Oregon's Greenhouse Gas Emissions: 1990 - 2016

Prepared for the Oregon Office of Carbon Policy

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Executive Summary

Increasing atmospheric concentration of greenhouse gases caused by emissions from human activities is leading to global climate change[1]. To understand Oregon's contribution to climate change we must understand the contributions of Oregon and Oregonians to global emissions of greenhouse gases. This report includes greenhouse gas emissions data compiled by the Oregon Department of Environmental Quality and a discussion of the key drivers and recent trends in these data.

The report discusses the sector-based inventory, which is the traditional method for tracking Oregon's emissions, and is similar to the methods many other states and countries use. The sector-based inventory includes emissions produced in Oregon from its transportation, residential, commercial, industrial and agriculture sectors, including electricity produced elsewhere but used in state. The data in this report includes emissions from 1990 through 2015, with preliminary 2016 data.

Sector-based inventory

Figure ES.1 portrays Oregon's sector-based emissions from 1990 through 2015 and preliminary 2016 emissions data. The graph illustrates trends in emissions in this period within key sectors, including emissions from the generation of electricity used in Oregon, regardless of where that electricity was generated. For example, a portion of electricity used in Oregon is generated at coal and natural gas facilities located outside of the state. Emissions from the generation of that electricity are included in this inventory.

In 2015, sector-based emissions were 63 million metric tons of carbon dioxide equivalent ($MTCO_2e$). Statewide emissions declined from 2007 through 2012 but recent data do not indicate a continuation of that downward trend. Transportation continues to be Oregon's largest in-state contributor to emissions and accounted for 36 percent of the sector-based total in 2015. In fact, transportation emissions have risen during each of the past three years. The second largest contributor is electricity, with the residential sector creating the greatest demand for electricity. Emissions from electricity use in any given year reflect both the impact associated with the demand for electricity and the influence of the availability of hydroelectricity, Oregon's largest source of zero-emitting energy.

Key Findings

Results from Oregon's latest sector-based greenhouse gas inventory indicates that Oregon's contribution to global concentrations of greenhouse gases is not subsiding. The combustion of fossil fuels, whether occurring within Oregon or as a result of our electricity use, is the key driver of greenhouse gas emissions.

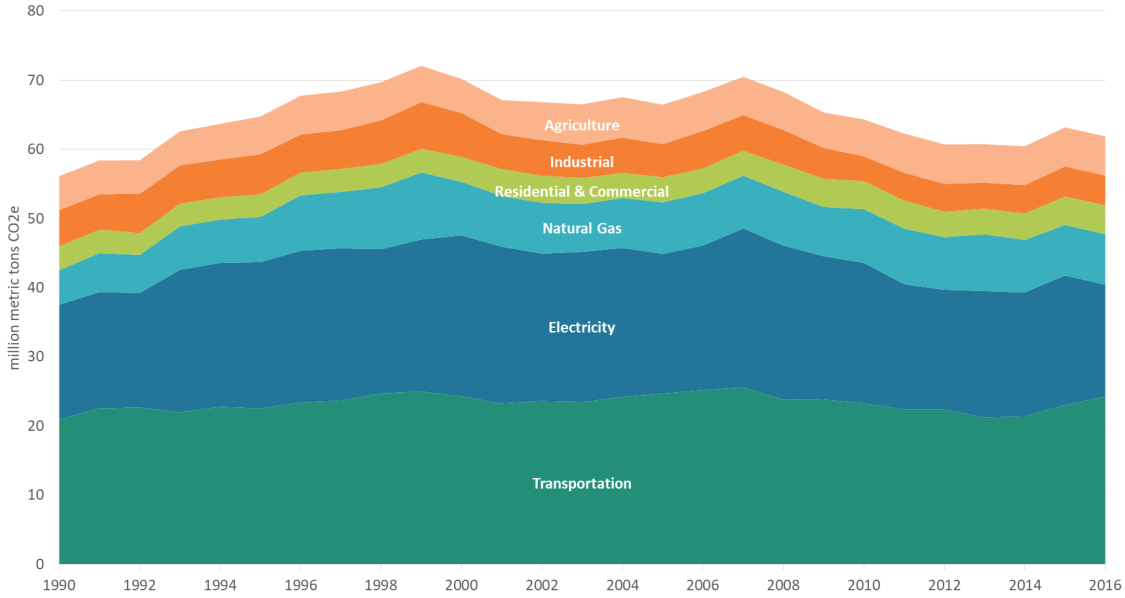
Highlights:

- Transportation is Oregon's largest in-state sector of emissions.
- Emissions from passenger vehicle use and freight transportation are increasing.
- Oregon's residential sector uses more electricity than any other sector.

Oregon has goals in statute to reduce in-state emissions 10 percent below 1990 levels by 2020 and 75 percent below 1990 levels by 2050. To evaluate our progress towards these goals and make recommendations to the Legislature the Oregon Global Warming Commission primarily utilizes data from the sector-based inventory. DEQ's latest inventory data indicates that our current trend is not on track to achieve levels at or below 1990 levels. Total sector-based emissions are 10 percent above 1990 levels. DEQ will continue to monitor Oregon's greenhouse gas emissions in future years to track the trajectory and identify key contributors to global greenhouse gas emissions.

[1] IPCC, 2013: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp.

Figure ES.1
Statewide sector-based greenhouse gas emissions 1990-2016



1. Greenhouse Gas Emissions Accounting

1.1 Overview

DEQ regularly updates statewide greenhouse gas emissions data through the statewide sector-based greenhouse gas inventory (formerly referred to as the in-boundary inventory). This report discusses the sector-based inventory in detail, reviewing the scope and methods of each approach and presenting and comparing 2015 emissions data, the most recent finalized statewide data.

- **Sector-based inventory:** Emissions produced in Oregon from its transportation, residential, commercial, industrial and agriculture sectors, including electricity produced elsewhere but used in state.

1.2 Why inventory emissions?

Oregon's greenhouse gas sector-based inventory is developed to characterize and quantify the anthropogenic (human-caused) greenhouse gas emissions resulting from activities occurring in Oregon and actions taken by Oregonians that contribute to global climate change. These emissions estimates inform strategies and help the Oregon Global Warming Commission track progress toward goals in emission reductions. Oregon's current greenhouse gas emission reduction goals are:

- By 2010, Oregon will arrest the growth of greenhouse gas emissions and begin to reduce emissions
- By 2020, Oregon will achieve greenhouse gas levels that are 10 percent below 1990 levels, and
- By 2050, Oregon will achieve greenhouse gas levels that are at least 75 percent below 1990 levels.

In order to incorporate best available data and methodology, DEQ periodically updates these inventories so that the most up-to-date information is provided to Oregon's residents, businesses and policy-makers. These updates also allow Oregon to better understand changes in emissions relative to different drivers like policy, the economy and changes in population. This data is also the basis for statewide greenhouse gas emission projections. These projections create a foundation to better understand how policy and programs implemented now might affect emissions in the future.

These data allow Oregon to meet sub-national reporting commitments making Oregon a national and global partner committed to better understanding global greenhouse gas emissions. DEQ annually reports statewide sector-based emissions to the Carbon Disclosure Project, which compiles global data on greenhouse gas emissions. Starting in 2017, data from the sector-based inventory is used to inform Oregon's commitment to The United States Climate Alliance, a coalition of states committed to reducing greenhouse gas emissions consistent with the Paris Agreement[2]. Inventory data also informs numerous local inventories developed at the community scale across Oregon.

[2] The United States Climate Alliance is a coalition of governors committed to reducing greenhouse gas emissions consistent with the Paris Agreement, aiming to reduce greenhouse gas emissions by at least 26-28 percent below 2005 by 2025.

1.3 Organization of this report

This chapter concludes with an introduction to greenhouse gas accounting. Chapter Two summarize data sources and high-level results of the sector-based inventory. Additional details regarding results (including data tables) and methodologies are provided in the appendix.

1.4 Greenhouse gas accounting

International greenhouse gas inventory accounting methods were originally developed so that inventories could be aggregated at sub-national, national and international levels. To prevent double counting, jurisdictions reported emissions using an "in-state production basis" approach, which included only emissions occurring within the reporting entity's jurisdictional boundary. Over time and in response to recommendations on improved inventory practices, Oregon modified the in-state production model to include emissions resulting from the generation of electricity used in Oregon, regardless of where that electricity was generated. A portion of the electricity used in Oregon is produced in other states, including through coal and natural gas combustion. The rationale for this change is that it more accurately reflects the impacts of state policy, like energy efficiency and renewable power requirements, on overall emissions. This approach for many years was referred to as Oregon's "in-boundary" inventory. With this report, DEQ changed the name to the "sector-based" inventory, a term more commonly used to describe the scope of emissions included in this inventory.

Oregon's sector-based inventory tracks anthropogenic emissions occurring within Oregon's key sectors, including agriculture, industry, residential and commercial operations and transportation. Emissions from electricity use, natural gas use and waste are estimated and apportioned to the key sectors. This method is closely aligned with conventional greenhouse gas accounting methods such as those utilized by the US Environmental Protection Agency (EPA) to develop the national greenhouse gas inventory.

2. Sector-Based Inventory

2.1 Introduction

Oregon's sector-based inventory estimates anthropogenic (human-caused) emissions occurring within Oregon by economic sector. These include transportation, industrial, residential, commercial and agriculture sectors and include emissions from stationary and transportation related fuel combustion, waste, industrial processes, natural gas distribution, and the use of high global warming potential (HGWP) gases such as refrigerants and aerosols. For the electricity sector, this inventory includes emissions associated with the electricity used in Oregon regardless of where that electricity is generated. Electricity emissions are estimated and apportioned to the industrial, residential, commercial and transportation sectors based on use. This report includes the most currently available sector-based information with finalized statewide data from 1990 through 2015 and preliminary estimates for 2016.

The sector-based emissions inventory accounts for anthropogenic carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and high global warming potential gases (HGWP) including hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6) and nitrogen trifluoride (NF_3). Because these different gases have different climate impacts, all are expressed on the basis of CO_2 equivalent (CO_2e). The accounting methods utilize Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4) global warming potentials (GWP) using a 100-year time horizon, as currently recommended by the United Nations Framework Convention on Climate Change (UNFCCC). The sector-based inventory accounts for anthropogenic greenhouse gas emissions and does not include carbon dioxide emissions from biomass and biofuel, which is considered biogenic (related to the natural carbon cycle). Biogenic carbon is accounted for separately from the sector-based emissions inventory through the accounting of emissions and sequestration in land use, land use change and forestry known as net carbon flux[3].

Data in the sector-based inventory is compiled by integrating reported data from DEQ's Greenhouse Gas Reporting Program, waste emissions estimates from DEQ's Materials Management section and modeled emissions estimates from EPA's State Inventory Tool (SIT). The SIT is the primary source of emissions estimates for all years prior to the inception of the reporting program (1990 through 2009). For subsequent years, the SIT remains the primary source of emissions estimates for sources that do not report directly to DEQ, such as agriculture. The SIT emissions are estimated utilizing a "top down" approach in which modeling and estimation of emissions relies on the disaggregation of national data covering energy, industry, agriculture, population and socioeconomics.

Starting with the 2010 emission year, data collected through DEQ's Greenhouse Gas Reporting Program became the primary source of data used to compile the inventory. The reporting program annually collects greenhouse gas emissions information from major emitting sources in Oregon, including industrial facilities with air quality permits, fuel distributors, natural gas and electricity suppliers and large landfills. Since these data are reported directly from the emitting source and verified by the program, it is considered a "bottom-up" source of information and is state specific. Approximately 80 percent of the annual emissions in the inventory for 2010 through 2016 are derived from data reported directly to DEQ. These data are reported and published independently of the inventory by DEQ and is often available up to a year earlier than any of the SIT modeled estimates.

The integration of the modeled and reported data have allowed DEQ to update the sector-based inventory on an annual basis. Emissions are recalculated for the entire time series, 1990 through the most current year, based on the best available data and estimation methodology. Recalculation is best practice in international greenhouse gas

[3] In 2016 the Oregon Global Warming Commission established The Forest Carbon Task Force, a subcommittee focused on improving Oregon's understanding of natural carbon flux and the accounting of biogenic carbon.

inventory management and allows for DEQ to maintain a consistent time series of data. It's important to note that for this reason, historic data in the published inventory may vary from version to version. DEQ's website maintains the most up-to-date version of greenhouse gas emissions data. Details on the underlying data sources for the sector-based inventory and charts found in this section are available in Appendix A of this report.

2.1.1 An explanation of "preliminary" emissions data

DEQ frequently receives requests to provide the most up-to-date inventory data available and in response has developed a preliminary data compilation methodology that integrates the most recently available reported data from the Greenhouse Gas Reporting Program with EPA's most current SIT modeled estimates. Since EPA's tool requires extensive updates to many different data sets and emission factors, its results are often released a year to two years behind DEQ's verified reported data. For example, as of January 2018, the most recent version of the SIT provides estimates through 2015 while DEQ has verified reported data through 2016. To create a preliminary 2016 statewide emissions value, those portions of the inventory not directly reported to DEQ utilize 2015 proxy data from the SIT. More specifically, for this report DEQ integrated 2016 reported data for the industrial, natural gas, electricity and fuel sectors with the most recent data outputs from EPA's SIT model, utilizing 2015 data for the agriculture sector, a portion of the high global warming potential gases and a few small sources in other sectors. When an updated version of the SIT becomes available, DEQ will update and finalize 2016 emissions for all sectors.

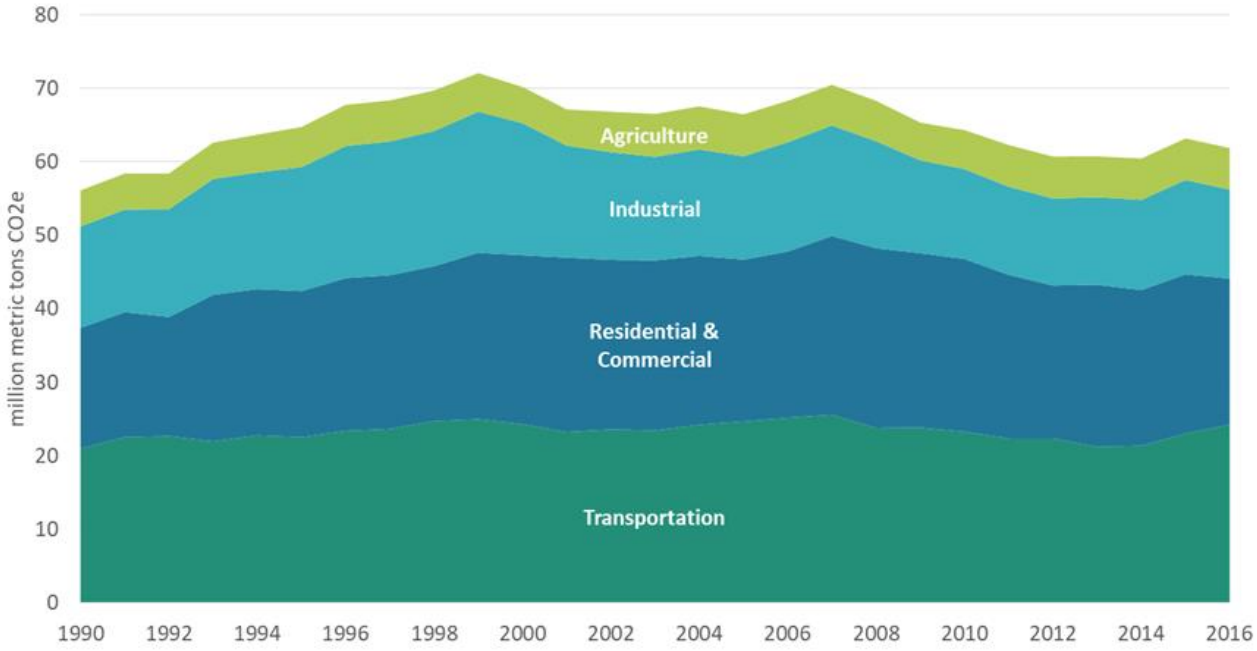
2.2 Classification of emissions and statewide data

In 2015 Oregon's sector-based anthropogenic emissions totaled to 63 million $MTCO_2e$. Oregon's emissions are approximately one percent of the world's second largest global emitter, the United States, emitting emissions equivalent to countries like Portugal and Ireland[4]. Oregon has experienced an increase in emissions within the transportation, residential, commercial and agriculture sectors when compared to 1990 levels and a small decrease within the industrial sector within the same time period. While Oregon's emissions have decreased slightly since 2007 that trend has not continued in recent years and Oregon's 2015 emissions are still 10 percent higher than 1990 levels.

An overall statewide emissions number provides a summary of emissions on an annual basis allowing us to better understand the trajectory of emissions for the state and to compare overall progress toward emission reduction goals. However, a total value does not provide details on the key drivers of emissions or reduction opportunities. For this reason, it is useful to review emissions by sector and examine the underlying drivers of emissions and energy use within each sector. Emissions within the transportation, residential/commercial and industrial sectors include the sector share of electricity use, fuel combustion, emissions from waste and high global warming potential gases (HGWP) emitted from activities originating in that sector. The transportation sector includes emissions from all mobile combustion including emissions from all highway, aviation and non-road vehicles (including farm equipment). The agriculture sector includes greenhouse gas emission unique to soil, animal rearing and farm waste management. Figure 2.1 displays Oregon's emissions by key sector from 1990 through 2016.

[4] World Resource Institute CAIT Climate Data Explorer. (2014). Total GHG Emissions Excluding Land-Use Change and Forestry Per Capita-2014. Retrieved from http://cait.wri.org/

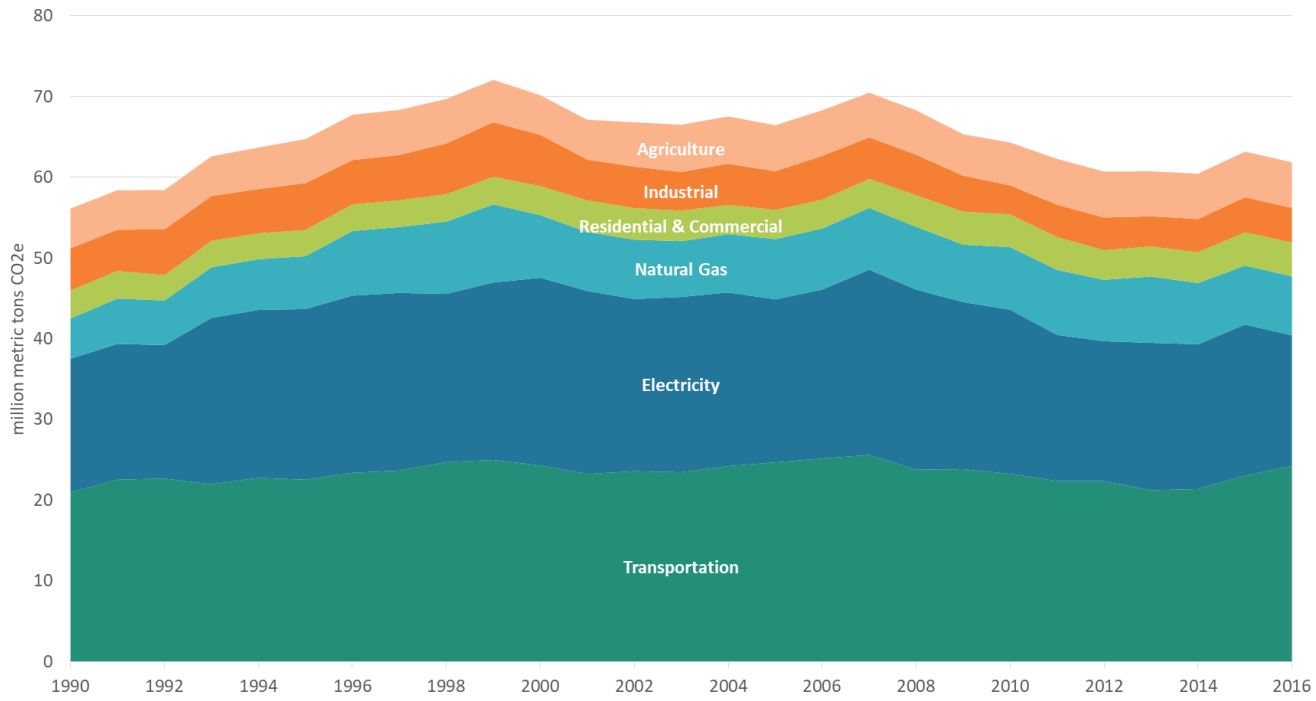
Figure 2.1
Statewide emissions by sector 1990-2016



The largest share of emissions originates from fuel combustion in Oregon's transportation sector followed by emissions from the residential and commercial sector, industrial and finally agriculture.

Within the transportation, industrial, residential and commercial sector the primary driver of greenhouse gas emissions is fossil fuel combustion. This includes fuel combusted to generate heat and electricity in the residential, commercial and industrial sector and fuel to power vehicle engines in the transportation sector. Figure 2.2 highlights the influence of emissions from energy use by creating a different view of statewide emissions, breaking out and aggregating electricity and natural gas emissions from all sectors. When viewed this way transportation is still Oregon's largest sector of emissions, however the influence of emissions from electricity use and natural gas combustion is more visible.

Figure 2.2
Emissions with electricity and natural gas aggregated for all sectors 1990-2016



While Oregon's emission reduction goals apply to in-state total annual emissions, as Oregon's population grows it is also helpful to understand emission trends from a population perspective. Oregon's population has increased 43 percent since 1990 while in-state emissions per capita have decreased in the same time period[5]. Since 2011, Oregon's in-state production emissions per capita have stayed relatively flat, around 13 $MTCO_2e$ per person[6].

EPA estimates that U.S. national per capita emissions are higher and closer to 20 metric tons per person[7]. In general, developed countries like the U.S. tend to have higher per capita emissions while countries that are developing have a higher rate of emissions growth[8]. For example, China, the world's largest emitter of greenhouse gas emissions, has per capita emissions of approximately 8 metric tons per person[9].

[5] Portland State University Population Research Center. (July, 2017) Certified Population Estimates July 1, 2017. Retrieved from https://www.pdx.edu/prc/population-reports-estimates

[6] Total in-state production emissions differ from the sector-based emissions discussed in this chapter for the electricity sector. In-state emissions do not include emissions from imported power but do include emissions from electricity generated in Oregon and exported. In-state production emissions align more directly with national production emissions for a per capita comparison.

[7] United States Environmental Protection Agency. (April 13, 2017). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2015. Retrieved from https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2015.

[8] Union of Concerned Scientists. (November 20, 2017). Each Country's Share of CO2 Emissions. Retrieved from https://www.ucsusa.org/global-warming/science-and-impacts/science/each-countrys-share-of-co2.html#.WmJyBbynFEZ

[9] World Resource Institute CAIT Climate Data Explorer. (2014). Total GHG Emissions Excluding Land-Use Change and Forestry Per Capita-2014. Retrieved from http://cait.wri.org/

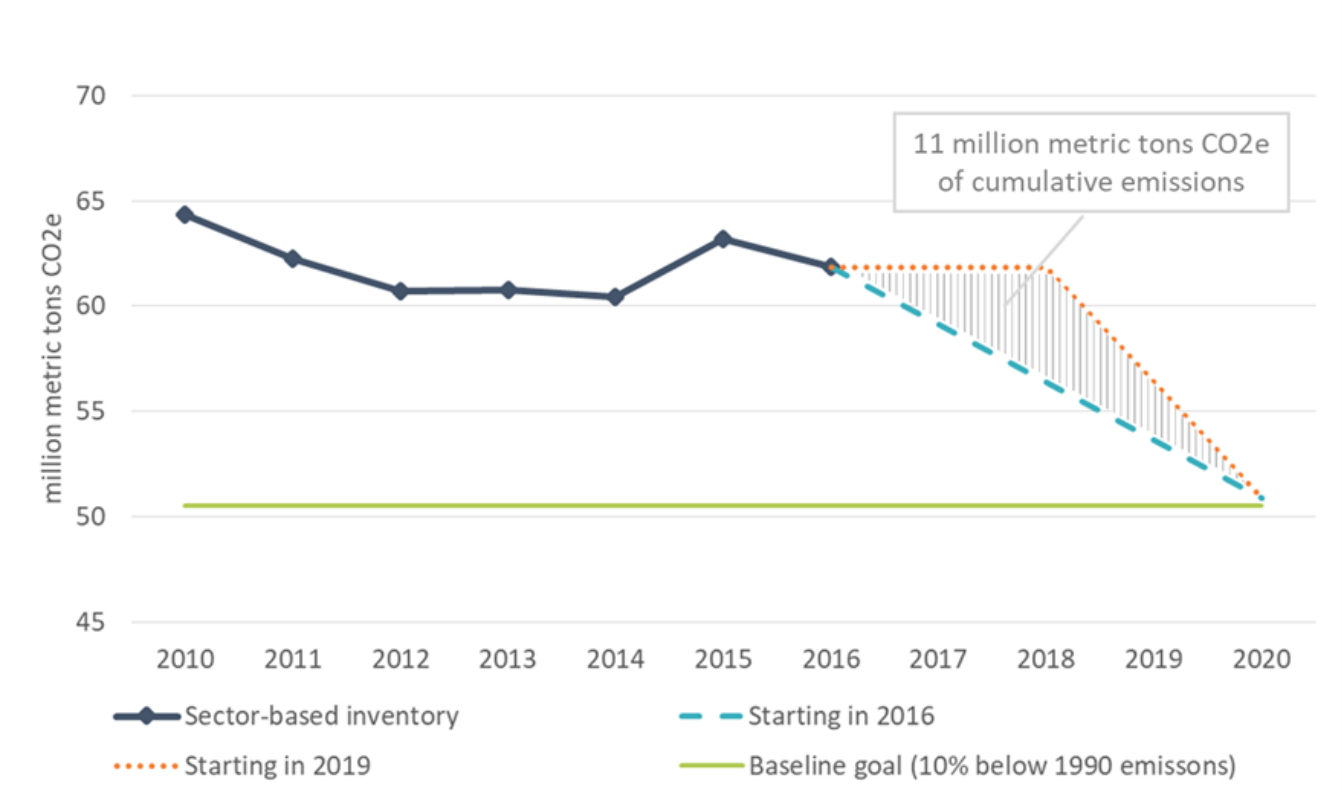
2.2.1 Cumulative emissions

Oregon's cumulative emissions for the sector-based inventory time period, including all anthropogenic emissions emitted from 1990 through 2016, total 1.75 billion $MTCO_2e$. Although traditional accounting methods and Oregon's greenhouse gases emission reduction goals focus on annual emissions, greenhouse gases persist in the atmosphere and influence the climate for long periods of time. Emissions occurring in 1990 still have an impact on our climate. Since the effects on Earth's climate stem from the overall concentration of emissions in the atmosphere and not just what is emitted in a single year it is important to acknowledge both our current and historic contribution to global concentrations.

Viewing emissions from a cumulative approach also allows us to better understand how the timing and trajectory of emission reductions affect our ability to reduce global concentrations of greenhouse gases. Delaying emissions mitigation results in a need for a more rapid decline in emissions in later years while more immediate action allows for a less steep trajectory to meet the same targets.

Figure 2.3 illustrates the impacts of an emission reduction trajectory on annual reduction requirements and cumulative emissions. To meet Oregon's 2020 goal of 10 percent below 1990 levels, Oregon needs to reduce emissions by 11 million $MTCO_2e$, from an estimated 62 million $MTCO_2e$ in 2016 to 51 million $MTCO_2e$ in 2020. A steady reduction over that time period requires an annual reduction of approximately 3 million $MTCO_2e$ to achieve the goal. If emission reductions are delayed until 2019, Oregon would need to annually reduce emissions by more than 5 million $MTCO_2e$ in 2019 and again in 2020 to achieve the same goal. In addition to a more gradual reduction, the scenario in which mitigation starts in 2016 actually reduces cumulative emissions during that time period by 11 million $MTCO_2e$ when compared to the delayed reduction scenario.

Figure 2.3
Emission reduction trajectories for scenarios beginning 2016

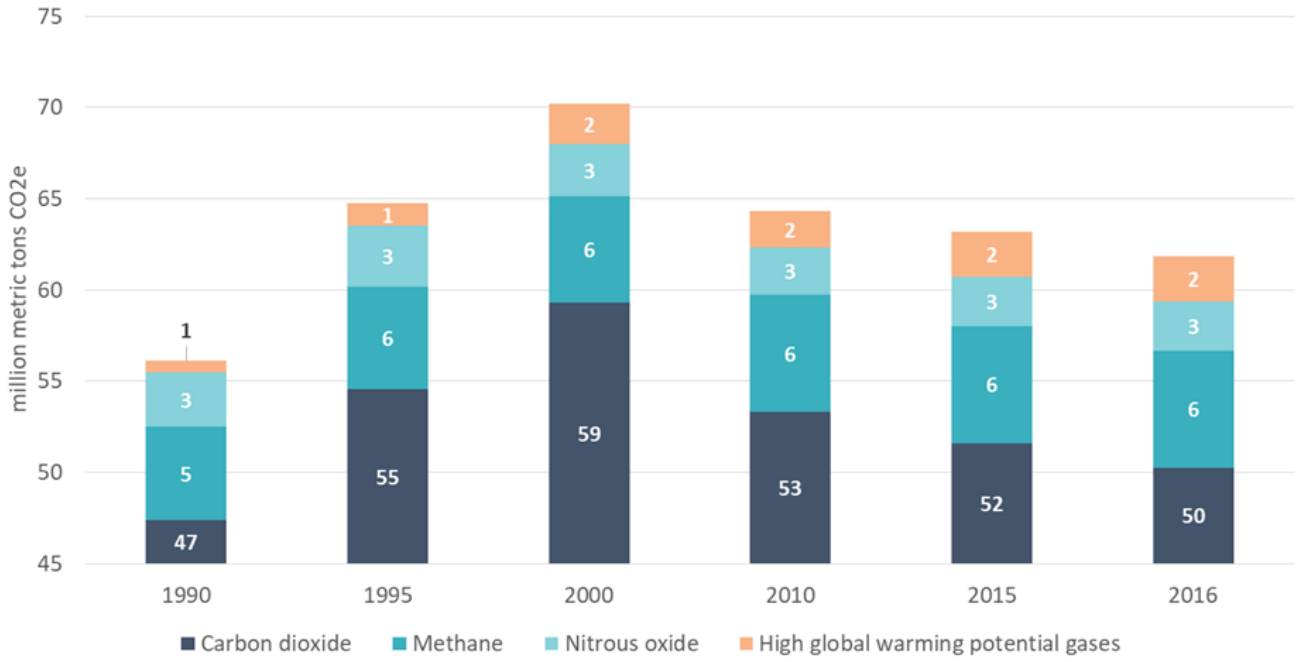


2.2.2 Emissions by greenhouse gas

Figure 2.4 represents Oregon's greenhouse gas emissions by individual gas including carbon dioxide, methane, nitrous oxide and high global warming potential gases. Carbon dioxide comprises approximately 80 percent of statewide emissions and primarily originates from fossil fuel combustion in vehicle engines and to generate electricity. The second highest emissions are of methane, which comprises approximately10 percent of the statewide sector-based total. Methane is primarily a result of agricultural activities but also originates from landfills and natural gas distribution.

Over time the relative contributions from carbon dioxide, methane, and nitrous oxide have stayed relatively constant while the share of HGWP gases has grown from 1 percent of statewide emissions in 1990 to 4 percent of emissions in 2016. Although HGWP gases are emitted in small quantities, their climate impact is significant due to their long atmospheric lifetimes and their ability to trap heat in the atmosphere, which is hundreds to thousands of times higher than that of carbon dioxide[10].

Figure 2.4
Statewide greenhouse gas emissions by gas over time



[10] DEQ utilizes Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment (AR4) 100-year Global Warming Potentials to quantify greenhouse gas emissions in accordance with the most current accounting guidance from the United Nations Framework Convention on Climate Change (UNFCCC).

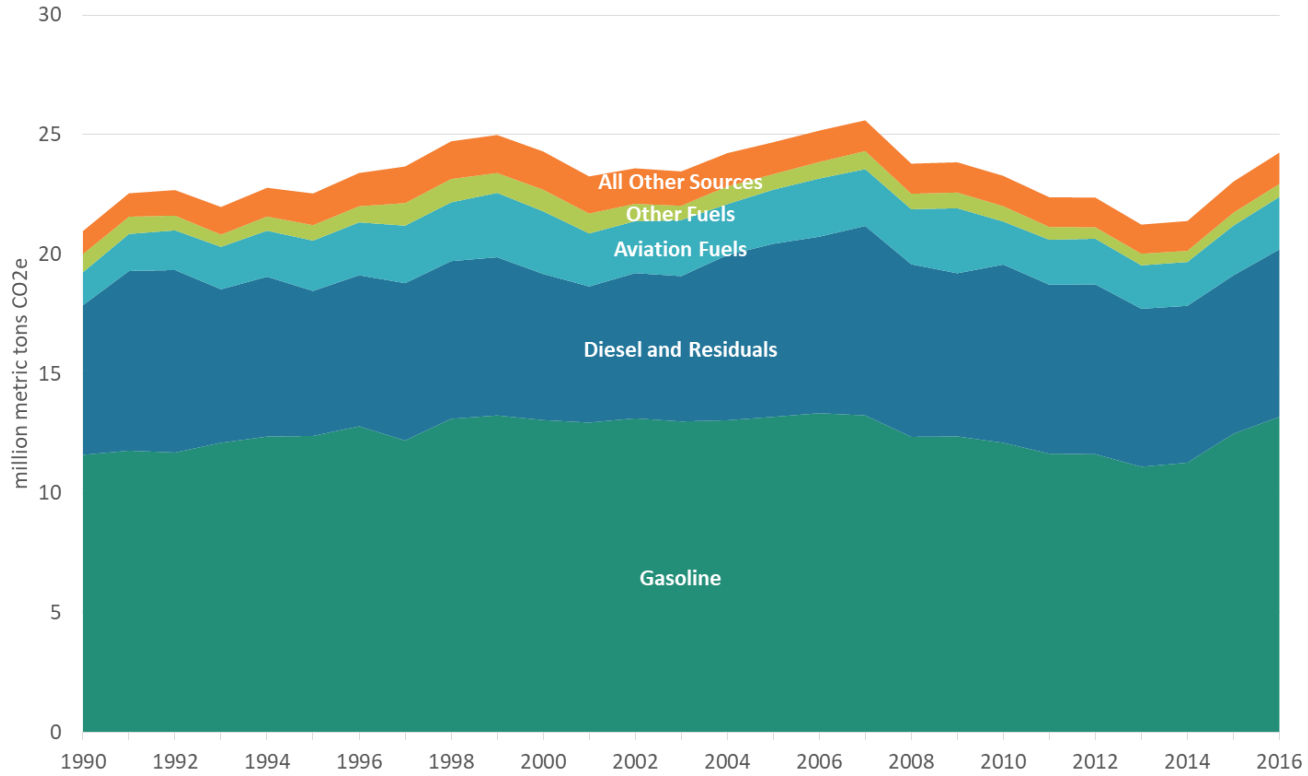
2.3 Transportation

The transportation sector includes carbon dioxide, methane and nitrous oxide emissions from the use of cars, trucks, boats, aviation and non-road vehicles but excludes bunker fuel used in international marine vessels. Starting with the 2010 emissions year, estimates are based on imported fuel volumes reported to DEQ's greenhouse gas reporting program. This method allows for the calculation of emissions associated with vehicles purchasing fuel within Oregon, however, it does not account for users that purchase fuel outside of the state and operate their vehicles within Oregon. This sector also includes emissions from refrigerant used in vehicle air conditioning equipment and refrigeration systems in freight.

Transportation is Oregon's largest in-state sector contributing to global greenhouse gases and on-road transportation is the largest sub-sector of transportation emissions. In 2015, the transportation sector comprised 36 percent of statewide emissions (23 Million $MTCO_2e$). Within the sector, DEQ estimates that in 2015 47 percent of combustion emissions are generated from passenger vehicles and light duty trucks and approximately 23 percent from heavy-duty vehicles. When compared to statewide emissions passenger vehicles and light duty trucks are responsible for approximately 17 percent of emissions from all sources.

2016 data indicates that emissions in the transportation sector have increased 15 percent since 1990 along with a 37 percent increase in vehicle miles traveled (VMT)[11]. Not only has VMT increased in Oregon but recently VMT per capita has increased annually starting in 2012.

Figure 2.5
Oregon emissions from transportation



[11] Oregon Department of Transportation. (2017). Oregon Statewide VMT Data. Retrieved from http://www.oregon.gov/ODOT/Data/documents/VMT_Statewide.pdf

2.4 Residential and commercial sectors

In 2015, the residential and commercial sectors accounted for 34 percent of statewide emissions (22 million $MTCO_2e$). Within the sectors, emissions are primarily a result of energy use including emissions from electricity use and natural gas and petroleum combustion. Emissions from these specific sources total to 18 million $MTCO_2e$ and make up 85 percent of residential and commercial sector emissions. The other 15 percent of emissions in this sector include emissions from sources such as waste and the use of high global warming potential gases in refrigerants and air conditioning.

Emissions within the residential and commercial sector have increased from 1990 to 2015 by 20 percent. Within the sector, emissions from electricity use increased by 28 percent and emissions from fuel combustion increased by 22 percent. After electricity use and fuel combustion, the third largest emissions source within the residential and commercial sector is waste.

Figure 2.6
Emissions from the residential and commercial sector 1990-2016

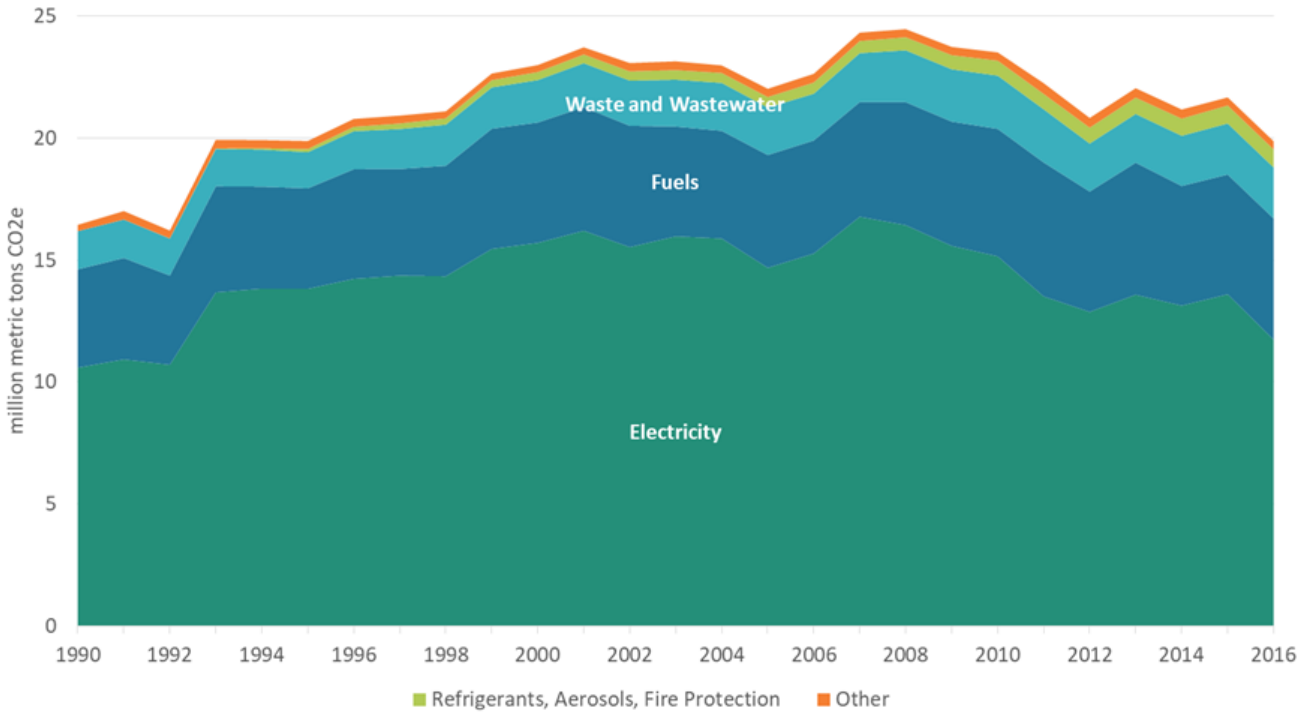
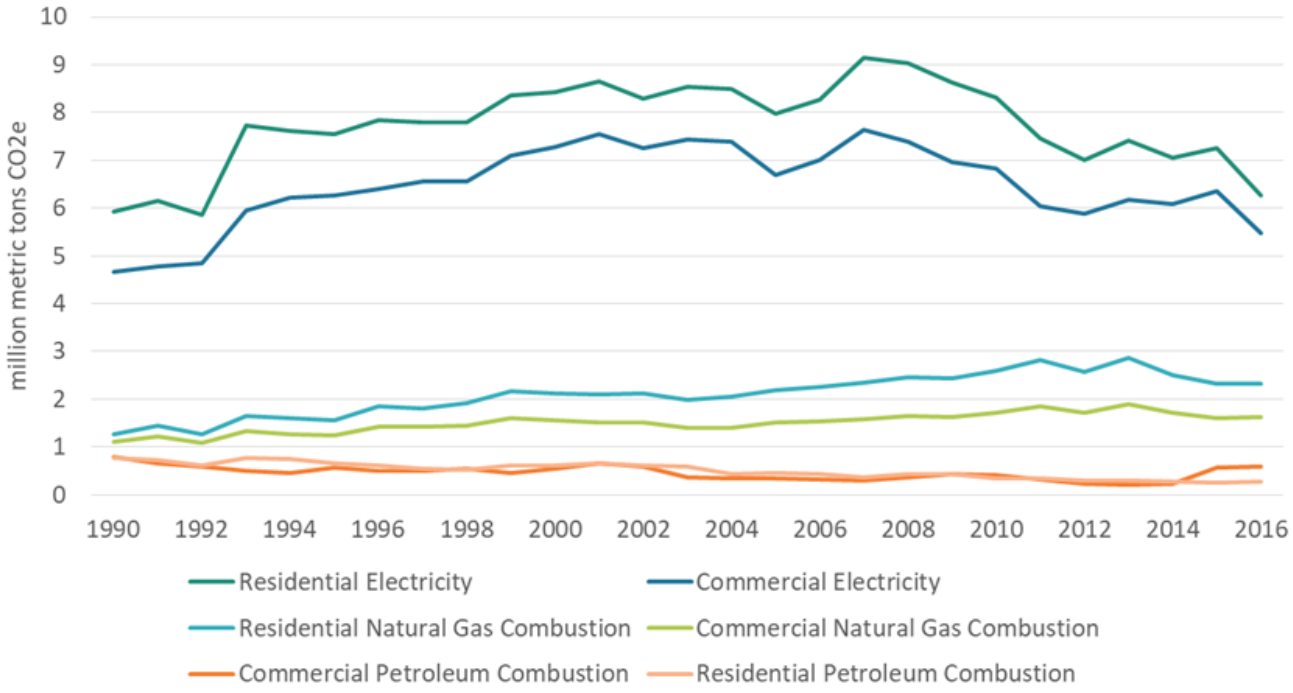


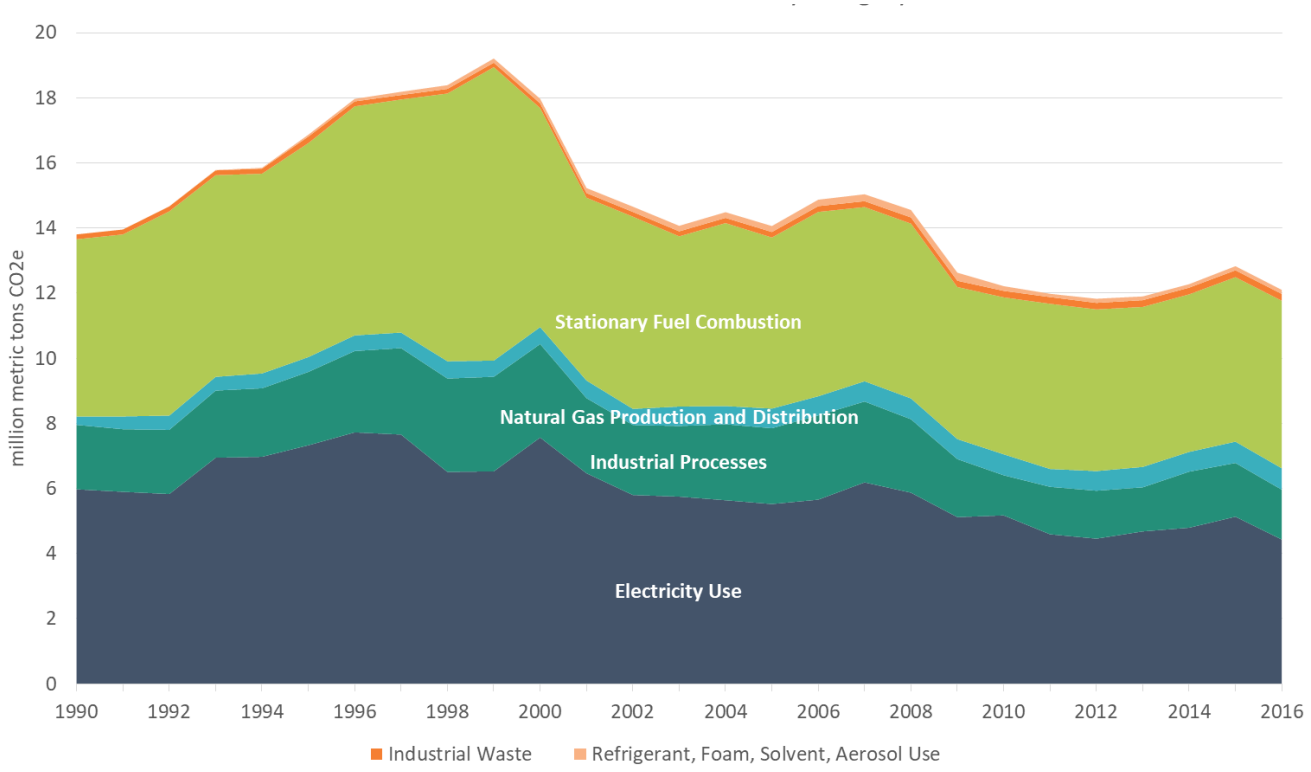
Figure 2.7
Emissions from residential and commercial electricity, natural gas and petroleum use 1990-2016



2.5 Industrial sector

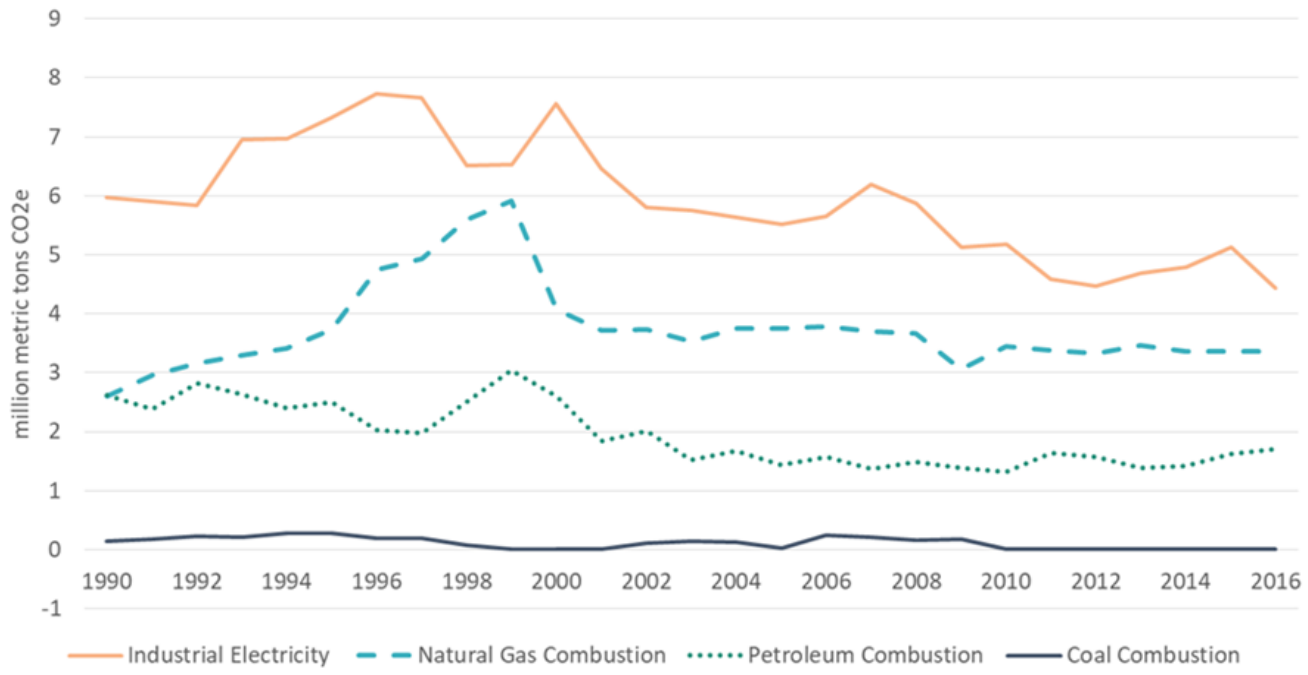
Starting in 2010 industrial facilities located within Oregon with an air quality permit that emit over 2,500 $MTCO_2e$ of greenhouse gases are required to report annual greenhouse gas emissions to DEQ. Reported data includes emissions from onsite stationary combustion and emissions from industrial processes that emit greenhouse gases, such as cement manufacturing or iron and steel production. Other emissions attributed to this sector include emissions from waste and high global warming potential gases from the use of refrigerants, foams and aerosols. The largest contributor to emissions within this sector are emissions from stationary combustion and emissions from electricity use at the industrial facilities.

Figure 2.8
Industrial sector emissions



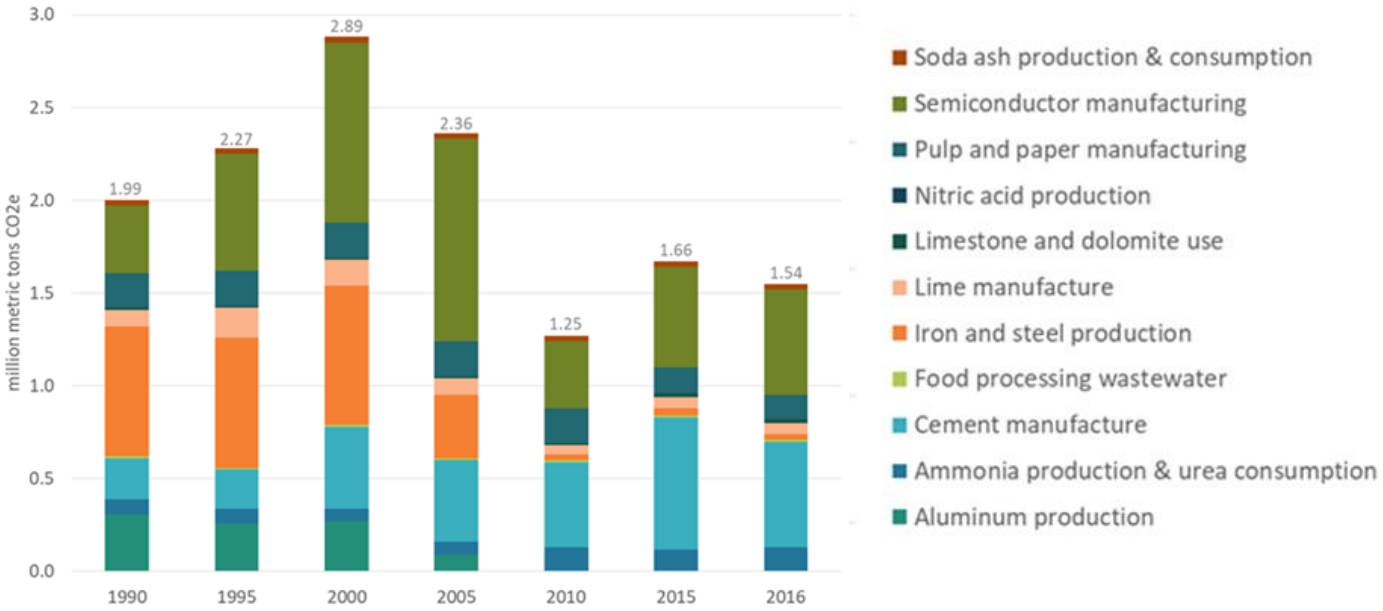
In 2015, Oregon's industrial sector emitted 12.8 million $MTCO_2e$ which accounted for 20 percent of statewide emissions. In 1990 industrial emissions, at 14 million $MTCO_2e$, accounted for 25 percent of statewide emissions. The reductions in this sector are primarily the result of the reduction of emissions from electricity use and petroleum combustion.

Figure 2.9
Industrial electricity and stationary combustion



Industrial processes emit greenhouse gases which are accounted for separately from energy related activities within the industrial sector, called process emissions. Process emissions data reported for the 2016 emissions year from industrial facilities accounted for 13 percent of the industrial sector and 2 percent of total statewide emissions. In the 1990s, Oregon's largest source of industrial process emissions came from the production of aluminum, iron and steel. More recently, emissions from those industries in Oregon have either reduced dramatically or stopped completely. Data from the greenhouse gas reporting program now indicates that the primary sources of process emissions arise from cement and semiconductor manufacturing.

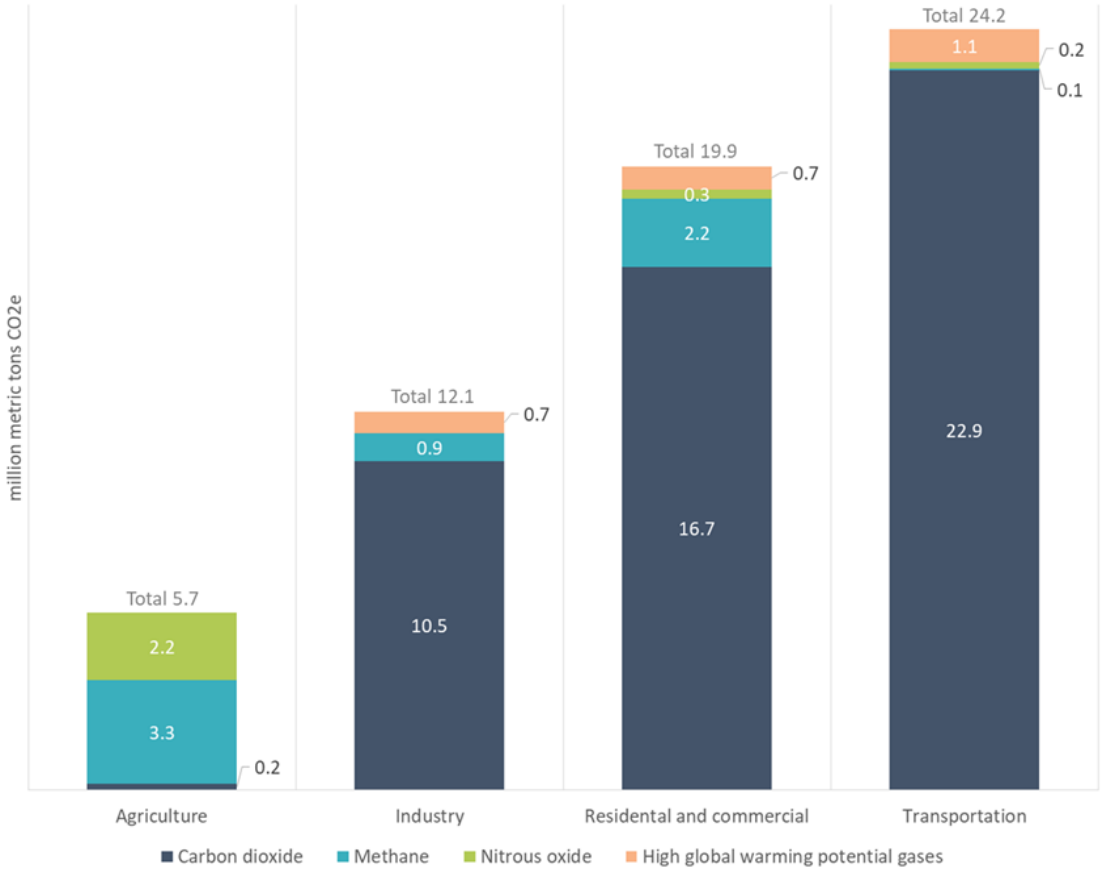
Figure 2.10
Industrial process emissions



2.6 Agricultural emissions

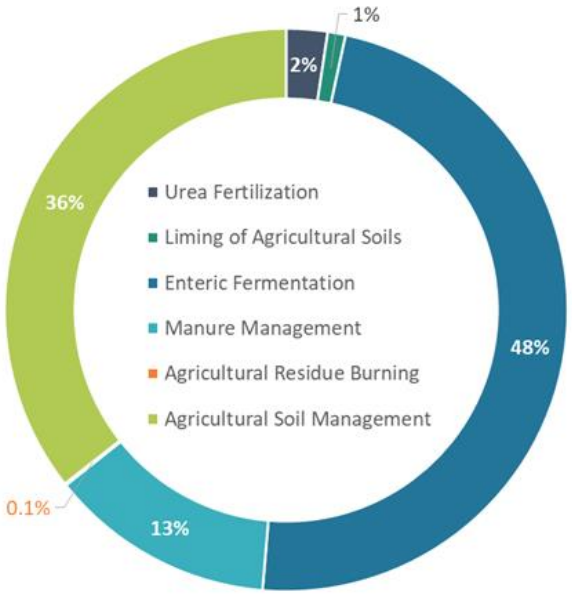
Emissions from the agriculture sector include emissions from agricultural activities such as managing soils, emissions from livestock and livestock-related waste, and methane and nitrous oxide emissions from the burning of agricultural residual waste. Emissions from fuel combusted for farm equipment use, such as for the operation of tractors, are included within the transportation sector emissions. Unlike other sectors, where carbon dioxide is overwhelmingly the primary greenhouse gas emitted, in the agricultural sector the majority of emissions are methane followed by nitrous oxide.

Figure 2.11
2015 emissions by greenhouse gas for each sector



In Oregon agricultural emissions consistently account for 8-9 percent of statewide emissions from 1990 through 2015; around 5-7 million $MTCO_2e$ annually. Within this sector, the largest contributor to greenhouse gas emissions is a result of enteric fermentation (methane emissions resulting from fermentation occurring in the digestive systems of ruminant animals, primarily cows). It is estimated that in 2015 enteric fermentation resulted in 2.7 million $MTCO_2e$ of greenhouse gas emissions. The next largest contributing source, at 2 million $MTCO_2e$, is from the application of nitrogen fertilizers to agricultural soils. The remaining emissions within this sector include emissions from manure management, urea fertilization, liming of soils, and the burning of agricultural residue which accounts for less than 1 million $MTCO_2e$. Since carbon dioxide from the burning of agricultural residue is considered biogenic carbon, only the methane and nitrous oxide emissions from combustion are included in the inventory.

Figure 2.12
2015 Agriculture emissions by sub-category



2.7 Additional Considerations

2.7.1 Electricity Use

Oregon's electricity use emissions are associated with the generation of electricity serving Oregonians, regardless of where that electricity is generated. Some of the electricity used in Oregon is generated in other states, and the emissions associated with the generation of that electricity are included in the electricity use sector of this inventory. Similarly, there are emissions from electricity generated in Oregon that are utilized outside of the state. Those emissions are not included in the electricity sector of this inventory. Since a large portion of the electricity utilized in Oregon comes from hydropower, the emissions profile of Oregon's electricity is influenced annually by stream flow. In years when there is less hydropower available, utilities must supplement with other sources and this may include electricity from greenhouse gas emitting sources such as natural gas or market purchases of unspecified electricity. This purchased power can increase the emissions intensity of electricity used in Oregon.

Annual emissions from electricity use in Oregon are influenced by both the emissions intensity of the electricity provided to end users (measured in $MTCO_2e$ per megawatt-hour) and the amount of electricity utilized. Based on data reported to DEQ in 2016, Oregon's statewide emissions per megawatt-hour were 0.338 $MTCO_2e/MWh$ and total emissions from the electricity sector were 16 million $MTCO_2e$. However, depending on the individual provider of electricity, the emissions intensity for electricity can vary across different parts of the state. In regions that are served by consumer-owned utilities (COUs), which receive a majority or all of their electricity from the Bonneville Power Administration (BPA), the intensity of the electricity per megawatt hour can be up to 95 percent less than the statewide average. This is because BPA's electricity provided to COUs comes primarily from hydropower. In regions served by one of Oregon's investor-owned utilities (IOUs), average emissions per megawatt hour are higher than the statewide average. Additionally, Oregon's IOUs provide approximately 65 percent of Oregon's total electricity resulting in more than 90 percent of the emissions in the electricity use sector.

Total emissions within the electricity use sector are also influenced by the amount of power that is consumed. Fortunately, a history of energy efficiency programs in Oregon has helped to reduce the overall demand for electricity. However, overtime the residential sector is consistently the greatest consumer of electricity for activities like heating, running electrical equipment, lighting and refrigeration. This is followed by the commercial and industrial sectors.

Figure 2.13
Emissions from electricity use by sector 1990-2016

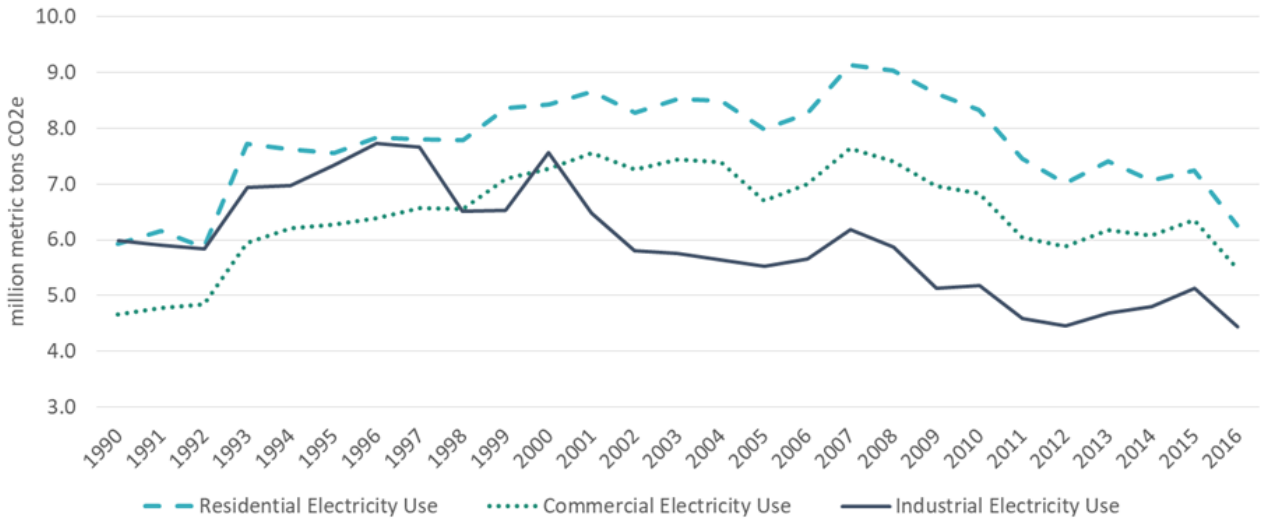


Figure 2.14

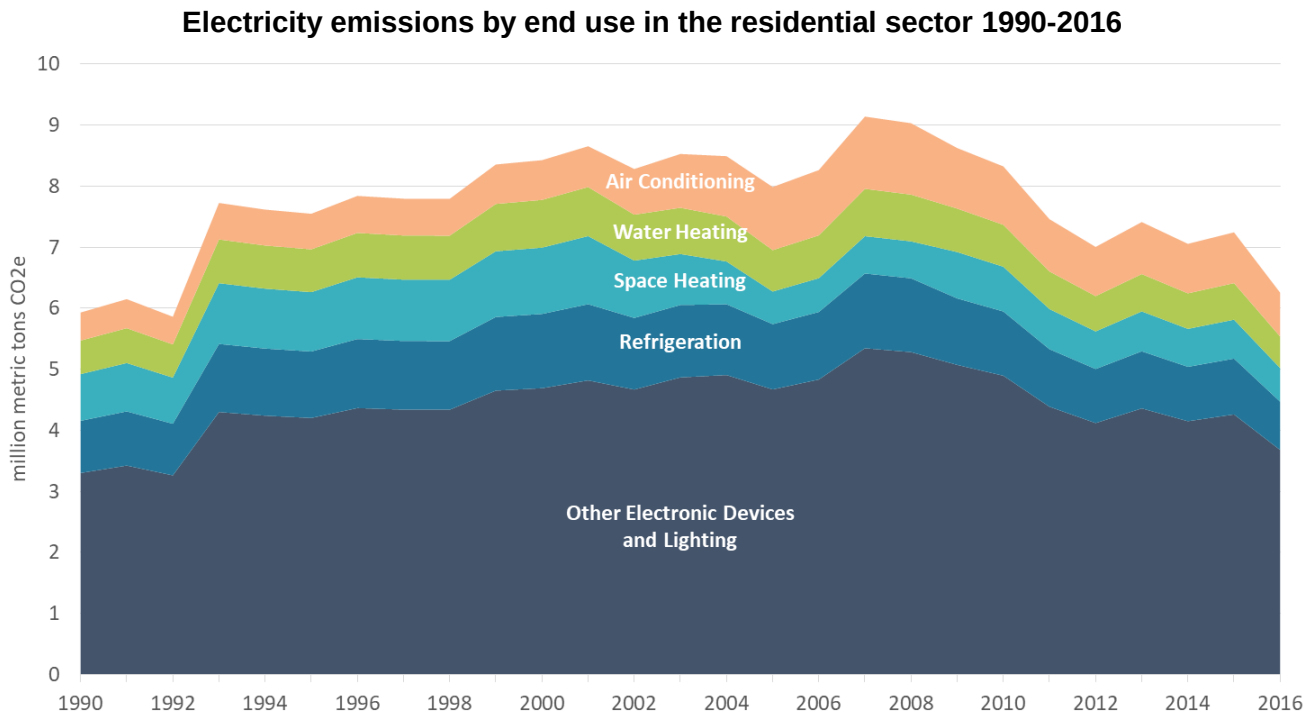


Figure 2.14 illustrates how emissions from residential electricity use have changed since 1990. Emissions from lighting and other uses (clothes dryers, small appliances, consumer electronics) contribute approximately 60 percent of emissions from electricity use in the residential sector. In the commercial sector lighting has historically consumed the greatest amount of electricity as shown in Figure 2.15. However, since 2000 the share of emissions from lighting has decreased while electricity use emissions from cooling, refrigeration, and the use of computers and office equipment has increased. Unlike the residential and commercial sectors, lighting in the industrial sector is less of a driver of overall electricity use. Emissions in the industrial sector primarily result from electricity needed to power machinery (machine drive) or equipment for industrial processes, as shown in Figure 2.16.

Figure 2.15
Commercial sector electricity emissions by end use 1990-2016

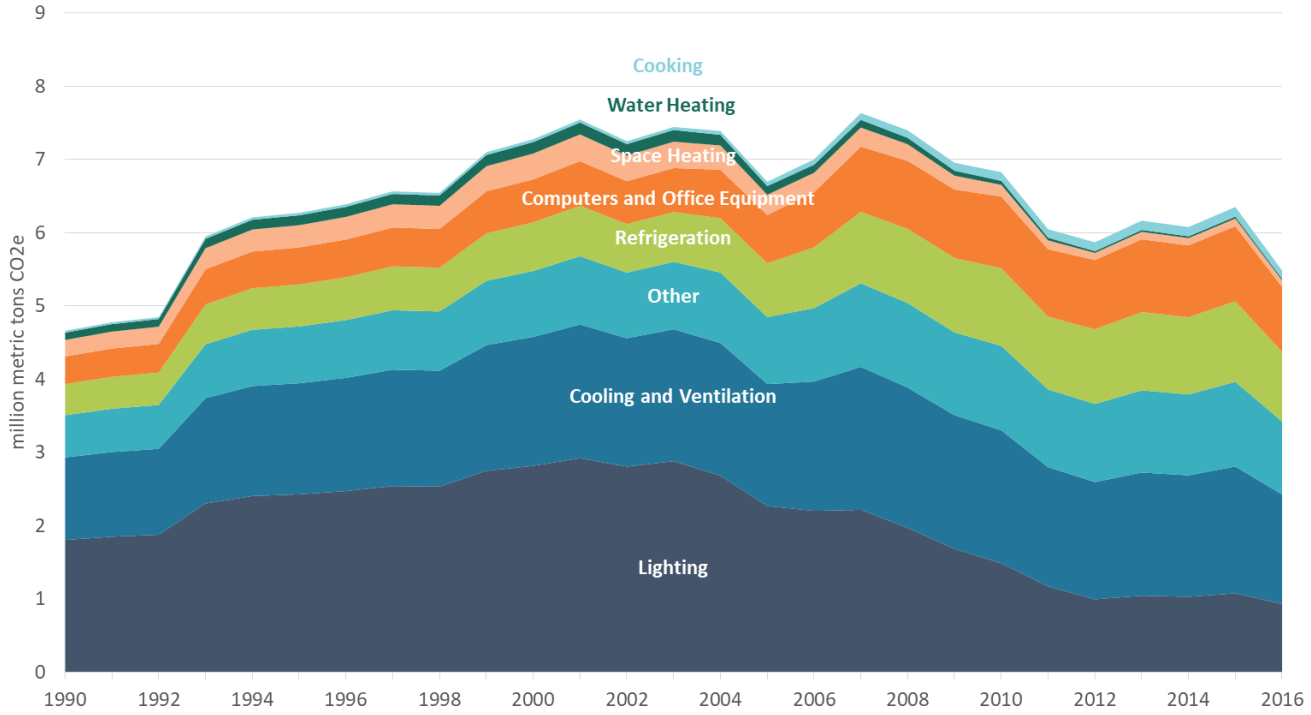
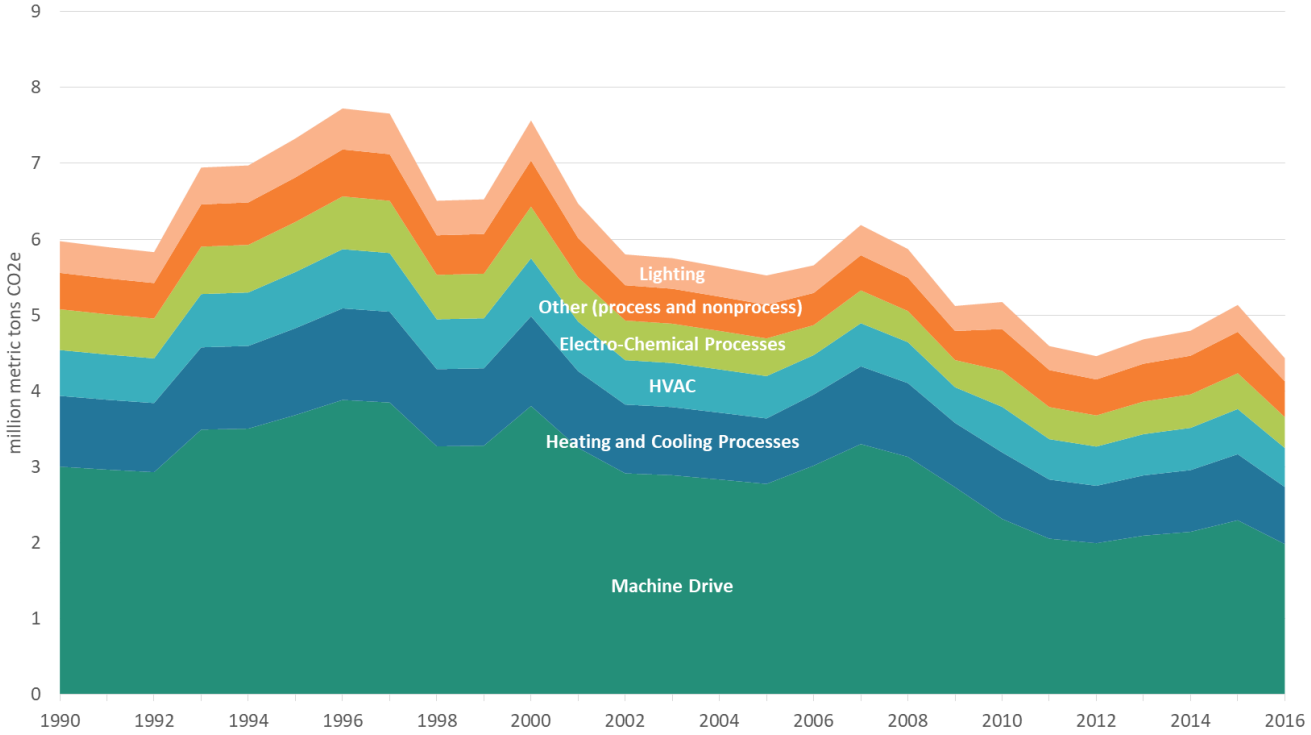


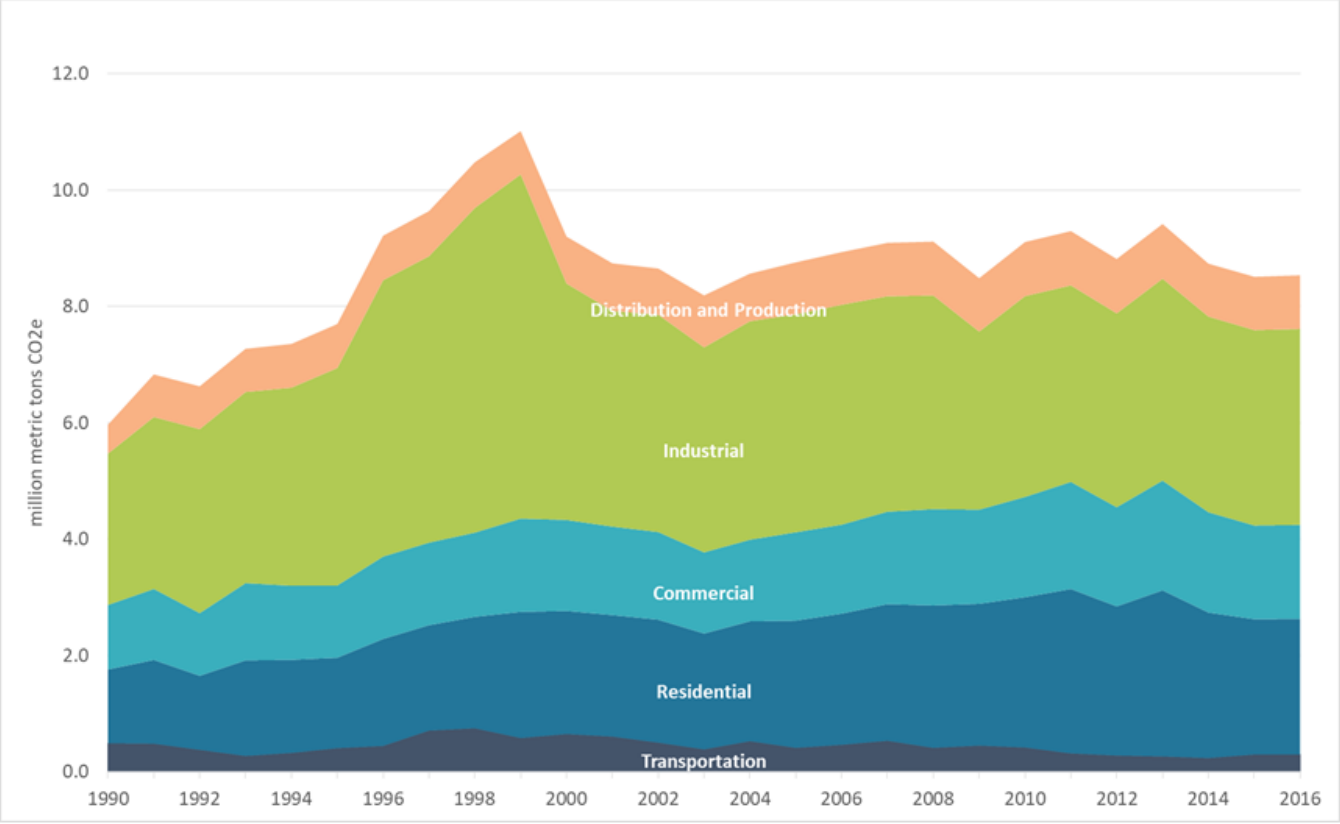
Figure 2.16
Industrial sector electricity emissions by end use 1990-2016



2.7.2 Natural Gas Use

The sector-based inventory accounts for emissions from natural gas occurring at the point of combustion and fugitive methane emissions from pipeline and compressor stations in Oregon delivering natural gas to end users. Emissions are attributed to the combustion, production and distribution of natural gas by individual sector. When looked at collectively, natural gas use is the third largest source of in-state emissions. In 2016, reported data indicates that natural gas combustion from the transportation, residential, commercial and industrial sources (not including emissions from distribution or in-state electricity generation) emit 7 million $MTCO_2e$. In 1990, emissions from natural gas combustion were closer to 5 million $MTCO_2e$. The percentages of statewide emissions from natural gas combustion have increased over time and in 2016 natural gas represented 12 percent of statewide emissions.

Figure 2.17
Natural gas emissions from the sector-based inventory 1990-2016

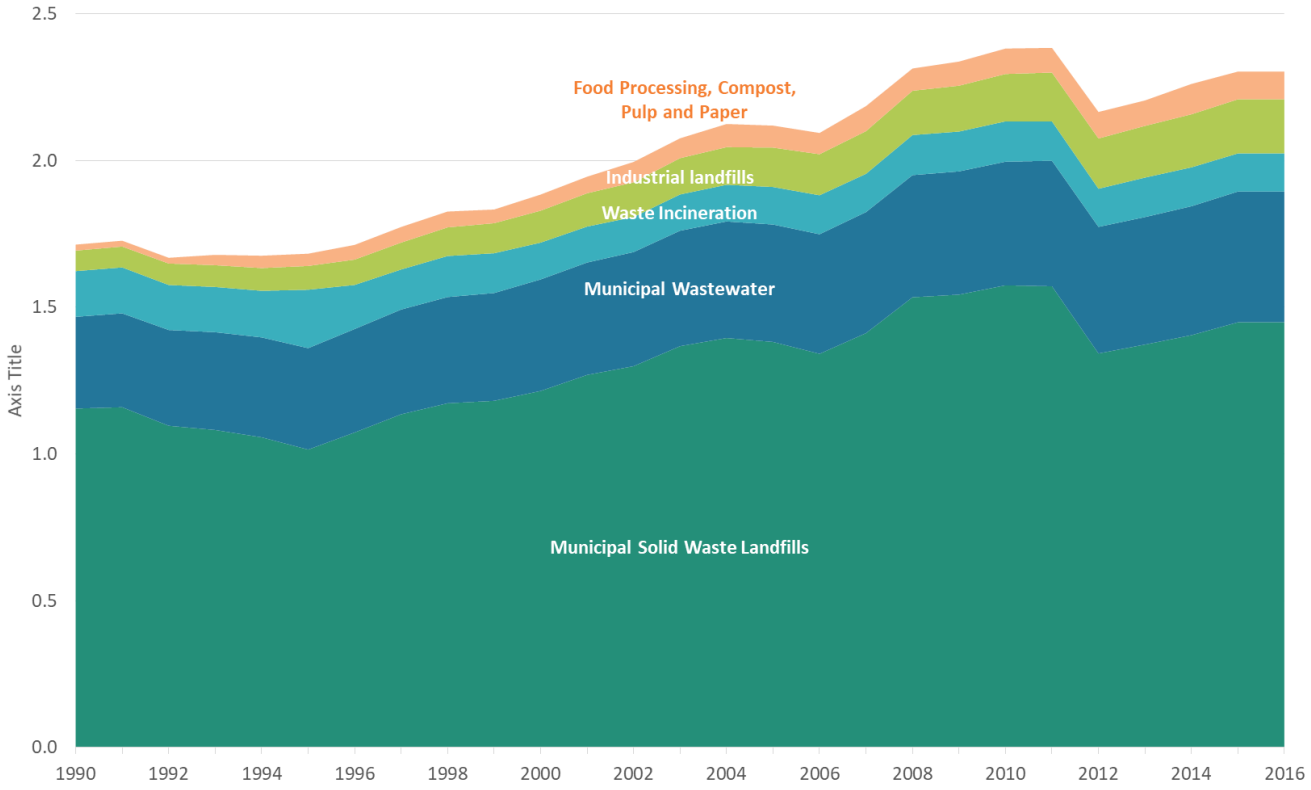


2.7.3 Waste

The sector-based inventory relies on mandatory reports from Oregon's waste incinerators and larger landfills (beginning in 2010), coupled with estimates provided by DEQ's Materials Management Program to develop the majority of waste sector estimates. This includes emissions from waste incineration, municipal solid waste and wastewater, and compost in the Residential and Commercial sector, as well as industrial waste, industrial landfills, food processing wastewater, pulp and paper, and waste incineration in the industrial sector. EPA's SIT tool provides statewide estimates on emissions from wastewater, including emissions from municipal wastewater and from industrial sources such as food production and pulp and paper manufacturing.

Since 1990, statewide emissions from waste have increased from 1.7 million $MTCO_2e$ to 2.3 million $MTCO_2e$. Additionally, while statewide emissions decreased from 2005 through 2011, emissions from waste increased during the same time period[12]. The majority of emissions from waste are fugitive methane emissions from municipal solid waste landfills in Oregon. When waste decomposes naturally under aerobic (with oxygen) conditions, it primarily produces carbon dioxide. Under these natural conditions, the carbon dioxide is considered biogenic and not typically included in a greenhouse gas inventory. However, waste in landfills decomposes under anaerobic conditions generating methane. Since the majority of the methane emitted does not result from natural decomposition, these emissions are considered anthropogenic and are included in the sector-based inventory. Methane captured by landfills and burned (either to produce energy or simply for destruction) primarily produces carbon dioxide as an emission, this carbon dioxide is considered biogenic and not included in the inventory.

Figure 2.18
Emissions from waste from all sectors 1990-2016



[12] The drop in emissions from 2011 to 2012 in Figure 2.18 is a result of to changes in emissions estimation methodology

3. Conclusion

The sector-based inventory estimates emissions from multiple types of sources, including transportation, residential, commercial, industry and agriculture. It accounts for all emissions that physically originate within Oregon's borders, and the emissions at the point of generation for all electricity used in Oregon regardless of where that electricity is produced.

Oregon's sector-based greenhouse gas emissions rose steadily throughout the 1990s, from 56 to 72 million $MTCO_2e$ in 1999. After that peak year, emissions began to trend downward, but have more recently shown mixed results in the different sectors. Emissions have consistently remained higher than 1990 levels.

Fuel use in Oregon has increased steadily for the past three years. Recent reported data indicates that growth in the transportation sector is the primary driver of recent statewide emissions. This trend is also supported by the observed increase in statewide vehicle miles traveled reported by the Oregon Department of Transportation. Emissions from passenger vehicles and light duty trucks are the largest sub-group within the transportation sector and account for 17 percent of statewide emissions.

As Oregon's population increases achieving emission reduction goals will become a greater challenge. The residential and commercial sectors contributed 35 percent of statewide emissions in 2015 and the residential sector continues to create the greatest demand for electricity, particularly to power appliances, electronics, and lighting.

Fortunately, Oregon's electricity sector continues to benefit from the availability of hydropower and an increase in adoption of renewable electricity. The availability of zero-emitting electricity along with a history of energy efficiency measures have helped to reduce emissions within that sector and offset emissions growth in other sectors.

Sector-based emissions in 2015 were estimated at 63 million $MTCO_2e$ and preliminary 2016 data indicates increased emissions in the transportation sector are offset by emission reductions in the electricity sector. Preliminary 2016 sector-based emissions data indicates that Oregon's emissions are 10 percent higher than 1990 levels.

Oregon has statutory goals to reduce in-state emissions 10 percent below 1990 levels by 2020 and 75 percent below 1990 levels by 2050. Current data suggest that Oregon is not on track to achieve the near-term 2020 target of 10 percent below 1990 levels.

Appendix A

Appendix A includes emission values and details on the methodology utilized to quantify emissions for the sector-based greenhouse gas inventory 2015 report. The inventory utilizes three primary sources of data including:

- EPA's State Inventory Tool (SIT)
- DEQ's Mandatory Greenhouse Gas Reported data
- Emissions estimates from DEQ's Materials Management section.

The tables in the first section of this document contain summary and detailed emissions data from the sector-based inventory. The second section provides a table describing the primary data source, by sub-category, used to calculate the emissions values. Additional information on sector-based emissions quantification methodology, mandatory reported emissions data and the full set of emissions data are available from DEQ's Greenhouse Gas Reporting Program: GHGReport@deq.state.or.us.

Preliminary emissions data

Emissions data for calendar year 2016 is considered preliminary. DEQ integrates mandatory greenhouse gas reported data for the industrial, natural gas, electricity, waste and fuel sectors with the most recent data outputs from the EPA State Inventory Tool to develop these preliminary emissions estimates. When an updated version of the State Inventory Tool becomes available, DEQ updates and finalizes preliminary emission estimates. DEQ is committed to updating the sector-based inventory on an annual basis.

1. Emissions data

The sector-based emissions inventory accounts for anthropogenic carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), and high global warming potential gases (HGWP) including hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF6) and nitrogen trifluoride (NF3). The accounting methods utilize Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4) global warming potentials (GWP) using a 100-year time horizon, as currently recommended by the United Nations Framework Convention on Climate Change (UNFCCC). All data is represented in million metric tons of carbon dioxide equivalent (million MTCO2e)[13].

Table A-1
Sector-based emissions summary (million MTCO2e)
Emissions from all sources are summed into the four key sectors.

Emissions by Key Sector	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
Transportation	21	23	24	25	23	22	22	21	21	23	24
Residential & Commercial	16	20	23	22	24	22	21	22	21	22	20
Industrial	14	17	18	14	12	12	12	12	12	13	12
Agriculture	5	5	5	6	5	6	6	6	6	6	6
Total Emissions	**56**	**65**	**70**	**66**	**64**	**62**	**61**	**61**	**60**	**63**	**62**

[13] Totals for tables may not sum due to rounding.

Table A-2
Sector-based detail data 1990-2016 (million $MTCO_2e$)
Tables below include detailed emissions data for each sector listed in Table A-1.

Transportation		**1990**	**1995**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
CO_2	Motor Gasoline	11.61	12.40	13.06	13.20	12.11	11.66	11.64	11.11	11.28	12.49	13.20
CO_2	Distillate Fuel	4.53	4.57	5.52	6.36	6.73	6.64	6.72	6.34	6.51	6.50	6.87
CO_2	Jet Fuel, Kerosene	1.25	2.05	2.57	2.21	1.75	1.84	1.86	1.78	1.80	2.04	2.16
CO_2	Natural Gas	0.49	0.40	0.65	0.41	0.42	0.31	0.28	0.26	0.23	0.30	0.30
CO_2	Residual Fuel	1.72	1.49	0.59	0.88	0.73	0.43	0.38	0.27	0.05	0.12	0.13
CO_2	Lubricants	0.22	0.21	0.23	0.19	0.18	0.17	0.16	0.16	0.17	0.19	0.19
CO_2	Aviation Gasoline	0.04	0.05	0.05	0.05	0.05	0.04	0.04	0.03	0.03	0.04	0.04
CO_2	Liquefied Petroleum Gas	0.04	0.03	0.01	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05
CO_2	Light Rail Electricity	0.00	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CO_2	Jet Fuel, Naphtha	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CH_4	Passenger & Light Vehicles	0.10	0.08	0.07	0.04	0.03	0.02	0.02	0.02	0.02	0.02	0.03
CH_4	Non-Road Vehicles & Equipment	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CH_4	Heavy-Duty Vehicles	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CH_4	Natural Gas Distribution (sector share)	0.04	0.04	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02
N_2O	Passenger & Light Vehicles	0.76	0.94	0.93	0.58	0.27	0.23	0.20	0.16	0.15	0.15	0.15
N_2O	Non-Road Vehicles & Equipment	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.04
N_2O	Heavy-Duty Vehicles	0.02	0.02	0.03	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01
HGWP	Refrigerants, A/C, Fire Protection	0.00	0.18	0.47	0.61	0.88	0.90	0.93	0.96	1.00	1.06	1.06
Transportation Sub-total		**20.97**	**22.54**	**24.29**	**24.68**	**23.27**	**22.38**	**22.36**	**21.24**	**21.38**	**23.03**	**24.25**

Residential & Commercial		**1990**	**1995**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
CO_2	Residential Electricity Use	5.93	7.55	8.43	7.99	8.32	7.46	7.00	7.41	7.06	7.24	6.25
CO_2	Commercial Electricity Use	4.66	6.27	7.28	6.70	6.83	6.05	5.87	6.17	6.08	6.35	5.49
CO_2	Residential Natural Gas Combustion	1.27	1.56	2.12	2.19	2.58	2.83	2.56	2.86	2.50	2.33	2.33
CO_2	Commercial Natural Gas Combustion	1.11	1.24	1.56	1.52	1.72	1.84	1.70	1.89	1.72	1.61	1.61
CO_2	Commercial Petroleum Combustion	0.79	0.56	0.54	0.34	0.42	0.33	0.24	0.20	0.22	0.56	0.60

CO_2	Residential Petroleum Combustion	0.76	0.65	0.62	0.46	0.35	0.34	0.29	0.29	0.27	0.26	0.27
CO_2	Waste Incineration	0.08	0.08	0.09	0.09	0.10	0.09	0.10	0.10	0.10	0.10	0.10
CO_2	Residential Coal Combustion	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO_2	Commercial Coal Combustion	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CH_4	Municipal Solid Waste Landfills	1.15	1.02	1.21	1.38	1.57	1.57	1.34	1.37	1.40	1.45	1.45
CH_4	Natural Gas Distribution	0.20	0.26	0.24	0.26	0.26	0.36	0.31	0.30	0.29	0.24	0.24
CH_4	Municipal Wastewater	0.23	0.25	0.27	0.29	0.31	0.31	0.31	0.31	0.32	0.32	0.32
CH_4	Residential Combustion Byproducts	0.06	0.08	0.07	0.08	0.11	0.11	0.10	0.14	0.14	0.10	0.10
CH_4	Commercial Combustion Byproducts	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
CH_4	Waste Incineration	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CH_4	Compost	0.00	0.02	0.02	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05
N_2O	Fertilization of Landscaped Areas	0.06	0.06	0.04	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09
N_2O	Residential Combustion Byproducts	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02
N_2O	Waste Incineration	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
N_2O	Compost	0.00	0.01	0.02	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04
N_2O	Commercial Combustion Byproducts	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N_2O	Municipal Wastewater	0.08	0.09	0.11	0.11	0.11	0.12	0.12	0.12	0.12	0.12	0.12
HGWP	Refrigerants, Aerosols, Fire Protection	0.00	0.13	0.33	0.43	0.61	0.63	0.65	0.67	0.70	0.74	0.74
Residential & Commercial Sub-total		**16.45**	**19.88**	**22.99**	**22.02**	**23.51**	**22.25**	**20.82**	**22.04**	**21.17**	**21.67**	**19.87**

Industrial		**1990**	**1995**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
CO_2	Industrial Electricity Use	5.98	7.33	7.57	5.52	5.17	4.59	4.46	4.68	4.80	5.13	4.43
CO_2	Natural Gas Combustion	2.60	3.74	4.07	3.75	3.45	3.38	3.33	3.47	3.36	3.36	3.37
CO_2	Petroleum Combustion	2.62	2.50	2.60	1.43	1.32	1.64	1.57	1.38	1.41	1.62	1.71
CO_2	Cement Manufacture	0.22	0.21	0.44	0.44	0.46	0.46	0.45	0.49	0.69	0.71	0.57
CO_2	Coal Combustion	0.14	0.27	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO_2	Ammonia Production	0.07	0.07	0.07	0.06	0.11	0.13	0.11	0.13	0.13	0.10	0.11
CO_2	Urea Consumption	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
CO_2	Waste Incineration	0.07	0.10	0.02	0.01	0.02	0.02	0.01	0.01	0.01	0.00	0.00

CO_2	Iron & Steel Production	0.70	0.70	0.75	0.34	0.03	0.03	0.03	0.04	0.03	0.04	0.03
CO_2	Soda Ash Production & Consumption	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
CO_2	Limestone and Dolomite Use	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.02	0.02	0.02	0.02
CO_2	Lime Manufacture	0.09	0.16	0.15	0.09	0.05	0.05	0.05	0.05	0.06	0.06	0.06
CO_2	Pulp & Paper including wastewater	0.19	0.19	0.19	0.19	0.19	0.19	0.18	0.14	0.14	0.14	0.13
CH_4	Natural Gas Distribution & Production	0.26	0.46	0.52	0.60	0.64	0.55	0.60	0.63	0.61	0.66	0.66
CH_4	Industrial Landfills	0.07	0.08	0.11	0.13	0.16	0.17	0.17	0.18	0.18	0.18	0.18
CH_4	Combustion Byproducts	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.03	0.02
CH_4	Food Processing Wastewater	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CH_4	Waste Incineration	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01
N_2O	Combustion Byproducts	0.05	0.04	0.04	0.03	0.03	0.03	0.04	0.04	0.04	0.05	0.04
N_2O	Waste Incineration	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
N_2O	Nitric Acid Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HGWP	Semiconductor Manufacturing	0.36	0.62	0.96	1.06	0.36	0.55	0.59	0.45	0.61	0.54	0.57
HGWP	Refrigerant, Foam, Solvent, Aerosol Use	0.00	0.06	0.14	0.18	0.15	0.10	0.13	0.11	0.11	0.13	0.12
HGWP	Aluminum Production	0.31	0.26	0.27	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial Sub-total		**13.81**	**16.87**	**17.97**	**14.06**	**12.22**	**11.98**	**11.83**	**11.90**	**12.28**	**12.83**	**12.10**

Agriculture		**1990**	**1995**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
CO_2	Urea Fertilization	0.06	0.07	0.05	0.12	0.12	0.13	0.13	0.13	0.13	0.13	0.13
CO_2	Liming of Agricultural Soils	0.03	0.03	0.04	0.04	0.03	0.04	0.04	0.05	0.05	0.06	0.06
CH_4	Enteric Fermentation	2.58	2.94	2.82	2.97	2.68	2.80	2.82	2.72	2.68	2.71	2.71
CH_4	Manure Management	0.30	0.32	0.35	0.49	0.50	0.54	0.57	0.57	0.59	0.59	0.59
CH_4	Agricultural Residue Burning	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.00
N_2O	Agricultural Soil Management	1.80	1.94	1.49	1.91	1.84	2.00	2.00	1.95	2.01	2.01	2.01
N_2O	Manure Management	0.14	0.15	0.16	0.16	0.14	0.14	0.15	0.14	0.15	0.15	0.15
N_2O	Agricultural Residue Burning	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agriculture Sub-total		**4.91**	**5.46**	**4.92**	**5.70**	**5.32**	**5.67**	**5.71**	**5.57**	**5.62**	**5.65**	**5.65**

Table A-3
Greenhouse gas emissions by gas
Total greenhouse gas emissions by gas including carbon dioxide (CO2), methane (CH4), nitrous oxide (N20), and high global warming potential gases (HGWP) including hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6) and nitrogen trifluoride (NF_3).

Year	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
Carbon dioxide	47.40	54.56	59.31	54.70	53.32	50.79	49.32	49.56	48.97	51.61	50.26
Methane	5.08	5.61	5.81	6.39	6.40	6.58	6.39	6.37	6.38	6.42	6.43
Nitrous oxide	2.97	3.34	2.90	3.00	2.61	2.73	2.72	2.63	2.69	2.69	2.69
High global warming potential	0.67	1.24	2.17	2.37	1.99	2.18	2.30	2.19	2.42	2.46	2.49
Total	**56.13**	**64.75**	**70.18**	**66.46**	**64.32**	**62.28**	**60.73**	**60.75**	**60.45**	**63.18**	**61.87**

Table A-4
Industrial process emissions by type (million MTCO2e)
Certain industrial processes emit greenhouse gases. This table includes non-energy related emissions from industrial activities. Starting with the 2010 emissions year industrial process emissions data is provided by DEQ's Greenhouse Gas Reporting program.

Data Source	EPA SIT data estimates				DEQ mandatory reported data						
Year	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
Aluminum Production	0.313	0.256	0.272	0.087	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Ammonia Production	0.069	0.071	0.067	0.056	0.113	0.130	0.115	0.129	0.130	0.101	0.110
Cement Manufacture	0.216	0.207	0.445	0.443	0.455	0.461	0.452	0.490	0.694	0.713	0.571
Food Processing Wastewater	0.012	0.012	0.009	0.008	0.008	0.009	0.009	0.009	0.009	0.009	0.009
Iron & Steel Production	0.704	0.704	0.750	0.340	0.030	0.031	0.030	0.035	0.033	0.038	0.027
Lime Manufacture	0.085	0.157	0.145	0.095	0.051	0.052	0.052	0.054	0.055	0.055	0.055
Limestone and Dolomite Use	0.009	0.011	0.008	0.009	0.000	0.000	0.014	0.015	0.018	0.018	0.018
Nitric Acid Production	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
Pulp & Paper	0.186	0.186	0.186	0.186	0.186	0.192	0.180	0.138	0.139	0.140	0.133
Semiconductor Manufacturing	0.357	0.619	0.957	1.064	0.356	0.548	0.588	0.449	0.608	0.540	0.571
Soda Ash Production & Consumption	0.031	0.032	0.032	0.032	0.027	0.026	0.026	0.026	0.027	0.026	0.026
Urea Consumption	0.008	0.009	0.007	0.015	0.016	0.017	0.016	0.017	0.017	0.017	0.017

Table A-5
Gross production emissions
For national data and US DOE state-level reporting, the federal government uses emissions attributable to in-state power generation (production based). The sector-based inventory uses power consumption and includes emissions produced outside of the state (emissions from electricity use). For purposes of comparison, emissions data using the production based method are below:

Year	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
Sector-based inventory total	56	65	70	66	64	62	61	61	60	63	62
Add in-state electric power generation	2	3	8	8	10	7	7	9	8	9	8
Remove electricity consumption total	(17)	(21)	(23)	(20)	(20)	(18)	(17)	(18)	(18)	(19)	(16)
Gross emissions, Production Basis	**42**	**47**	**54**	**54**	**54**	**51**	**51**	**52**	**51**	**53**	**54**

2. Data sources for the sector-based inventory

The sector-based inventory data are primarily derived from two sources: Data reported to DEQ's mandatory greenhouse gas reporting program and model outputs from the EPA's State Inventory Tool (SIT). The SIT is the primary source of data for the sector-based inventory from 1990 through 2009. Starting in 2010 DEQ's mandatory reporting program data is the source for approximately 80% of the inventory data. Table A-6 lists the source of data utilized for each emissions category listed in the sector-based inventory starting in 2010. Within each sector, sources are divided by type of greenhouse gas (CO_2, CH_4, N_2O and HGWP gases). DEQ's materials management program provides emissions data for small landfills, waste incineration and compost portions of the inventory for all years.

Abbreviations:
MR = Oregon Department of Environmental Quality Greenhouse Gas Reporting Program (mandatory reporting)
SIT = US Environmental Protection Agency State Inventory Tool
EIA SEDS = Energy Information Administration State Energy Data System (from US Department of Energy)
HGWP = High Global Warming Potential gases (HFCs, PFCs, and SF6)

Table A-6.
Data sources for the sector-based inventory

Gas	Emissions Source Category	Emissions Source Category	MB	SIT	Data Sources, Methodologies, and Assumptions
Transportation					
CO_2	Motor Gasoline		**X**		Applied EIA SEDS transportation sector proportion to derive share of Emissions from data reported by fuel importers.
	Distillate Fuel		**X**		Applied EIA SEDS transportation sector proportion to derive share of emissions from data reported by fuel importers.
	Jet Fuel, Kerosene		**X**		Applied EIA SEDS transportation sector proportion to derive share of emissions from data reported by fuel importers.
	Natural Gas		**X**		Applied EIA SEDS transportation sector proportion to derive share of emissions from data reported by natural gas suppliers
	Residual Fuel		**X**		Applied EIA SEDS transportation sector proportion to derive share of emissions from data reported by fuel importers.
	Lubricants			**X**	Derived from EIA SEDS
	Aviation Gasoline		**X**		Applied EIA SEDS transportation sector proportion to derive share of emissions from data reported by fuel importers.
	LPG			**X**	Derived from EIA SEDS
	Light Rail Electricity Use		**X**		Applied EIA SEDS sector proportion to the emissions reported to DEQ by utilities
	Jet Fuel, Naphtha			**X**	Derived from EIA SEDS
CH_4	Passenger & Light Vehicles			**X**	EPA modeling outputs
	Non-Road Vehicles & Equipment			**X**	EPA modeling outputs
	Heavy-Duty Vehicles			**X**	EPA modeling outputs
	Natural Gas Distribution (sector share)			**X**	Proportional sector share of total SIT natural gas distribution based on EIA SEDS sector proportion
N_2O	Passenger & Light Vehicles			**X**	EPA modeling outputs
	Non-Road Vehicles & Equipment			**X**	EPA modeling outputs
	Heavy-Duty Vehicles			**X**	EPA modeling outputs
HGWP	Refrigerants, A/C, Fire Protection Use			**X**	50% of total modeled HGWP gases (population-based from national total) assigned to sector based on consumption modeling for US national inventory

Residential & Commercial				
CO_2	Residential Electricity Use	**X**		Applied EIA SEDS residential sector proportion to derive share of emissions from data reported by utilities
	Commercial Electricity Use	**X**		Applied EIA SEDS commercial sector proportion to derive share of emissions from data reported by utilities
	Residential Natural Gas Combustion	**X**		Applied EIA SEDS residential sector proportion to derive share of emissions from data reported by natural gas suppliers
	Commercial Natural Gas Combustion	**X**		Applied EIA SEDS commercial sector proportion to derive share of emissions from data reported by natural gas suppliers
	Commercial Petroleum Combustion	**X**		Applied EIA SEDS commercial sector proportion to derive share of emissions from data reported by fuel importers.
	Residential Petroleum Combustion	**X**		Applied EIA SEDS residential sector proportion to derive share of emissions from data reported by fuel importers.
	Waste Incineration	neither		Data provided by DEQ Materials Management program
	Residential Coal Combustion		**X**	Derived from EIA SEDS
	Commercial Coal Combustion		**X**	Derived from EIA SEDS
CH_4	Municipal Solid Waste Landfills	**X**		Data reported by MSW landfills, supplemented with DEQ estimates for non-reporting landfills
	Natural Gas Distribution (sector share)		**X**	Proportional sector share of total SIT natural gas distribution based on EIA SEDS sector proportion
	Municipal Wastewater		**X**	Derived from population and US national inventory
	Residential Combustion Byproducts	**X**	**X**	Reported data for natural gas, SIT data for other fuels (fuel oil, propane, etc.)
	Commercial Combustion Byproducts	**X**	**X**	Reported data for natural gas, SIT data for other fuels (fuel oil, propane, etc.)
	Waste Incineration	neither		Data provided by DEQ Materials Management program
N_2O	Fertilization of Landscaped Areas		**X**	EPA modeling outputs (see national inventory)
	Residential Combustion Byproducts	**X**	**X**	Reported data for natural gas, SIT data for other fuels (fuel oil, propane, etc.)
	Waste Incineration	neither		Data provided by DEQ Materials Management program
	Commercial Consumption Byproducts	**X**	**X**	Reported data for natural gas, SIT data for other fuels (fuel oil, propane, etc.)
	Municipal Wastewater		**X**	Derived from population and US national inventory
HGWP	Refrigerants, Aerosols, Fire Protection Use		**X**	35% of total modeled HGWP gases (population-based from national total) assigned to sector based on consumption modeling for US national inventory

Industrial				
CO_2	Industrial Electricity Use	**X**		Applied EIA SEDS industrial sector proportion to derive share of emissions from data reported by utilities
	Natural Gas Combustion	**X**		Applied EIA SEDS industrial sector proportion to derive share of emissions from data reported by natural gas suppliers
	Petroleum Combustion	**X**		Applied EIA SEDS industrial sector proportion to derive share of emissions from data reported by fuel importers.
	Cement Manufacture	**X**		Reported data
	Coal Combustion		**X**	Derived from EIA SEDS
	Ammonia Production & Urea Consumption	**X**		Reported data
	Waste Incineration	neither		Data provided by DEQ Materials Management program
	Iron & Steel Production	**X**		Reported data
	Soda Ash Production & Consumption	**X**		Reported data
	Limestone and Dolomite Use	**X**		Reported data
	Lime Manufacture	**X**		No reported emissions
CH_4	Pulp & Paper Wastewater	**X**		Reported data
	Natural Gas Distribution & Production		**X**	Proportional sector share of total SIT natural gas distribution based on EIA SEDS sector proportion, plus additional emissions associated with production
	Industrial Landfills	neither		Data provided by DEQ Materials Management program
	Combustion Byproducts	**X**	**X**	Reported data for natural gas, SIT data for other fuels (fuel oil, propane, etc.)
	Food Processing Wastewater		**X**	Derived from estimates of processed foods in the Oregon Agripedia (ODA statistics book)
N_2O	Combustion Byproducts	**X**	**X**	Reported data for natural gas, SIT data for other fuels (fuel oil, propane, etc.)
	Waste Incineration	neither		Data provided by DEQ Materials Management program
	Nitric Acid Production	**X**		Reported data
HGWP	Semiconductor Manufacturing	**X**		Reported data
	Refrigerant, Foam, Solvent, Aerosol Use	**X**		Reported data (note: approach taken in industrial sector for HGWP gases is different from in other sectors, but accuracy of data justifies differing treatment. Some emission sources likely missing.)
	Aluminum Production	**X**		No reported emissions, no known production in OR

Agriculture				
CO_2	Urea Fertilization		X	Derived from Oregon Agripedia (ODA statistics book)
	Liming of Agricultural Soils		**X**	Derived from Oregon Agripedia (ODA statistics book)
CH_4	Enteric Fermentation		**X**	EPA modeling outputs (see national inventory)
	Manure Management		**X**	EPA modeling outputs (see national inventory)
	Agricultural Residue Burning		**X**	EPA modeling outputs (see national inventory)
N_2O	Agricultural Soil Management		**X**	Derived from Oregon Agripedia (ODA statistics book)
	Manure Management		**X**	EPA modeling outputs (see national inventory)
	Agricultural Residue Burning		**X**	EPA modeling outputs (see national inventory)

In-State Electric Power Generation				
CO_2	OR Power Plant Natural Gas Combustion	**X**		Reported data
	OR Power Plant Coal Combustion	**X**		Reported data
	OR Power Plant Petroleum Combustion	**X**		Reported data
CH_4	OR Power Plant Combustion Byproducts	**X**		Reported data
N_2O	OR Power Plant Combustion Byproducts	**X**		Reported data
HGWP	Transmission and Distribution Systems		**X**	EPA modeling outputs (see national inventory)