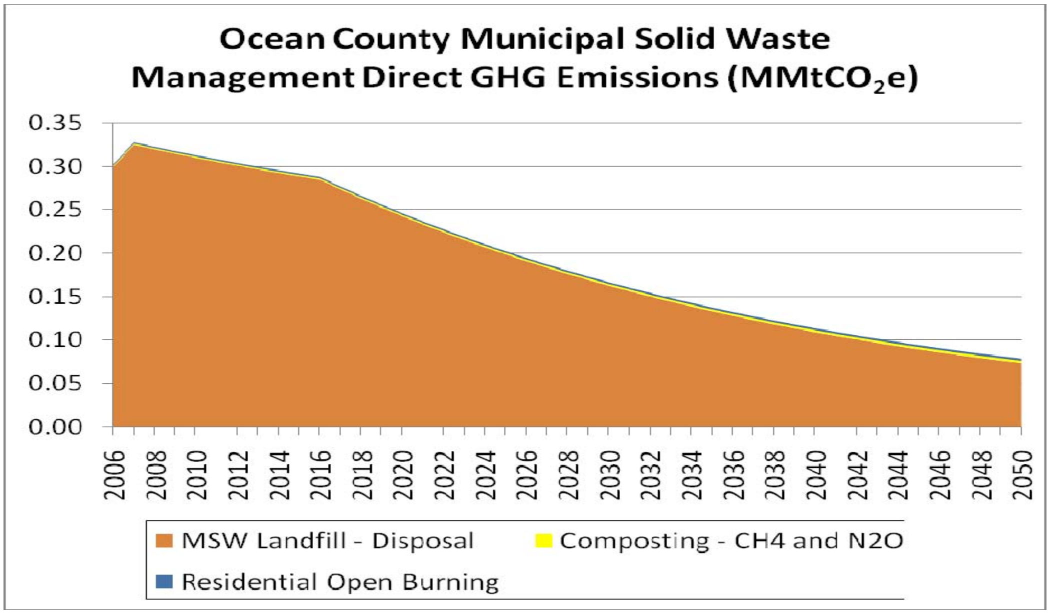
Especially important is the projection of the energy-cycle emissions inventory and forecast on a statewide scale, as the direct emissions from the solid waste sector are minimal compared to the energy-cycle emissions. Future updates to these estimates should be based on the updated consumption-based inventory and forecast described above. Updates to EPA's WARM model should be incorporated into the energy-cycle emission factors developed for this project.

A.8.6 Inventory & Forecast Results

Direct Emissions

Section 3.8 of the report provides NJTPA region results for direct emissions. Figure A.8-2 below provides a sample of sub-regional data for Ocean County. This is standard GHG accounting which captures emissions associated with a single closed landfill (with declining emissions over the forecast period), and small contributions from composting and open burning.

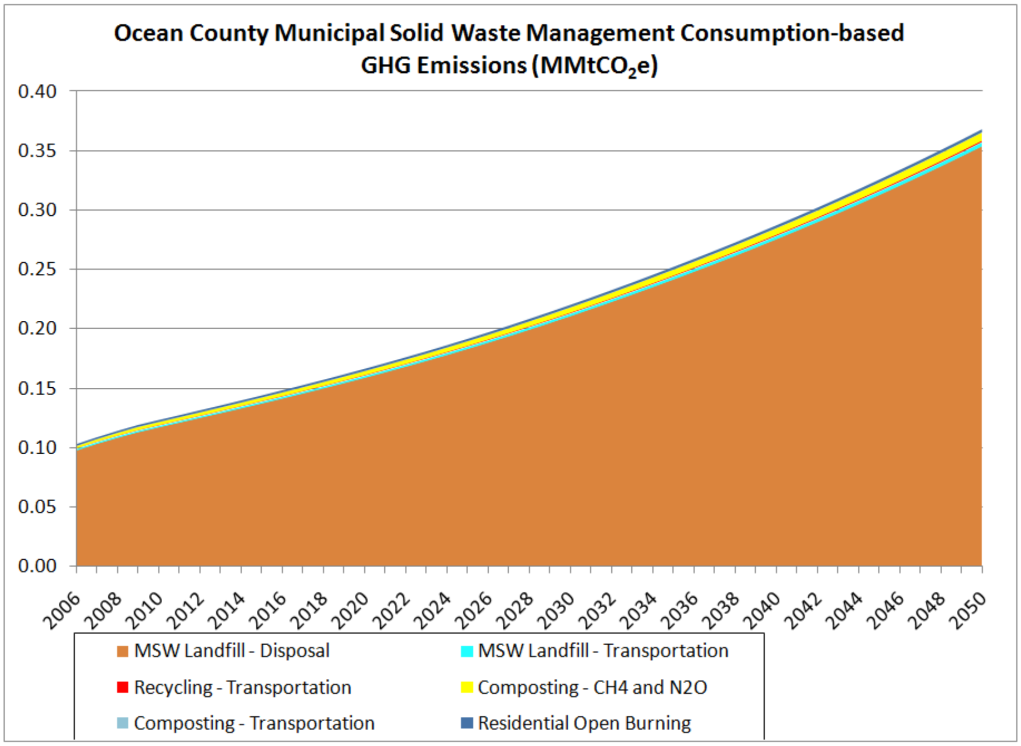
Figure A.8-2. Sample Direct Inventory & Forecast for MSW Management



Consumption-Based Accounting

Figure A.8-3 provides an example of consumption-based MSW management GHG accounting for Ocean County. On a consumption basis, the emissions forecast looks quite different than the direct forecast above. The emissions here are actually increasing over the forecast period because all emissions for solid waste management, regardless of where they occur, are captured (much of the waste generated in Ocean County is exported outside the county for disposal).

Figure A.8-3. Sample Consumption-Based Inventory & Forecast for MSW Management



Energy-Cycle Emissions

Figure 3.8-4 below provides a summary of energy-cycle GHG estimates for MSW management in Ocean County. The emissions associated with the embedded energy of the waste generated are shown. These represent order of magnitude increases over either the direct or consumption-based estimates alone.

Figure A.8-4. Sample Energy-Cycle Inventory & Forecast for MSW Management

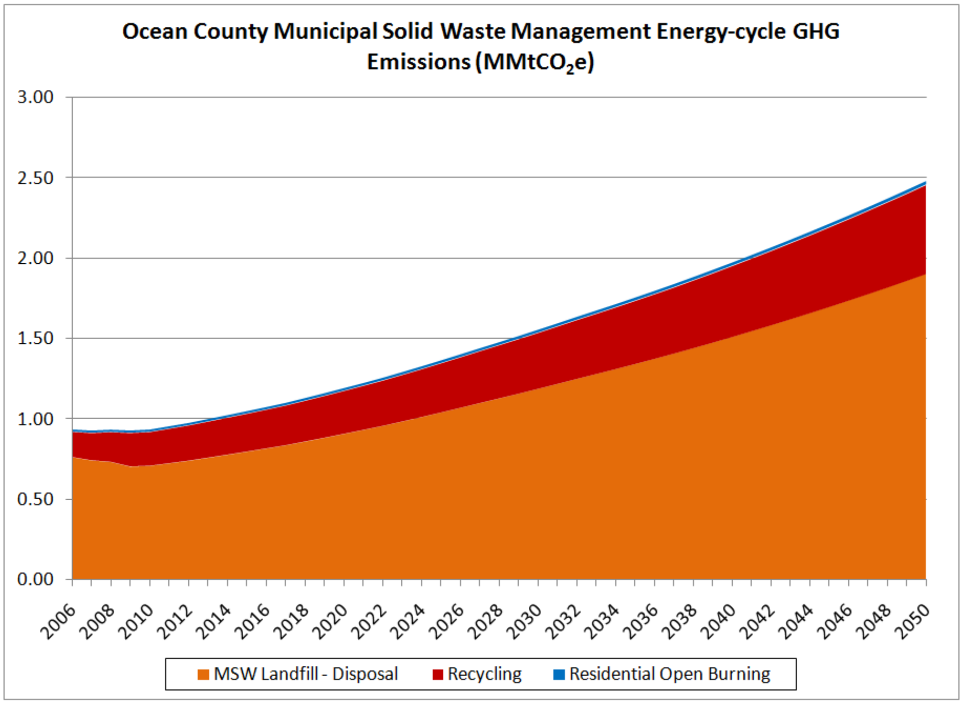
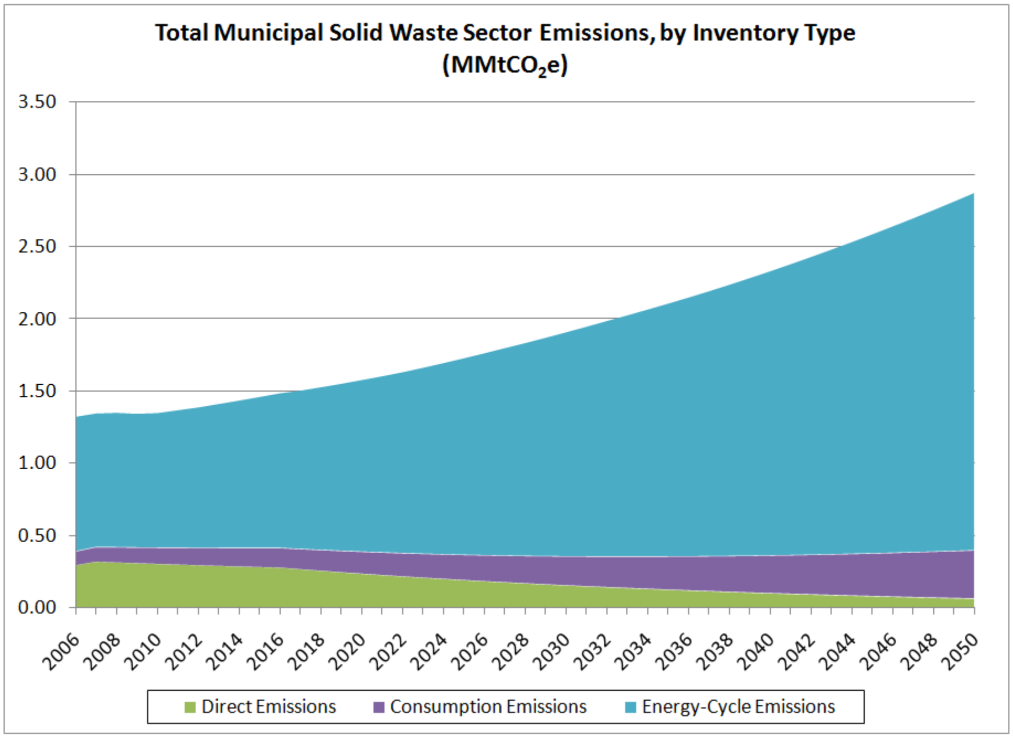


Figure A.8-5 shows all three accounting methods on a single chart. The upshot is that source reduction and recycling programs can have substantial GHG benefits (at relatively low cost); however, emission reductions largely occur outside of the generating jurisdiction. However, if emissions only within the geographic boundaries of the jurisdiction are considered (i.e., standard direct emissions accounting), then these alternative waste management strategies seem unimportant.

Figure A.8-5 Comparison of Direct, Consumption-Based, and Energy-Cycle Emissions for MSW Management



3.8.7 Recommendations for Future Improvement

There are several recommendations to this work that could not be addressed during this project due to time and resource constraints. Additionally, further research may need to be completed on the energy-cycle impact of several materials. The following is a list of recommendations for future improvement to this study (see also Section 3.8.5 above):

- Continue to work with county and municipal waste management experts to attain specific waste disposal, export, recycling, composting, combustion, and composition data for each area that is able to provide such information.

- Identify one or more studies that address the embedded emissions associated with yard and food waste. Additionally, account for the fuel combustion emissions during waste management (e.g., nonroad engine emissions) at landfills, material recovery facilities, and compost facilities.

- This study does not include analysis of construction and demolition (C&D) debris to the extent that it is managed outside of existing MSW landfills. Some of this debris, such as cement, can be very emissions-intensive, and recycling these wastes can lead to significant energy-cycle GHG emission reductions. Also, the landfills studied within the MSW landfill direct inventory and forecast only include MSW. Other waste types, such as industrial and C&D waste, may release CH_4 emissions. However, much of this waste is not biodegradable and will not release CH_4

emissions.[102] An in-depth analysis into the quantity and composition of waste managed at sites other than MSW landfills would be an improvement to this study.

- The allocation of residential open burning emissions from the county level to the MCD level is based on the population of each MCD in proportion to the total county population. The data source used to develop the throughput for the residential open burning emissions calculations was from a study that assessed open burning emissions at the county level. The study assumed differential open burning throughput based on the proportion of each county that is rural or urban. By allocating emissions to the MCD level based on population, the Team is not accounting for the land use classification of each MCD. Further studies should consider the open burning emissions based on local knowledge if available, or MCD level land use classification, if necessary.

- When biomass residuals are disposed at landfill sites, some of the carbon is permanently (or semi-permanently) stored. Some inventories have accounted for the carbon storage impact of landfills, but the Team elected not to include landfill carbon sinks in this inventory.

- The transportation emissions estimation included in this study are not comprehensive. The energy-cycle transportation emissions (i.e. transportation emissions embedded within waste disposed or diverted) do not include the embedded energy from the fuels combusted, the emissions from transportation of goods from the manufacturer to the retail location, or the emissions from transportation of goods from the retail location to the point of use and waste generation.

[102] NJ DEP confirmed that data for industrial and C&D landfills is not widely available. For its statewide inventory, NJ DEP assumed that the industrial landfill emissions were equal to 7% of the MSW landfill emissions. Since this 7% cannot be broken down to the MCD level, industrial landfill emissions are not included in this study. NJ DEP also believes that emissions from C&D landfills are minimal.

A.9 Wastewater Treatment

A.9.1 Source Description

Direct Emissions

Direct emissions from the wastewater treatment (WWT) sector include CH_4 and N_2O emissions from municipal and industrial wastewater treatment facilities. These are process emissions only. Any fuel combustion-related emissions in the WWT sector are included within the industrial/commercial fuel combustion sector totals.

The N_20 emissions include both those that occur on-site as well as "indirect N_2O" emissions that occur downstream in the receiving waters of the plant. For simplicity, as well as accurate source attribution, all emissions are assigned to the actual WWT plant.

Consumption-Based Emissions

Total regional consumption-based emissions from the wastewater sector do not differ from direct emissions; however, the geographic allocation differs between direct and consumption-based accounting. Direct emissions are associated with the location of wastewater treatment plants, while consumption-based emissions should be associated with the residential and non-residential generators of wastewater.

Energy-Cycle Emissions

Energy-cycle emissions from wastewater treatment include the emissions associated with the electricity usage at wastewater treatment plants, as well as the upstream potable water system. Additional fuel combustion emissions could also occur at these plants (e.g. emergency generators); however, these are likely to be small in comparison to the emissions from the process and electricity consumption.

A separate estimate of energy-cycle emissions was developed for this project due to its importance in subsequent GHG mitigation planning; however, these emissions will overlap with electricity consumption emissions for the commercial/industrial sectors. The emission estimates presented here for WWT energy-cycle emissions were modeled using methods described below, while those for commercial/industrial consumption are based on the actual electricity usage reported by NJTPA utilities (however, details aren't available in the utility data to break-out WWT electricity consumption from the rest of the commercial/industrial sectors). Therefore, the user of the estimates presented here needs to understand that these energy-cycle estimates overlap and adjustments will be needed when they are used along with those from the broader commercial/industrial sectors.

Table A.9-1. Source Categories for the Wastewater Treatment Sector

Subsector	SCC	SCC Level 1	SCC Level 2	SCC Level 3	SCC Level 4
Direct Emissions					
Wastewater Treatment	2630020000	Waste Disposal, Treatment, and Recovery	Wastewater Treatment	Public Owned	Total Processed

Subsector	SCC	SCC Level 1	SCC Level 2	SCC Level 3	SCC Level 4
Wastewater Treatment	2630020005	Waste Disposal, Treatment, and Recovery	Wastewater Treatment	Public Owned	Total Processed - Indirect N2O Emissions
Consumption-Based Emissions					
Same as those listed above for direct emissions.					
Energy-Cycle Emissions					
Wastewater Treatment	2630020098	Waste Disposal, Treatment, and Recovery	Wastewater Treatment	Public Owned	Energy-Cycle, electricity consumed during WWT
Wastewater Treatment	2630020099	Waste Disposal, Treatment, and Recovery	Wastewater Treatment	Public Owned	Energy-Cycle, electricity consumed during upstream potable water treatment

A.9.2 General Inventory Approach

Direct Emissions

For municipal WWT, the Team used the population-based methods from the state I&F and recommended by EPA in the draft Regional Guidance to estimate emissions. As with the state I&F, emissions from industrial wastewater treatment were not estimated due to the lack of data for this sub-sector and its likely small contribution to regional GHG emissions.

County-level emissions were developed by applying CH_4 and N_2O emission factors, shown in Table A.9-2, to the population for each county. The county emissions were then allocated to each municipality with one or more WWT plants based on the average daily volume treated provided by NJDEP.[103]

[103] M. Aucott, NJDEP, personal communication with S. Roe, E.H. Pechan & Associates, March, 2010

Table A.9-2. Emission Factors for the Wastewater Treatment Sector

Direct and Consumption				
SCC	**SCC Description**	**GHG**	**Value**	**Units**
2630020000	Wastewater Treatment, Public Owned, Total Processed	CH4	3.20	kg/capita-yr
2630020000	Wastewater Treatment, Public Owned, Total Processed	N2O	0.0036	kg/capita-yr
2630020005	Wastewater Treatment, Public Owned, Total Processed - Indirect N2O Emissions	N2O	0.078	kg/capita-yr
Energy-cycle				
2630020098	Electricity consumed during WWT	CO_2e	0.87	tCO_2e/million gallons
2630020099	Electricity consumed during upstream potable water treatment	CO_2e	0.49	tCO_2e/million gallons

Consumption-Based & Energy-Cycle Emissions

Consumption-Based Accounting

MCD-level consumption-based emissions were estimated by applying CH_4 and N_2O emissions factors to MCD-level population data.[104]

Energy-Cycle Emissions

Energy-cycle GHG estimates were developed by applying emission factors for the electricity consumption associated with treatment of wastewater and potable water to county-level water treatment plant flow rates provided by NJDEP. The emissions were allocated to MCDs based on population.

The emission factors were based on estimates of electricity consumed in WWT in a study conducted for the New York State Energy Development Authority (NYSERDA) for WWT in that state.[105] The state-wide average of 1,480 kWh/MG treated was used. The electricity consumption estimate was then combined with the consumption-based emission factor for electricity use from EPA's eGRID2007 (RFCE subregion = 0.5529 tCO_2e/MWh), which includes grid losses. The upstream energy-cycle emissions associated with fuels used to generate the electricity were also added (0.0349 tCO_2e/MWh). The resulting emission factors are shown in Table A.9-2 above.

Only wastewater flow rates were available, therefore the flow of potable water was assumed to equal the flow of wastewater. This is likely an underestimate, since some of the wastewater generated will be lost via leaks before it gets to the WWT plant. Also, there will be other uses of potable water, such as

[104] From NJTPA demographic projections.

[105] *Statewide Assessment of Energy Use by the Municipal Water and Wastewater Sector*, Final Report, prepared by Malcolm Pirnie for the NY State Energy Research and Development Authority, November 2008. NYSERDA Report 08-17.

landscape irrigation that are not handled by the municipal WWT system. On the other hand, some volume of the wastewater will be made up of solid or liquid wastes added to the wastewater by the generator. The Team was unable to find information that would allow for a netting out of these effects to better estimate the initial potable water use. However, additional research could potentially find these data from the region's potable water suppliers.

A.9.3 Inventory Allocation Method

Covered under the discussion above (Section A.9.2).

A.9.4 Forecast Method

Direct emission associated with WWT plants were forecasted based on county-level population growth, shown in Table A.9-3. Consumption and energy-cycle emissions estimated at the MCD level were projected based on MCD-level population growth.

Table A.9-3. Annual Growth Factors Applied to Wastewater Treatment Base Year Emissions

	Annual Population Growth Rate		
County	**2006-2020**	**2020-2035**	**2035-2050**
Bergen	0.34%	0.57%	0.53%
Essex	0.47%	0.44%	0.32%
Hudson	1.14%	0.54%	0.47%
Hunterdon	0.49%	0.42%	0.16%
Middlesex	0.87%	0.69%	0.60%
Monmouth	0.47%	0.27%	0.15%
Morris	0.15%	0.34%	0.00%
Ocean	1.06%	1.18%	0.93%
Passaic	0.68%	0.72%	0.49%
Somerset	0.66%	0.40%	0.24%
Sussex	1.11%	0.64%	0.72%
Union	0.64%	0.47%	0.30%

Warren	0.94%	0.38%	0.15%

A.9.5 Inventory & Forecast Update Methods

Based on the contributions of the wastewater treatment sector to NJTPA regional, county, and MCD emissions, the Team recommends using future updates to the NJDEP state I&F as the basis for updating the inventory and forecast estimates. These will potentially include updated base year emission estimation methods or activity data. It is possible that NJDEP will gather more plant-specific emissions data in the future that would allow for more refined estimates to be made than those made here using standard EPA emission factors.

For the energy-cycle estimates, the modeling methods employed here can continue to be used and emissions updated using updated WWT throughput values from NJDEP. The most recent eGRID emission factors or, even better, MCD-specific factors to achieve better consistency with the electricity consumption sector of the inventory. Further improvement of these estimates probably won't be possible unless a specific study of electricity consumption for NJTPA WWTPs and potable water treatment is developed or more refined data are provided from the relevant NJTPA utilities (i.e., those providing data on electricity consumption by WWT plants).

A.9.6 Inventory & Forecast Results

Direct Emissions

See the body of the report for a chart of the direct GHG inventory and forecast. The table below shows total CO_2e emissions for the inventory and forecast years for the wastewater treatment sector in the NJTPA region. As mentioned above, these estimates only cover municipal WWT, since data for industrial WWT were not readily available. The results include all of the direct emissions source categories listed under Section A.9.1 above.

Table A.9-4. Direct Emissions for the WWT Sector

Geographic Area	**tCO_2e /yr**			
	2006	**2020**	**2035**	**2050**
NJTPA Region Totals	604,741	662,966	722,180	771,127

Consumption-Based Accounting

The NJTPA regional and county-level consumption-based emissions for the WWT sector are the same as those for direct (only difference is in allocation of emissions to each MCD). The table below provides a summary comparison the direct, consumption-based, and energy-cycle emissions for select MCDs. These comparisons show Newark, which has a WWTP and therefore both direct and consumption-based emissions and Ocean Township, a municipality that does not have a WWTP. Hence, for Ocean Township the direct emissions are zero; however, on a consumption-basis with capture of the energy-cycle GHG, the emissions are 1,093 tCO_2e/yr in 2006 and 1,609 tCO_2e/yr in 2020.

Table A.9-5. Comparison of WWT Estimates Based on Accounting Method

County	Municipality	Sectorname	Method	GHG	2006 (t/yr)	2006 (tCO2e/yr)	2020 (tCO2e/yr)
ESSEX	Newark	Municipal WWT	Direct	CH4	2,432	51,080	54,546
ESSEX	Newark	Municipal WWT	Direct	N2O	62	19,301	20,611
			Direct	**Total**		**70,381**	**75,157**
ESSEX	Newark	Municipal WWT	Consumption	CH4	892	18,737	20,085
ESSEX	Newark	Municipal WWT	Consumption	N2O	23	7,080	7,589
			Consumption	**Total**		**25,817**	**27,674**
ESSEX	Newark	Municipal WWT	Energy-cycle	CO2e		51,617	55,330
ESSEX	Newark	Municipal WWT	**Consumption + Energy-cycle**	**Total**		**77,433**	**83,005**
OCEAN	Ocean Twn.	Municipal WWT	Direct	CH4	0.00	0.00	0.00
OCEAN	Ocean Twn.	Municipal WWT	Direct	N2O	0.00	0.00	0.00
			Direct	**Total**	**0.00**	**0.00**	**0.00**
OCEAN	Ocean Twn.	Municipal WWT	Consumption	CH4	25.8	542	798.2
OCEAN	Ocean Twn.	Municipal WWT	Consumption	N2O	0.66	205	301.60
			Consumption	**Total**		**747**	**1,100**
OCEAN	Ocean Twn.	Municipal WWT	Energy-cycle	CO2e		346	510
OCEAN	Ocean Twn.	Municipal WWT	**Consumption + Energy-cycle**	**Total**		**1,093**	**1,609**

Energy-Cycle Emissions

The energy-cycle emissions estimate for the NJTPA region is 402,123 tCO_2e in 2006. This compares to 604,741 tCO_2e in 2006 from WWTP processes (either on a direct or consumption-based accounting approach). See the table above for a comparison of energy-cycle emissions for two select municipalities.

A.9.7 Recommendations for Future Improvement

As mentioned above, the direct and consumption-based process emissions for CH_4 and N_2O could be improved in the future if NJDEP continues to gather plant-specific emission rates. The energy-cycle estimates could also be improved with plant-specific estimates of energy consumption. These initial estimates only capture electricity consumption, however, some smaller uses of fossil fuels could also be present at these facilities. Also, the upstream emissions associated with the production and transport of any chemical additions to wastewater or potable water treatment has not been included. Finally, the forecasted emissions associated with electricity consumption have not been adjusted to account for any anticipated changes in the carbon intensity of future electrical power in the NJTPA region.

Appendix B. County-level Solid Waste Management Profiles

Bergen County Waste Management Profile Summary

Waste Management Profile (tons)	1990	2000	2010	2020	2035	2050
Population	827,000	884,118	905,158	932,394	1,012,994	1,097,288
MSW Generation	884,487	1,040,859	1,227,491	1,497,951	2,098,513	2,931,108
MSW Generation per Capita	1.07	1.18	1.36	1.61	2.07	2.67
County MSW Disposed at Landfills	366,359	538,697	723,928	883,554	1,237,996	1,729,398
MSW Landfill Disposal at County Landfills	0	0	0	0	0	0
MSW Disposal Export to Landfills	366,359	538,697	723,928	883,554	1,237,996	1,729,398
County MSW Combusted	576	616	631	650	706	765
MSW Combustion Disposal - Waste-to-Energy (WTE)	0	0	0	0	0	0
MSW Disposal - Residential Open Burning	576	616	631	650	706	765
County MSW Recycling	359,006	347,903	348,865	425,733	596,418	833,050
County MSW Composting	158,546	153,643	154,067	188,014	263,393	367,895
Assumptions for Waste Management Profile Model	2008-2020	2021-2035	2036-2050			
Assumed growth rate of per-capita generation:	1.7%	1.7%	1.7%			
Proportion of Landfilled MSW Exported	100.0%	100.0%	100.0%			
Assumed Recycling Rate	28.4%	28.4%	28.4%			
Assumed Composting Rate	12.6%	12.6%	12.6%			

Essex County Waste Management Profile Summary

Waste Management Profile (tons)	1990	2000	2010	2020	2035	2050
Population	773,400	793,633	799,551	833,039	894,085	938,540
MSW Generation	641,598	837,772	993,557	1,400,341	2,364,718	3,905,579
MSW Generation per Capita	0.83	1.06	1.24	1.68	2.64	4.16
County MSW Disposed at Landfills	413,726	484,195	630,210	888,380	1,500,443	2,478,410
MSW Landfill Disposal at County Landfills	0	0	0	0	0	0
MSW Disposal Export to Landfills	413,726	484,195	630,210	888,380	1,500,443	2,478,410
County MSW Combusted	392	402	405	422	453	475
MSW Combustion Disposal - Waste-to-Energy (WTE)	0	0	0	0	0	0
MSW Disposal - Residential Open Burning	392	402	405	422	453	475
County MSW Recycling	157,795	244,984	251,760	354,835	599,201	989,643
County MSW Composting	69,686	108,191	111,183	156,704	264,622	437,050
Assumptions for Waste Management Profile Model	2008-2020	2021-2035	2036-2050			
Assumed growth rate of per-capita generation:	3.1%	3.1%	3.1%			
Proportion of Landfilled MSW Exported	100.0%	100.0%	100.0%			
Assumed Recycling Rate	25.3%	25.3%	25.3%			
Assumed Composting Rate	11.2%	11.2%	11.2%			

Hudson County Waste Management Profile Summary

Waste Management Profile (tons)	1990	2000	2010	2020	2035	2050
Population	553,400	608,975	641,178	710,063	772,963	830,537
MSW Generation	449,402	550,643	591,179	714,795	887,687	1,088,120
MSW Generation per Capita	0.81	0.90	0.92	1.01	1.15	1.31
County MSW Disposed at Landfills	297,999	388,095	408,760	494,233	613,776	752,362
MSW Landfill Disposal at County Landfills	0	0	0	0	0	0
MSW Disposal Export to Landfills	297,999	388,095	408,760	494,233	613,776	752,362
County MSW Combusted	0	0	0	0	0	0
MSW Combustion Disposal - Waste-to-Energy (WTE)	0	0	0	0	0	0
MSW Disposal - Residential Open Burning	0	0	0	0	0	0
County MSW Recycling	143,688	143,578	173,187	209,401	260,050	318,768
County MSW Composting	7,715	18,970	9,231	11,161	13,861	16,990
Assumptions for Waste Management Profile Model	2008-2020	2021-2035	2036-2050			
Assumed growth rate of per-capita generation:	0.9%	0.9%	0.9%			
Proportion of Landfilled MSW Exported	100.0%	100.0%	100.0%			
Assumed Recycling Rate	29.3%	29.3%	29.3%			
Assumed Composting Rate	1.6%	1.6%	1.6%			

Hunterdon County Waste Management Profile Summary

Waste Management Profile (tons)	1990	2000	2010	2020	2035	2050
Population	108,500	121,989	131,531	137,481	147,313	150,841
MSW Generation	100,826	112,152	113,908	113,704	113,707	108,661
MSW Generation per Capita	0.93	0.92	0.87	0.83	0.77	0.72
County MSW Disposed at Landfills	73,627	86,914	79,141	78,727	78,295	74,378
MSW Landfill Disposal at County Landfills	0	0	0	0	0	0
MSW Disposal Export to Landfills	73,627	86,914	79,141	78,727	78,295	74,378
County MSW Combusted	4,781	5,375	5,795	6,058	6,491	6,646
MSW Combustion Disposal - Waste-to-Energy (WTE)	0	0	0	0	0	0
MSW Disposal - Residential Open Burning	4,781	5,375	5,795	6,058	6,491	6,646
County MSW Recycling	15,551	13,778	20,097	20,060	20,061	19,171
County MSW Composting	6,868	6,085	8,875	8,859	8,859	8,466
Assumptions for Waste Management Profile Model	2008-2020	2021-2035	2036-2050			
Assumed growth rate of per-capita generation:	-0.5%	-0.5%	-0.5%			
Proportion of Landfilled MSW Exported	100.0%	100.0%	100.0%			
Assumed Recycling Rate	17.6%	17.6%	17.6%			
Assumed Composting Rate	7.8%	7.8%	7.8%			

Middlesex County Waste Management Profile Summary

Waste Management Profile (tons)	1990	2000	2010	2020	2035	2050
Population	674,400	750,162	805,612	877,545	977,404	1,070,311
MSW Generation	693,455	846,272	1,033,863	1,318,252	1,859,478	2,578,785
MSW Generation per Capita	1.03	1.13	1.28	1.50	1.90	2.41
County MSW Disposed at Landfills	374,087	506,007	654,607	835,152	1,178,870	1,635,809
MSW Landfill Disposal at County Landfills	374,087	506,007	654,607	835,152	1,178,870	1,635,809
MSW Disposal Export to Landfills	0	0	0	0	0	0
County MSW Combusted	2,161	2,404	2,582	2,812	3,132	3,430
MSW Combustion Disposal - Waste-to-Energy (WTE)	0	0	0	0	0	0
MSW Disposal - Residential Open Burning	2,161	2,404	2,582	2,812	3,132	3,430
County MSW Recycling	228,530	243,409	271,372	346,020	488,083	676,889
County MSW Composting	88,678	94,452	105,302	134,268	189,394	262,657
Assumptions for Waste Management Profile Model	2008-2020	2021-2035	2036-2050			
Assumed growth rate of per-capita generation:	1.6%	1.6%	1.6%			
Proportion of Landfilled MSW Exported	0.0%	0.0%	0.0%			
Assumed Recycling Rate	26.2%	26.2%	26.2%			
Assumed Composting Rate	10.2%	10.2%	10.2%			

Monmouth County Waste Management Profile Summary

Waste Management Profile (tons)	1990	2000	2010	2020	2035	2050
Population	558,000	615,301	651,484	683,180	715,936	731,989
MSW Generation	482,515	701,120	946,194	1,480,164	2,826,154	5,264,697
MSW Generation per Capita	0.86	1.14	1.45	2.17	3.95	7.19
County MSW Disposed at Landfills	286,179	420,189	603,768	947,852	1,815,661	3,388,313
MSW Landfill Disposal at County Landfills	286,179	420,189	552,694	867,671	1,662,071	3,101,689
MSW Disposal Export to Landfills	0	0	51,074	80,181	153,590	286,624
County MSW Combusted	5,575	6,147	6,508	6,825	7,152	7,313
MSW Combustion Disposal - Waste-to-Energy (WTE)	0	0	0	0	0	0
MSW Disposal - Residential Open Burning	5,575	6,147	6,508	6,825	7,152	7,313
County MSW Recycling	85,387	105,640	168,666	263,850	503,782	938,470
County MSW Composting	105,374	169,144	167,252	261,637	499,558	930,601
Assumptions for Waste Management Profile Model	2008-2020	2021-2035	2036-2050			
Assumed growth rate of per-capita generation:	4.1%	4.1%	4.1%			
Proportion of Landfilled MSW Exported	8.5%	8.5%	8.5%			
Assumed Recycling Rate	17.8%	17.8%	17.8%			
Assumed Composting Rate	17.7%	17.7%	17.7%			

Morris County Waste Management Profile Summary

Waste Management Profile (tons)	1990	2000	2010	2020	2035	2050
Population	421,330	470,212	489,486	497,384	523,011	523,527
MSW Generation	420,309	576,089	747,654	1,046,717	1,779,973	2,881,423
MSW Generation per Capita	1.00	1.23	1.53	2.10	3.40	5.50
County MSW Disposed at Landfills	273,445	294,123	292,064	411,760	705,141	1,146,419
MSW Landfill Disposal at County Landfills	0	0	0	0	0	0
MSW Disposal Export to Landfills	273,445	294,123	292,064	411,760	705,141	1,146,419
County MSW Combusted	6,435	7,182	7,476	7,597	7,988	7,996
MSW Combustion Disposal - Waste-to-Energy (WTE)	0	0	0	0	0	0
MSW Disposal - Residential Open Burning	6,435	7,182	7,476	7,597	7,988	7,996
County MSW Recycling	76,143	148,992	242,974	340,163	578,458	936,409
County MSW Composting	64,286	125,792	205,140	287,196	488,385	790,599
Assumptions for Waste Management Profile Model	2008-2020	2021-2035	2036-2050			
Assumed growth rate of per-capita generation:	3.3%	3.3%	3.3%			
Proportion of Landfilled MSW Exported	100.0%	100.0%	100.0%			
Assumed Recycling Rate	32.5%	32.5%	32.5%			
Assumed Composting Rate	27.4%	27.4%	27.4%			

Ocean County Waste Management Profile Summary

Waste Management Profile (tons)	1990	2000	2010	2020	2035	2050
Population	438,300	510,916	570,572	634,749	761,527	876,434
MSW Generation	435,806	576,078	688,682	878,353	1,293,574	1,827,527
MSW Generation per Capita	0.99	1.13	1.21	1.38	1.70	2.09
County MSW Disposed at Landfills	277,463	381,255	405,629	519,202	768,107	1,089,147
MSW Landfill Disposal at County Landfills	277,463	381,255	393,366	503,506	744,886	1,056,221
MSW Disposal Export to Landfills	0	0	12,263	15,696	23,221	32,926
County MSW Combusted	8,761	10,213	11,406	12,688	15,223	17,520
MSW Combustion Disposal - Waste-to-Energy (WTE)	0	0	0	0	0	0
MSW Disposal - Residential Open Burning	8,761	10,213	11,406	12,688	15,223	17,520
County MSW Recycling	103,759	128,057	188,432	240,328	353,937	500,033
County MSW Composting	45,822	56,553	83,216	106,135	156,307	220,827
Assumptions for Waste Management Profile Model	2008-2020	2021-2035	2036-2050			
Assumed growth rate of per-capita generation:	1.4%	1.4%	1.4%			
Proportion of Landfilled MSW Exported	3.0%	3.0%	3.0%			
Assumed Recycling Rate	27.4%	27.4%	27.4%			
Assumed Composting Rate	12.1%	12.1%	12.1%			

Passaic County Waste Management Profile Summary

Waste Management Profile (tons)	1990	2000	2010	2020	2035	2050
Population	453,200	489,049	504,992	537,861	603,077	649,363
MSW Generation	452,528	532,958	673,370	884,355	1,357,720	2,001,732
MSW Generation per Capita	1.00	1.09	1.33	1.64	2.25	3.08
County MSW Disposed at Landfills	231,518	307,403	563,055	740,292	1,137,995	1,679,346
MSW Landfill Disposal at County Landfills	0	0	0	0	0	0
MSW Disposal Export to Landfills	231,518	307,403	563,055	740,292	1,137,995	1,679,346
County MSW Combusted	2,952	3,185	3,289	3,503	3,928	4,229
MSW Combustion Disposal - Waste-to-Energy (WTE)	0	0	0	0	0	0
MSW Disposal - Residential Open Burning	2,952	3,185	3,289	3,503	3,928	4,229
County MSW Recycling	151,259	154,250	74,240	97,501	149,690	220,693
County MSW Composting	66,800	68,120	32,786	43,059	66,107	97,464
Assumptions for Waste Management Profile Model	2008-2020	2021-2035	2036-2050			
Assumed growth rate of per-capita generation:	2.1%	2.1%	2.1%			
Proportion of Landfilled MSW Exported	100.0%	100.0%	100.0%			
Assumed Recycling Rate	11.0%	11.0%	11.0%			
Assumed Composting Rate	4.9%	4.9%	4.9%			

Somerset County Waste Management Profile Summary

Waste Management Profile (tons)	1990	2000	2010	2020	2035	2050
Population	244,200	297,490	322,094	344,420	369,405	382,832
MSW Generation	215,723	312,799	426,038	616,069	1,039,103	1,693,473
MSW Generation per Capita	0.88	1.05	1.32	1.79	2.81	4.42
County MSW Disposed at Landfills	55,213	150,604	291,713	424,683	721,271	1,180,642
MSW Landfill Disposal at County Landfills	0	0	0	0	0	0
MSW Disposal Export to Landfills	55,213	150,604	291,713	424,683	721,271	1,180,642
County MSW Combusted	78,542	79,795	7,574	8,098	8,686	9,002
MSW Combustion Disposal - Waste-to-Energy (WTE)	0	0	0	0	0	0
MSW Disposal - Residential Open Burning	5,742	6,995	7,574	8,098	8,686	9,002
County MSW Recycling	41,038	41,253	63,458	91,763	154,774	252,242
County MSW Composting	40,931	41,147	63,294	91,525	154,373	251,588
Assumptions for Waste Management Profile Model	2008-2020	2021-2035	2036-2050			
Assumed growth rate of per-capita generation:	3.1%	3.1%	3.1%			
Proportion of Landfilled MSW Exported	100.0%	100.0%	100.0%			
Assumed Recycling Rate	14.9%	14.9%	14.9%			
Assumed Composting Rate	14.9%	14.9%	14.9%			

Sussex County Waste Management Profile Summary

Waste Management Profile (tons)	1990	2000	2010	2020	2035	2050
Population	132,500	144,166	157,480	175,284	194,227	215,860
MSW Generation	89,699	115,583	143,216	197,480	301,723	462,370
MSW Generation per Capita	0.68	0.80	0.91	1.13	1.55	2.14
County MSW Disposed at Landfills	53,192	80,279	79,199	111,002	172,753	268,240
MSW Landfill Disposal at County Landfills	53,192	80,279	79,199	111,002	172,753	268,240
MSW Disposal Export to Landfills	0	0	0	0	0	0
County MSW Combusted	5,684	6,184	6,755	7,519	8,331	9,259
MSW Combustion Disposal - Waste-to-Energy (WTE)	0	0	0	0	0	0
MSW Disposal - Residential Open Burning	5,684	6,184	6,755	7,519	8,331	9,259
County MSW Recycling	21,381	20,199	39,721	54,771	83,682	128,237
County MSW Composting	9,442	8,921	17,542	24,188	36,956	56,633
Assumptions for Waste Management Profile Model	2008-2020	2021-2035	2036-2050			
Assumed growth rate of per-capita generation:	2.2%	2.2%	2.2%			
Proportion of Landfilled MSW Exported	0.0%	0.0%	0.0%			
Assumed Recycling Rate	27.7%	27.7%	27.7%			
Assumed Composting Rate	12.2%	12.2%	12.2%			

Union County Waste Management Profile Summary

Waste Management Profile (tons)	1990	2000	2010	2020	2035	2050
Population	492,500	522,541	536,239	569,791	617,563	645,924
MSW Generation	450,677	518,569	597,756	730,083	975,158	1,256,933
MSW Generation per Capita	0.92	0.99	1.11	1.28	1.58	1.95
County MSW Disposed at Landfills	275,762	368,350	443,710	541,936	723,853	933,012
MSW Landfill Disposal at County Landfills	0	0	0	0	0	0
MSW Disposal Export to Landfills	275,762	368,350	443,710	541,936	723,853	933,012
County MSW Combusted	0	0	0	0	0	0
MSW Combustion Disposal - Waste-to-Energy (WTE)	0	0	0	0	0	0
MSW Disposal - Residential Open Burning	0	0	0	0	0	0
County MSW Recycling	121,332	104,201	106,856	130,511	174,321	224,691
County MSW Composting	53,583	46,018	47,190	57,637	76,984	99,229
Assumptions for Waste Management Profile Model	2008-2020	2021-2035	2036-2050			
Assumed growth rate of per-capita generation:	1.4%	1.4%	1.4%			
Proportion of Landfilled MSW Exported	100.0%	100.0%	100.0%			
Assumed Recycling Rate	17.9%	17.9%	17.9%			
Assumed Composting Rate	7.9%	7.9%	7.9%			

Warren County Waste Management Profile Summary

Waste Management Profile (tons)	1990	2000	2010	2020	2035	2050
Population	92,600	102,437	115,297	125,490	133,891	136,862
MSW Generation	65,175	93,292	105,012	137,534	193,695	261,348
MSW Generation per Capita	0.70	0.91	0.91	1.10	1.45	1.91
County MSW Disposed at Landfills	5,629	20,490	19,589	42,957	83,666	132,983
MSW Landfill Disposal at County Landfills	717	1,686	12,992	28,490	55,489	88,197
MSW Disposal Export to Landfills	4,912	18,804	6,597	14,467	28,177	44,786
County MSW Combusted	44,269	55,968	57,140	57,535	57,861	57,976
MSW Combustion Disposal - Waste-to-Energy (WTE)	40,678	51,996	52,669	52,669	52,669	52,669
MSW Disposal - Residential Open Burning	3,591	3,972	4,471	4,866	5,192	5,307
County MSW Recycling	10,597	13,681	22,986	30,104	42,397	57,205
County MSW Composting	4,680	3,153	5,297	6,938	9,771	13,184
Assumptions for Waste Management Profile Model	2008-2020	2021-2035	2036-2050			
Assumed growth rate of per-capita generation:	1.9%	1.9%	1.9%			
Proportion of Landfilled MSW Exported	33.7%	33.7%	33.7%			
Assumed Recycling Rate	21.9%	21.9%	21.9%			
Assumed Composting Rate	5.0%	5.0%	5.0%			