PRE-PUBLICATION DRAFT

INVENTORY AND FORECAST OF OREGON'S GREENHOUSE GAS EMISSIONS

--- 2007 REVISION AND UPDATE ---

October 31, 2007

Revision and Update of the Oregon Greenhouse Gas Inventory first published in the *Oregon Strategy for Greenhouse Gas Reductions* in December 2004.

This document will be published as an appendix in the final report of the Climate Change Integration Group (CCIG), which will be completed at the end of 2007.

DISCLAIMER: Until final publication of this document at the end of 2007, both the narrative and data contained within may be subject to revision. However, unless substantial errors or key flaws in the software are discovered, the inventory data are unlikely to change.

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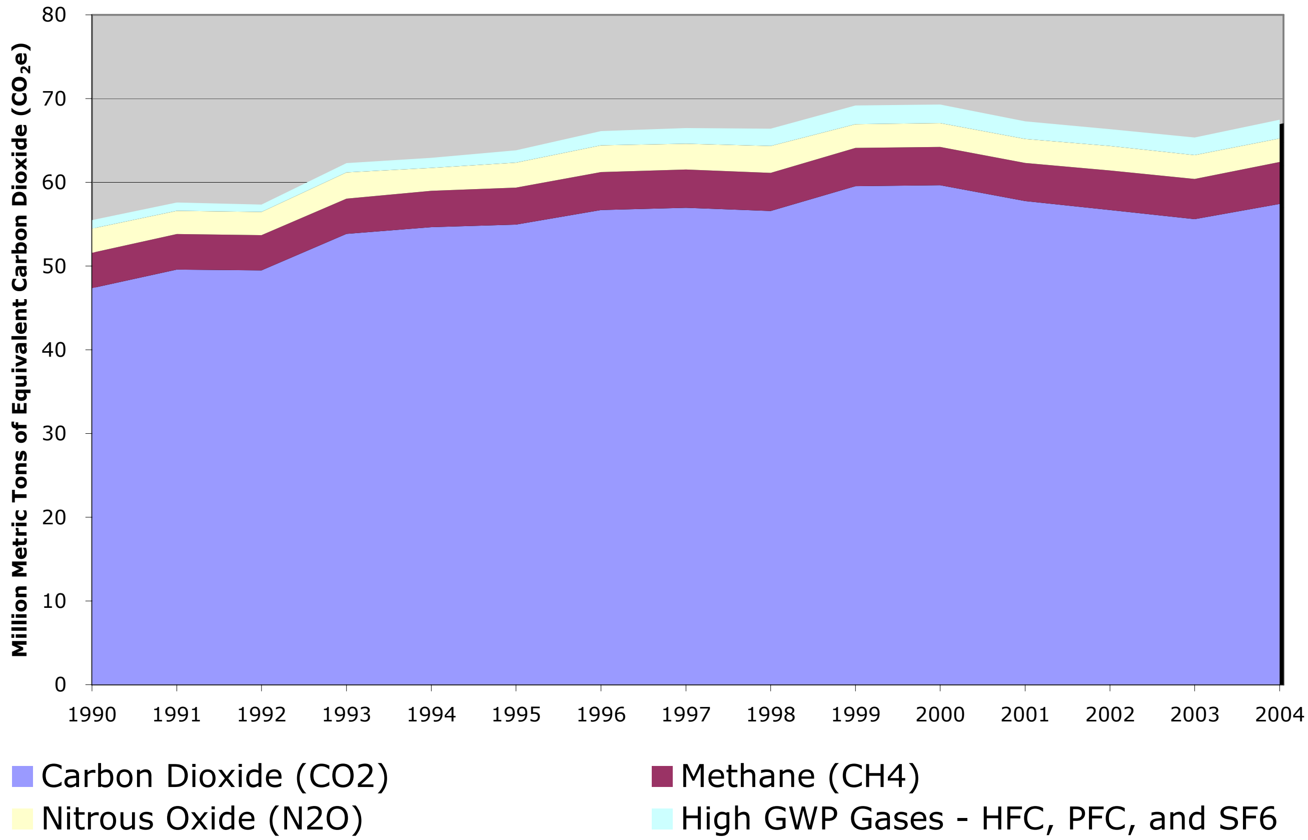
INVENTORY AND FORECAST OF OREGON'S GREENHOUSE GAS EMISSIONS

In 2004, Oregon's greenhouse gas (GHG) emissions were 67.5 million metric tons of carbon dioxide equivalent[1] (MMTCO_2e).[2] That was about one percent of greenhouse gas emissions for the United States as a whole, which were roughly 7.1 billion metric tons CO_2e.

Greenhouse gas emissions increased by 12 million metric tons from 1990 levels by 2004, which is a 22 percent increase over Oregon's 1990 greenhouse gas emissions of 55.5 million metric tons of eCO_2. This compares with a 16 percent increase for the United States. Figure 1 shows the change in emissions for different greenhouse gases between 1990 and 2004.

Figure 1: Oregon Greenhouse Gas Emissions 1990-2004



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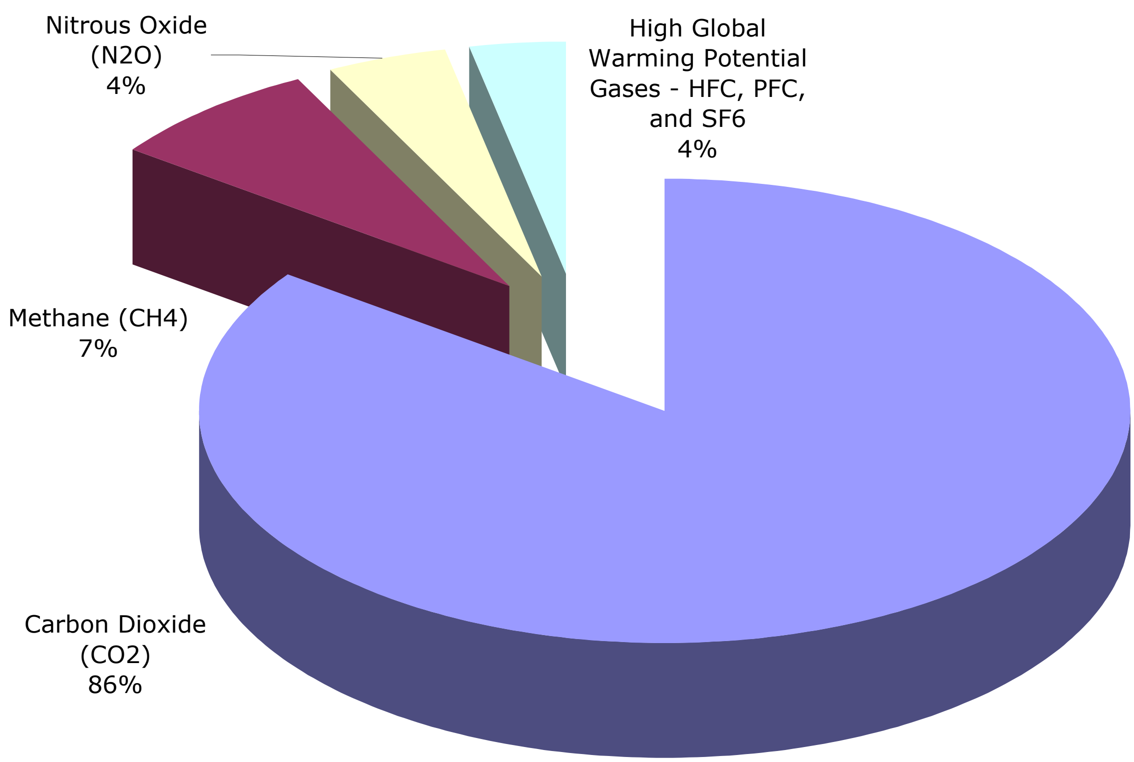
1 "Carbon dioxide equivalent (CO_2e)" refers to a comparison of the radiative force of different greenhouse gases related to CO_2, based on their global warming potential. It is a way to compare all greenhouse gases on a uniform scale of how much CO_2 would be needed to have the same warming potential as other gases over the same time scale. Following US Environmental Protection Agency (EPA) and international reporting protocols per the *Second Assessment Report*, methane is 21 times more powerful than CO_2 over 100 years and nitrous oxide is 310 times more powerful (newer IPCC GWPs are not used in this report).

2 The Department used the US Environmental Protection Agency State Inventory Tool (SIT) for estimating greenhouse gas emissions to prepare its inventory except for CO_2 emissions from electricity use and emissions from waste. Default data in the tool are often used, but other data sources are also used.

As shown in Figure 2, the vast majority of Oregon's greenhouse gas emissions (86 percent) came from carbon dioxide (CO_2). The primary source of CO_2 pollution came from burning fossil fuels, such as coal at power plants serving the state, gasoline, diesel, and natural gas. There were also emissions from industrial processes, such as the manufacture of cement and from combustion of fossil-fuel derived products in burning municipal and industrial wastes.

In 2004, emissions from methane (CH_4), primarily from cattle and landfills, contributed 7 percent of greenhouse gas emissions in Oregon. Nitrous oxide (N_2O) emissions, primarily from agricultural practices, contributed about 4 percent to greenhouse gas emissions. The "high global warming potential gases" (high GWP gases) which consist of two classes of gases -- hydrofluorocarbons (HFC) and perfluorocarbons (PFC) -- and one individual gas -- sulfur hexafluoride (SF_6) -- accounted for the remaining 4 percent of emissions.

Figure 2: Greenhouse Gas Emissions Breakdown by Gas for 2004



Greenhouse gas emission data for all gases from 1990 through 2004 is provided in Table 1 along with forecast data and in Table 2 (with detailed sector data) at the back of this appendix.

Carbon Dioxide Emissions

Fossil fuel combustion is the primary source of CO_2 emissions. Emissions from fossil fuel combustion are divided into two primary categories. Direct emissions from fossil fuel combustion and indirect emissions associated with the consumption of electricity in Oregon.

Electricity Generation. Electricity was the fastest growing source of CO_2 from the use of fossil fuels in the period 1990 through 2004. Emissions from electricity consumption grew 29 percent from 1990 to 2004. One reason for this increase is the phasing out of the Trojan nuclear power plant in the early 1990s.

Figure 3: Electricity Supply Mix in 2004

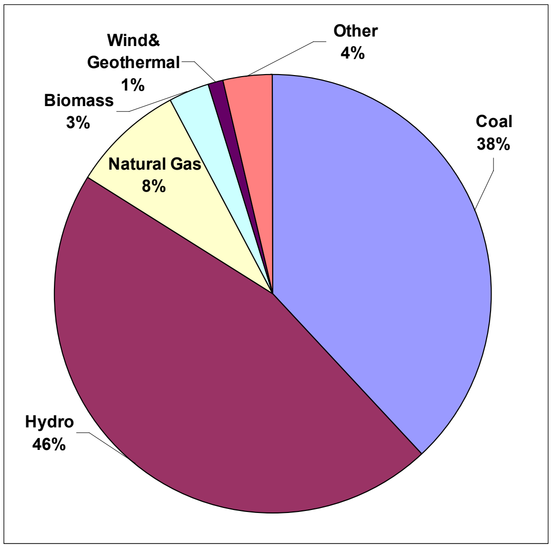
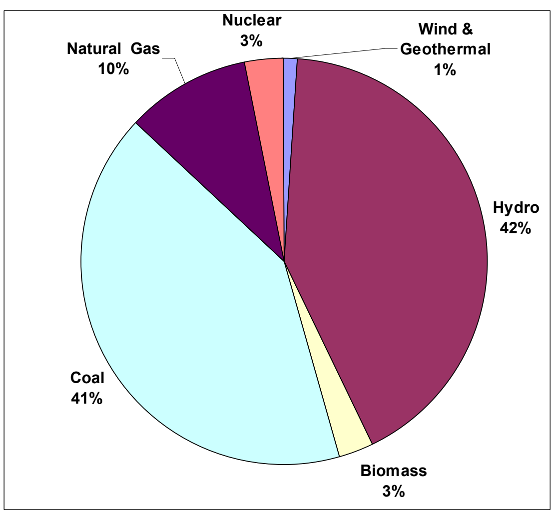


Figure 4: Electricity Supply Mix in 2005



An emerging consensus is for greenhouse gas inventories, especially at the state or regional level, to attribute energy emissions to the jurisdiction in which the energy is consumed. Following this convention, the Department calculates emissions from electricity generation based on the carbon content of the regional mix of electricity that serves Oregon's electrical load. This approach is known as a "consumption-based" inventory methodology.

In contrast, the federal government uses a "production-based" inventory methodology which counts emissions from power that is generated within a jurisdiction's geographic boundaries (but not from the consumption of electricity). At the national level this approach makes sense. However, the "consumption based" regional approach better reflects carbon emissions in Oregon for the following reasons:

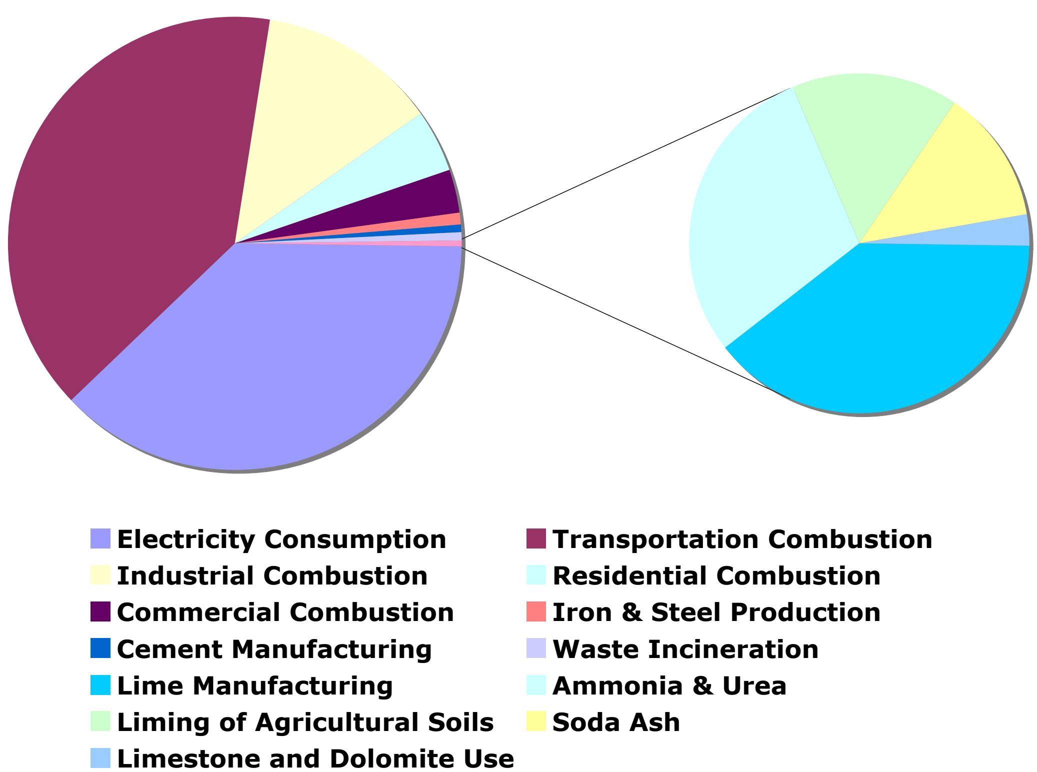
1) Oregon's second-largest utility, PacifiCorp, has most of its power generation out of state, and most of that is coal-fired.
2) Taking credit for hydropower generated for the Bonneville Power Administration from Columbia River dams, as it is allocated to Oregon in national inventories, does not reflect the way that electricity (and its associated emissions) is actually distributed in the region.
3) Using a "production based" inventory as a means to measure policy actions at the state level can lead to absurd results. In effect, an action to reduce emissions only leads to an emissions reduction if the emissions are physically generated within state boundaries.

It is important to understand the interaction between the mix of power sources serving Oregon's electrical load in any given year and CO_2 emissions associated with that power. Figures 3 and 4 above show the power supply mix serving Oregon load in 2004 and 2005, respectively. Note that in 2004 a greater proportion of Oregon's power came from zero emission hydropower sources, whereas in 2005 the ratio between coal power and hydropower was roughly equal. Historically, Oregon has had a fairly even balance between coal and hydropower emissions serving Oregon load in any given year (roughly 40+ percent each). In those years where that balance tilts toward hydropower there will normally be a drop in overall state greenhouse gas emissions. However, it is important to keep these year-to-year fluctuations in mind before drawing conclusions about short-term greenhouse gas emission trends for Oregon.

Emissions data for electricity were derived from several analyses. Data for 1990, 1991, and 1992 take into account the contributions of the Trojan nuclear plant based on a detailed analysis of power contracts in 1990. Data for 1993 through 2000 are based on a region-wide average of carbon content for that period. Data for 2001 through 2004 derive from detailed yearly analyses of the region-wide carbon content of electricity serving Oregon load.

Transportation. Gasoline and diesel fuel use in transportation[3] were the largest sources of CO_2 emissions from fossil fuels at 40 percent in 2004. Emissions from transportation grew 14 percent from 1990 to 2004, but the relative contribution has changed only slightly.

Figure 5: Breakdown of CO2 Emissions by Source in 2004



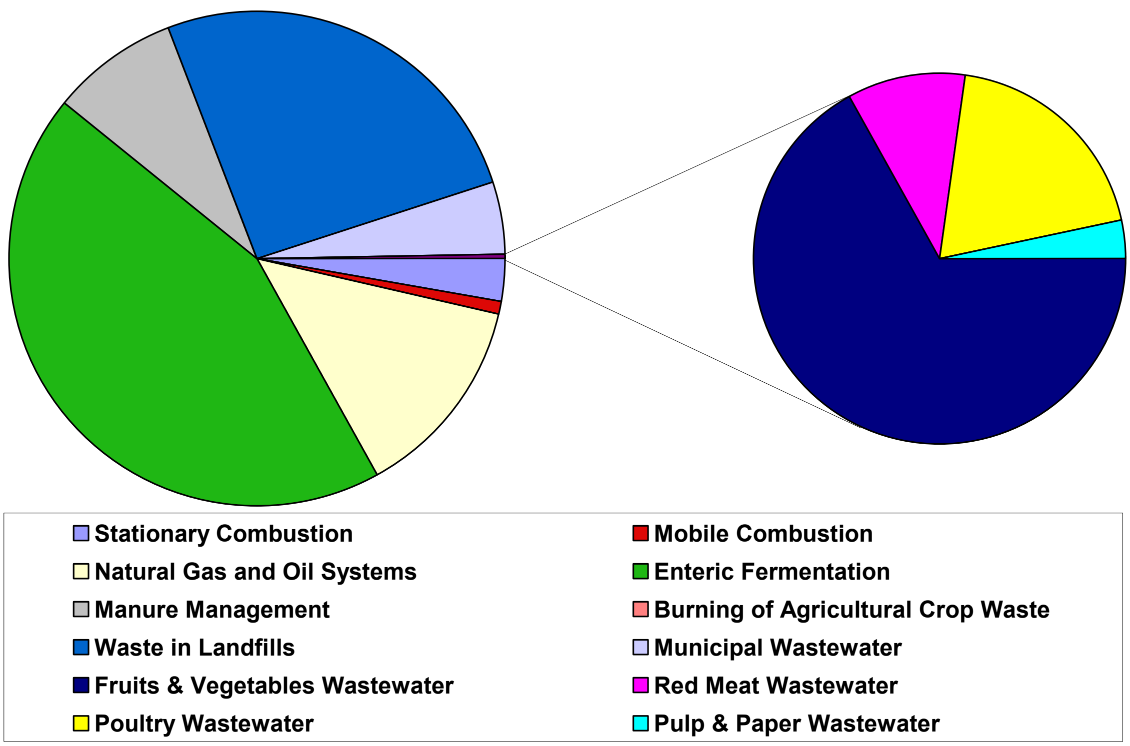
[3] Residual fuels use by vessels is not included because international ships are the primary purchasers. They purchase fuel at any port, based on price. Therefore combustion of the fuel is not directly related to economic activity within Oregon.

Direct Natural Gas and Distillate Use. CO_2 emissions from the industrial and residential sector from direct natural gas and distillate fuel combustion grew by 45 and 27 percent, respectively, from 1990 to 2004. Other sources were asphalt and petroleum coke in the industrial sector and liquefied petroleum gas in the residential sector. Emissions from the commercial sector were essentially flat, dropping only slightly (by about 5 percent).

Methane

Methane emissions contributed about 5 million metric tons of CO_2e in 2004. That represented about 7 percent of Oregon's 2004 greenhouse gas inventory. The distribution of methane emissions for 2004 is shown in Figure 6 below.

Figure 6: Methane Emissions by Source in 2004



More than half of methane emissions came from agricultural practices. Enteric fermentation, or burps from cattle and other domesticated animals, contributed 44 percent. The methane is generated in the rumen, or first stomach, of cattle and other ruminants. Another 8 percent came from manure management, both from that managed in lagoons on farms or that simply deposited on the ground.

The second largest source of methane was from waste in municipal and industrial landfills at 26 percent. Leaks from natural gas and oil systems (calculated from miles of pipeline and number of services) amount to about 13 percent of methane emissions. Another 5 percent came from wastewater from municipal facilities, pulp and paper production, fruit and vegetable processing, and red meat and poultry processing. Other sources include emissions from vehicles, and emissions from combustion of natural gas, distillate, residual fuel, and wood in homes and businesses.

Waste Emissions Data

Estimates of emissions from solid waste facilities combine data from several sources[4]. ODEQ tracks the quantity of solid waste disposed of at landfills and incinerators in Oregon, by state of origin. (Significant quantities of garbage from Washington are disposed of in Oregon.) Estimates are also made of the quantity of mixed wastes burned by households (backyard burning, etc.). For land filling and combustion of unsorted wastes, preliminary data from Oregon's periodic waste composition studies is used to estimate the composition of wastes land filled and incinerated. Composition estimates are combined with bulk tonnage estimates to estimate the tonnage of different materials (resins of plastics, wood, grades of paper, etc.) disposed of in different classes of facilities. DEQ's annual material recovery survey also tracks the quantities of certain wastes that are burned for energy. US EPA emissions factors (carbon dioxide and nitrous oxide) for combustion of individual materials (plastics, wood, paper, etc.) are then applied against estimates of tons of each waste type incinerated.

EPA emission factors (carbon) are also applied to estimated quantities of wastes land filled, in order to estimate sequestration of biogenic carbon buried in landfills. These sequestration estimates are assigned to the year in which the waste is land filled. For more information on carbon sequestration estimates, see the "Net Emissions and the Oregon Inventory" section.

Estimates of methane emissions from landfills are slightly more complex. First, estimates are made of the quantity of methane generated in each landfill. Generation (and related emissions) is assigned to the year the methane is assumed to be generated, not the year in which the waste is first disposed of. For each landfill, DEQ combines time series data on waste flows, EPA-approved generation factors, and generation curves (as a function of time) developed to estimate the quantity of methane generated in any given year. To simplify the analysis, the state's very small landfills are treated as a single unit.

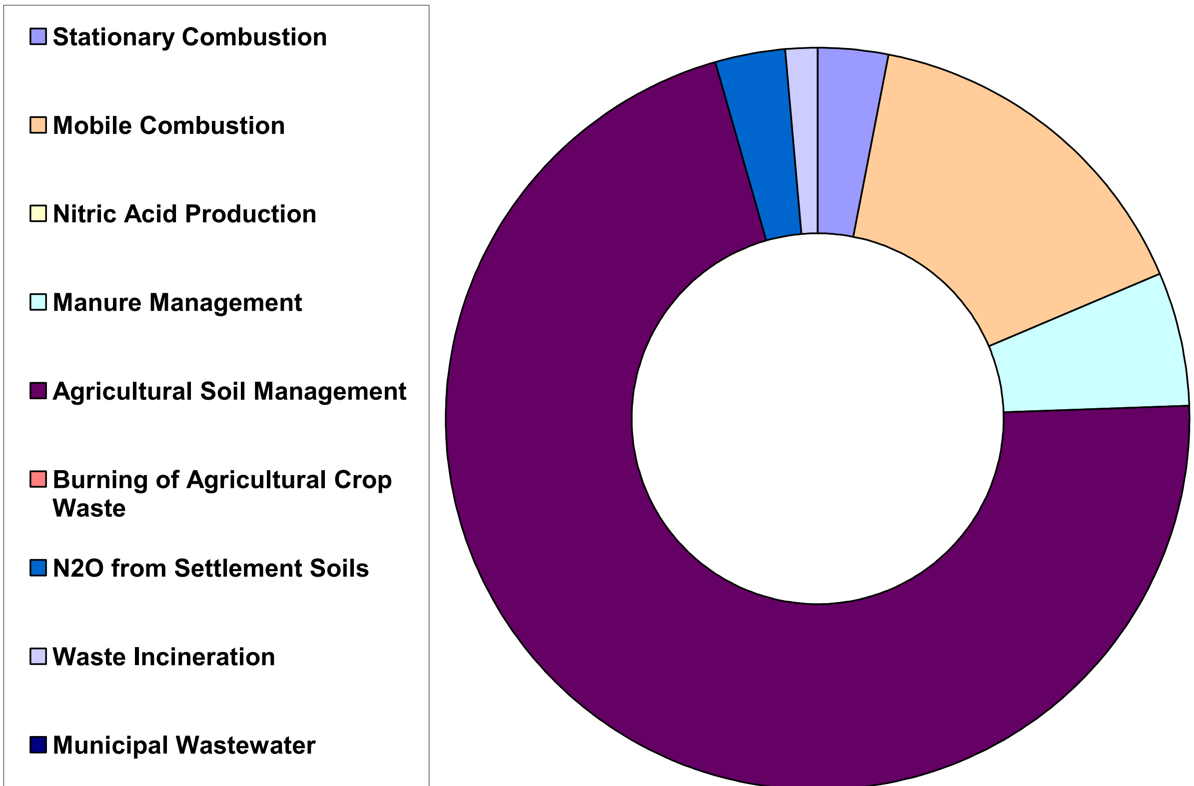
For wastes disposed of prior to 2003, an EPA model is used that treats waste disposed of as a homogenous mass. For waste disposed of in 2003 and subsequent years, DEQ uses waste composition data to estimate the tons of each waste type and applies these estimates against methane generation factors for individual waste types. Once methane generation is modeled, estimates are made as to the percentage of methane at each landfill that is captured through gas collection systems and the percentage of fugitive emissions that are oxidized as the methane passes through the landfill surface layer. Emissions to the atmosphere are estimated as methane generated, less methane captured and oxidized.

[4] It is important to note that for most materials, the emissions associated with producing materials are significantly greater than the emissions associated with disposing of them. Some of these production-related emissions are already captured in Oregon's inventory, but most are not, because they occur out of state. The greenhouse gas benefits of recycling and waste prevention are largely due to energy savings and forestry-related storage, not avoided emissions at waste disposal facilities.

Nitrous Oxide

Nitrous oxide (N_2O) emissions contributed about 2.8 $MMTCO_2e$ in 2004. That represented about 4 percent of Oregon's 2004 greenhouse gas emissions. The distribution of N_2O emissions for 2004 is shown in figure 7.

Figure 7: Nitrous Oxide Emissions in 2004



The primary source of N_2O emissions (over 70 percent) is from agricultural soil management through numerous pathways. N_2O is emitted from agricultural soils due to synthetic and organic fertilizer use, application of animal wastes through daily spread activities, application of managed animal wastes, crop residues remaining on agricultural fields, biological nitrogen fixation by certain crops, cultivation of highly organic soils, and land application of sewage sludge. N_2O also is emitted from soils from direct deposit of animal wastes in pastures, ranges and paddocks. There are also indirect emissions from fertilizers and from leaching and runoff. In addition to agricultural soils management, N_2O is directly emitted from the manure decomposition process.

About 16 percent of N_2O emissions) result from internal combustion engines and during the catalytic after-treatment of exhaust gases, but these processes are not well understood.

High Global Warming Potential Gases

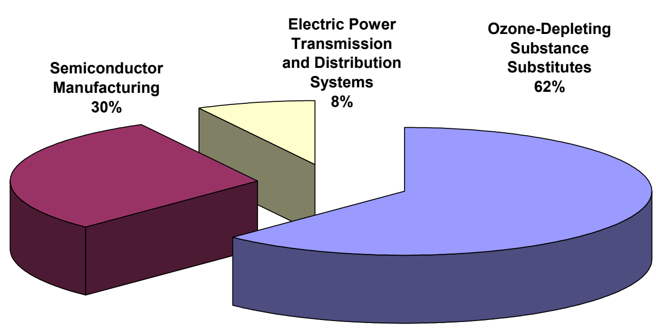
The so-called "high global warming potential gases" consist of two categories of gases – Perfluorocarbons (PFCs) and Hydrofluorcarbons (HFCs) – and one individual gas, Sulfur Hexafluoride (SF_6). These gases have a global warming potential (i.e., amount of radiative forcing) that is between 140 to 23,900 times more potent than CO_2 in terms of their impact on global climate over a 100-year time span. Thus, introducing even minute portions of these gases into the atmosphere can have major impacts.

In Oregon, the key sources for high global warming potential gases are replacement coolants and various processes in the semiconductor industry. Figure 8 shows the relative share of industries that contribute to the release of these gases. Emissions of the high global warming potential gases have more than doubled between 1990 and 2004, although this is largely due to the rise of substitutes for ozone-depleting substances in the cooling industry.

Perfluorocarbons (PFCs): Aluminum production was the major source of Perfluorocarbons from 1990 to 1996. The emissions occur during the reduction of alumina in the primary smelting process. (As of 2001, aluminum is no longer produced from alumina in Oregon, and recycling aluminum does not produce PFC emissions.) Beginning in 1997, emissions from PFCs for plasma etching and chemical deposition processes in the semiconductor industry exceeded aluminum production, and by 2004 represented all PFC emissions in this inventory.

Hydrofluorcarbons (HFCs): HFCs are most commonly used as a replacement for Chlorofluorocarbons (CFCs) in cooling and refrigeration systems. CFCs were formerly the most common refrigerant, but CFCs destroys the stratospheric ozone layer. Therefore, its production is banned by international treaty. Use and discharge of HFCs is controlled as a refrigerant, but not for other uses.

Figure 8: High Global Warming Potential Gas Emissions in 2004 (HFCs, PFCs, and SF_6)



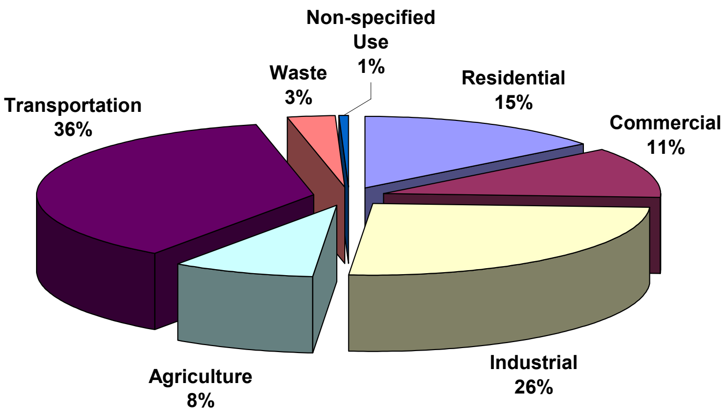
Hydrofluorcarbons are used for foam blowing, fire extinguisher applications, aerosols, sterilization, and as solvents. Hydrofluorcarbons are also used in plasma etching and chemical deposition processes in the semiconductor industry. While Hydrofluorcarbons do not damage the ozone layer, they are powerful greenhouse gases.

Sulfur Hexafluoride (SF6): Sulfur Hexafluoride is one of the most powerful greenhouse gases. It is 23,900 times more powerful than CO_2. The largest use of Sulfur Hexafluoride is as an electrical insulator in transmission and distribution equipment. Sulfur Hexafluoride is also used for plasma etching and chemical vapor deposition processes in the semiconductor industry. There was some Sulfur Hexafluoride emitted from aluminum production as well.

Contributions from Sectors of the Economy

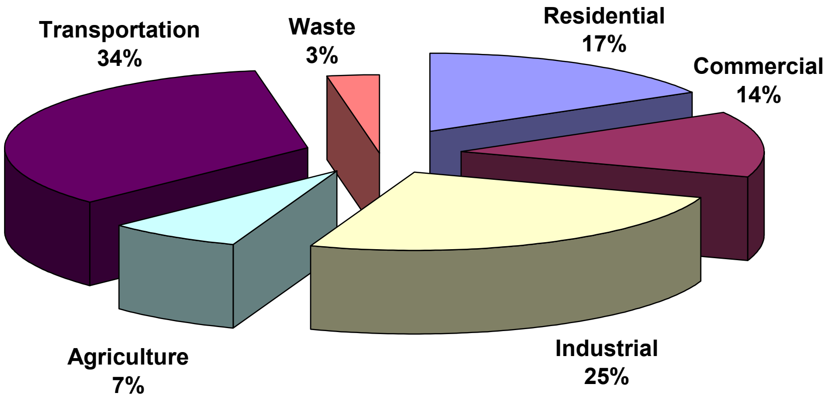
Different sectors of Oregon's economy contribute differently to the emissions of greenhouse gases. Those contributions have changed over time. Figures 9 and 10 illustrate how key sectors contribute in 1990 and in 2004 based on Oregon's economy.

Figure 10: Sector Contributions in 1990



Of particular note is the continuing dominance of the transportation sector as the major source of Oregon's greenhouse gas emissions. The industrial sector is a distant second. Oregon's population growth is reflected in the increase in emissions from the residential sector, and the nation's continuing trend toward service economy jobs is likely one reason for the growth in the commercial sector. Note that the electricity consumption associated with each sector is included in both Figures 9 and 10, but is embedded as part of the sub-totals in each relevant sector.

Figure 9: Sector Contributions in 2004



Emission Forecasts

Based on US EPA forecasting tools and previously conducted sector-specific forecasts, the Department forecasts that Oregon's greenhouse gas emissions will grow by 30 MMTCO$_2$e, or 55 percent, in the worst case estimate from 1990 to 2020. That rate assumes no change from current practices (a "business as usual" estimate). In reality, it will probably grow less. Table 1 shows the forecast by sources of gases, and contrasts it with historical data. Table 1 also provides a hybrid inventory/forecast estimate for 2005[5]. Unfortunately, the full set of data necessary to complete the inventory for 2005 will not be available until early 2008.

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[5] *Inventory* data derive from models, counts, or estimates that have been calculated or collected as a historical record. *Forecast* data derive from models or methodologies which use inventory data to project forward in time. Due to delays in federal data reporting, greenhouse gas inventories normally lag at least three years.

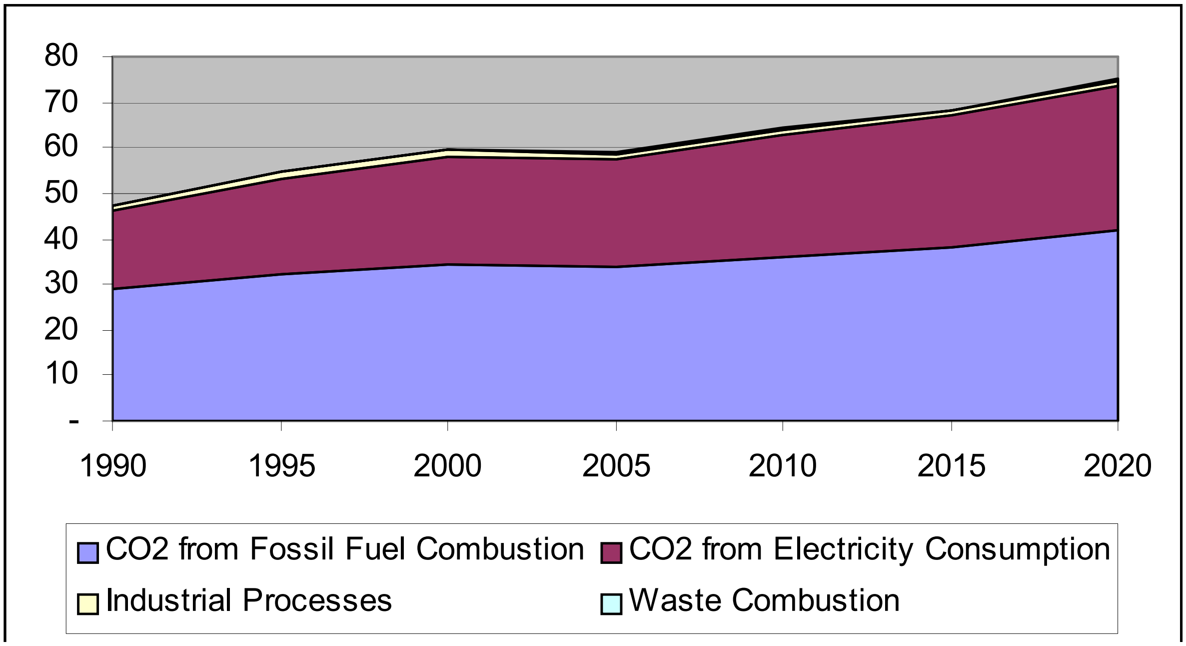
Table 1: Historical and Forecast Greenhouse Gas Emissions through 2020 (Consumption Basis)

Gross $MMTCO_2e$	Inventory Data				Forecast Data			
	1990	1995	2000	2004	2005	2010	2015	2020
Carbon Dioxide (CO_2)								
CO_2 from Fossil Fuel Combustion[1]	29.25	32.16	34.48	34.47	33.84 **	35.90	37.96	42.10
CO_2 from Electricity Consumption	16.70	21.27	23.41	21.54	23.85 *	27.01	28.92	31.49
Industrial Processes	1.11	1.19	1.46	1.06	0.98 *	1.21	1.21	1.20
Waste Combustion	0.27	0.31	0.27	0.32	0.36 *	0.31	0.32	0.34
CO_2 Total	47.33	54.93	59.61	57.39	59.03	64.43	68.41	75.13
Methane (CH_4)								
Stationary Combustion	0.10	0.10	0.10	0.14	0.10 **	0.09	0.09	0.09
Mobile Combustion	0.06	0.05	0.04	0.03	0.02 *	0.02	0.02	0.02
Natural Gas and Oil Systems	0.58	0.61	0.64	0.67	0.68 *	0.71	0.74	0.78
Enteric Fermentation	2.00	2.21	2.13	2.20	2.15 *	1.74	1.74	1.73
Manure Management	0.26	0.28	0.31	0.41	0.41 *	0.40	0.40	0.39
Burning of Agricultural Crop Waste	0.00	0.00	0.00	0.00	0.00 *	0.01	0.01	0.01
Waste	1.04	0.93	1.12	1.29	1.26 *	1.65	1.92	2.08
Wastewater	0.20	0.22	0.24	0.25	0.25 *	0.28	0.29	0.31
CH_4 Total	4.23	4.41	4.58	5.01	4.88	4.90	5.22	5.42
Nitrous Oxide (N_2O)								
Stationary Combustion	0.11	0.10	0.10	0.09	0.09 **	0.08	0.07	0.08
Mobile Combustion	0.52	0.62	0.60	0.44	0.44 **	0.32	0.31	0.27
Industrial Processes	0.00	0.00	0.00	0.00	0.00 *	0.00	0.00	0.00
Manure Management	0.11	0.09	0.12	0.16	0.13 *	0.18	0.20	0.23
Agricultural Soil Management	2.06	2.08	1.96	1.99	2.37 *	2.07	2.07	2.08
Burning of Agricultural Crop Waste	0.00	0.00	0.00	0.00	0.00 *	0.01	0.01	0.01
Waste Combustion	0.02	0.02	0.03	0.03	0.03 *	0.03	0.03	0.03
Wastewater	0.00	0.00	0.00	0.00	0.00 *	0.00	0.00	0.00
N_2O Total	2.82	2.92	2.82	2.70	3.07	2.68	2.69	2.70
HFC, PFC, and SF_6								
Industrial Processes	1.04	1.47	2.19	2.26	2.44 *	1.62	2.00	2.41
Total Emissions	55.42	63.72	69.19	67.36	69.42	73.63	78.32	85.66

* = Inventory data for 2005 ** = Forecast data for 2005 from EPA projection tool (data for 2005 inventory due in 2008)
NOTE: Totals for 1990 through 2004 differ slightly from the detailed inventory (in Table 2) due to rounding differences.
[1] The fossil fuel combustion totals do not count in-state generation of electricity (this is a consumption-based inventory).

Figures 11 and 12 below illustrate the projected future growth of greenhouse gas emissions. The relative contribution of electricity consumption as compared with the direct combustion of fossil fuels (particularly in the transportation sector) is highlighted in Figure 11. The overall contributions of each type of greenhouse gas through 2020[6] are plotted in Figure 12.

Figure 11: Historical & Projected CO_2 Emissions (Million Metric Tons of CO_2)



Electricity Forecast: For CO_2 emissions from electricity, the Department used a growth rate of 1.6 percent, which is a composite of Northwest Power and Conservation Council forecasts and forecasts in the integrated resource plans of Portland General Electric and PacifiCorp[7].

Waste Methane Forecast: For methane emissions from waste the historic trend is used as the starting point for projecting future growth in waste generation. Using Department of Environmental Quality and US EPA data, estimates were made of the rate of change in per-capita waste generation during the period 1993 to 2002 for 30 different categories of wastes. The rates of adjusted growth in per-capita waste generation (by material) were then related to the rate of growth in inflation-adjusted Oregon personal income during the same period.

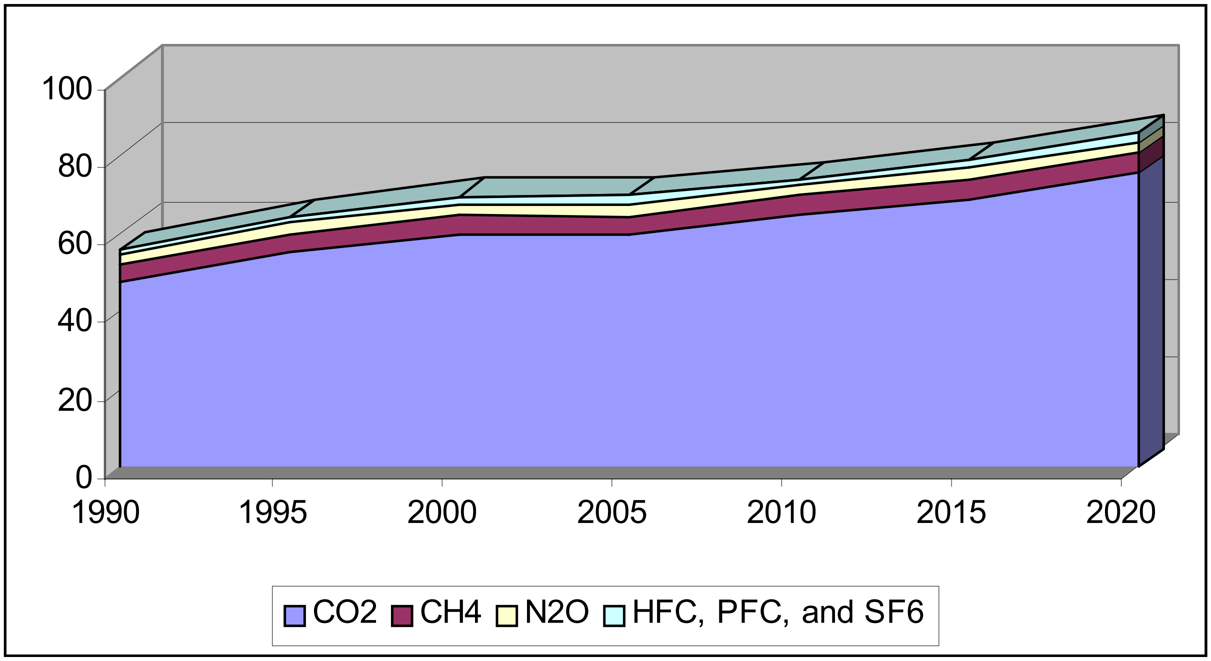
The estimate is that per-capita waste generation, aggregated across all 30 material categories, will grow to 10.1 pounds per person per day in 2025 under the "business as usual" scenario. This assumes that relationships between personal income and materials use/waste hold constant and is based on projections of inflation-adjusted personal income from the Oregon Department of Administrative Services. Coupled with projected population increases, total

[6] Note that in the 2004 inventory the forecasts extended to 2025. The EPA projection tool (which was not available for the last inventory process) only provides estimates to 2020, so that is the current upper limit.
[7] The electricity forecast used in this inventory is the same forecast that was used in the 2004 inventory.

in-state waste generation (all discards, including recycling and composting) is projected to grow from 5.1 million tons in 2003 to 8.4 million tons in 2025. The recovery rate (recycling and composting) of these wastes, at about 46 percent when these forecasts were made, is assumed to hold constant, so not all of the added discards end up in landfills.[8]

Oregon also imports significant quantities of municipal solid waste (garbage) from other states. Waste imports are modeled, growing at a rate of about 4.6 percent per year, from about 1.5 million tons projected in 2003 to 4.0 million tons in 2025. Only emissions associated with the disposal portion of the life cycle are counted for these imported wastes[9].

Figure 12: Projected Greenhouse Gas Emissions by Gas through 2020 (MMTCO$_2$e)



Forecasts for Sectors other than Electricity and Waste: All other sectors are forecasted using the US EPA projection tool, which is a relatively new addition to the State Inventory Tool (SIT) modules used for the majority of this inventory analysis. The EPA projection tool relies on the SIT inventory data to produce its forecasts by using economic and population indicator data as projection mechanisms. It also has a number of features particularly useful for the high global warming potential gases, where phase-out programs in place for many of those gases are included as part of the model. Where indicator data are not available, or where methods are not in place to predict future greenhouse gas emissions for certain sectors, the tool relies on linear forecasting methodology.

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[8] The non-landfill benefits of recycling, composting, and waste prevention, such as reduced fossil fuel use and increased carbon storage in forests and landfills, were included in estimates of the greenhouse gas benefits of specific measures. However, the state inventory does not account for non-landfill offsets, such as savings in industrial processes from using recycled feed-stocks, in part because many of the benefits involve emission reductions outside of Oregon.

[9] The waste forecasts for this inventory use the same data and models as the 2004 greenhouse gas inventory.

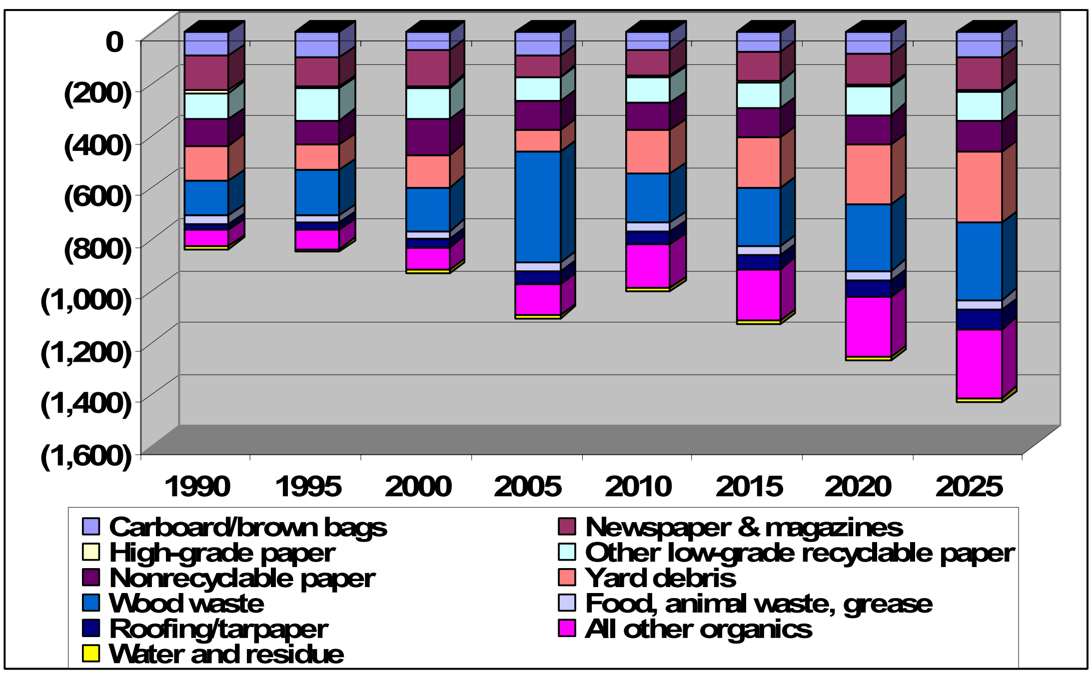
Net Emissions and the Oregon Inventory

The Oregon greenhouse gas inventory is a "gross" inventory process. Only emissions of greenhouse gases are counted and summarized in these pages. Some inventories also report on "net" emissions – which is the difference between the total emissions of greenhouse gases and carbon sinks (which sequester carbon out of the atmosphere). There are two major components to such an analysis. By far the largest potential sinks for Oregon are land use changes and forestry carbon dynamics (abbreviated "LUCF"). A secondary sink is carbon that is sequestered in landfills. However, due to substantial issues with forestry and land use data, Oregon is not yet ready to provide a net emissions total in its greenhouse gas inventory.

Waste Sequestration: Because food discards, yard trimmings, and paper do not completely decompose in the oxygen-depleted environment of a landfill, some of the carbon remains stored for long periods of time. (Exactly how long is not known.) This carbon storage would not normally occur under natural conditions, as discarded food, yard trimmings, and other plant-derived debris would normally be exposed to oxygen and thus degrade into carbon dioxide, thus completing the cycle of carbon between the atmosphere and the biosphere.

Because carbon storage in a landfill is caused by human intervention, it is counted as an anthropogenic sink, or sequestration. Carbon in plastic and rubber that remains in the landfill is not counted for sequestration, because it is of fossil origin and does not represent carbon removed from the atmosphere. A comparison of how carbon is sequestered in Oregon landfills historically and in the future is presented below in Figure 13[10].

Figure 13: Thousand Metric Tons of Carbon (in CO_2e) Sequestered in Oregon Landfills

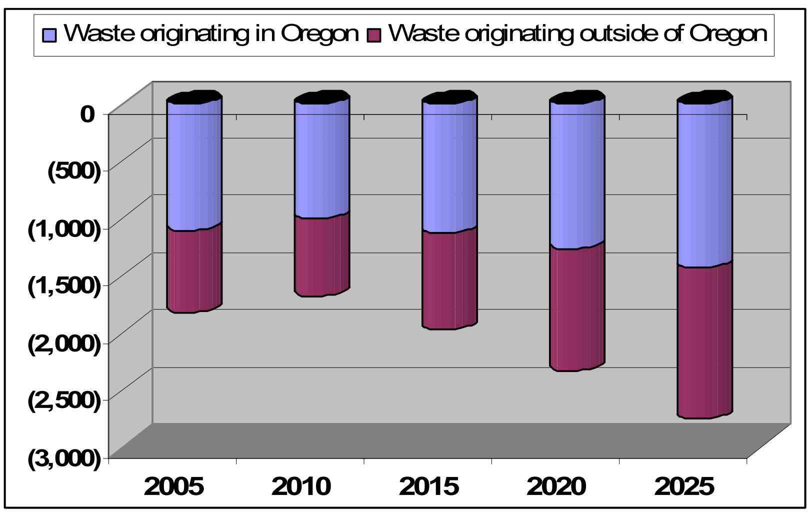


[10] The emission factors used in this analysis were slightly different in the years 2003-2005 than for data in previous years, and also for the projections from 2010 through 2025. This change in factors likely explains the discontinuity in both Figures 13 and 14 in the year 2005 numbers relative to the other years.

While all wastes containing biogenic carbon result in some sequestration, the land filling of these wastes also results in methane generation. For some wastes (food, for example), methane generation is expected to exceed carbon storage. For other, slow-to-degrade materials such as lumber, newspapers and phonebooks, however, sequestration may exceed methane emissions.

Care must be taken when considering the sequestration benefit of land filling wastes. Even though land filling these materials results in a net increase in carbon storage, the alternative – recycling – typically has far greater benefits. This is because the greenhouse gas impacts of producing manufactured goods is typically many times higher than the greenhouse gas impacts of disposal. Recycling newspapers, for example, saves considerable quantities of natural gas in the newsprint production process – producing newsprint from old newspapers requires much less energy than producing newsprint from wood chips. So while landfill sequestration provides a counter-intuitive carbon benefit, it should not be used to promote land filling of organic wastes.

Figure 14: Imported Waste Impacts on Sequestered Carbon in Oregon Landfills (Thousand Metric Tons CO_2e)



Oregon's inventory estimates separate landfill sequestration for wastes originating in Oregon versus wastes coming to Oregon from out-of-state. (Oregon exports very little waste for land filling in other states, but is a major recipient of waste from Washington.) Ownership of this sequestration benefits for waste originating in one state but land filled in another will need to be resolved between the states. Resolving the ownership of waste-related emissions and offsets for waste crossing state lines will need to address both sequestration and methane emissions. To put this issue in perspective Figure 14 demonstrates the substantial contribution of out-of-state imports of waste into Oregon landfills.

Forestry and Land Use: Reasonable estimates of the size of this sink are not currently available. The only data series currently available for use in this inventory process (from USDA) makes no logical sense and creates more confusion than clarity. Without data from forestry and land use, however, it is not possible to create a correct net emissions figure for this inventory. Therefore, until reasonable data are available, Oregon will continue to offer only a gross emissions inventory as its official record of greenhouse gas emissions.

Table 2: 2007 Revision and Update to Oregon Greenhouse Gas Inventory

Consumption-based Gross Emissions in Million Metric Tons of Carbon Dioxide Equivalent ($MMTCO_2e$) for 1990 through 2004

Emissions ($MMTCO_2e$)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Carbon Dioxide (CO_2)															
Direct Combustion															
Residential	2.038	2.186	1.896	2.415	2.353	2.220	2.474	2.371	2.460	2.789	2.752	2.765	2.777	2.664	2.584
Commercial	1.880	1.855	1.651	1.797	1.706	1.775	1.891	1.885	1.961	2.027	2.064	2.127	2.053	1.737	1.776
Industrial	5.308	5.513	6.190	6.565	6.501	6.924	6.716	6.662	6.338	7.618	7.068	6.932	7.167	6.474	7.317
Transportation	20.024	21.615	21.630	20.877	21.655	21.236	21.971	22.094	23.083	23.320	22.594	21.596	21.868	21.675	22.798
Electricity Consumption															
Residential	5.976	6.197	5.906	7.765	7.656	7.588	7.835	7.836	7.835	8.398	8.470	8.709	8.314	8.562	8.495
Commercial	4.398	4.512	4.592	5.676	5.888	6.000	6.069	6.405	6.403	6.935	7.111	7.372	7.058	7.474	7.394
Industrial	6.022	5.943	5.876	6.982	7.010	7.367	7.719	7.697	6.544	6.560	7.605	6.510	5.824	5.774	5.641
Transportation	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.008
Other (non-specified use)	0.303	0.307	0.298	0.309	0.361	0.313	0.321	0.201	0.185	0.218	0.221	0.239	0.238	0.000	0.000
Industrial Processes															
Cement Manufacturing	0.216	0.225	0.228	0.196	0.214	0.207	0.360	0.379	0.399	0.457	0.447	0.429	0.430	0.370	0.422
Lime Manufacturing	0.068	0.091	0.096	0.140	0.147	0.157	0.172	0.156	0.171	0.160	0.145	0.098	0.074	0.077	0.097
Limestone & Dolomite Use	0.009	0.009	0.009	0.009	0.007	0.013	0.006	0.012	0.011	0.013	0.009	0.006	0.008	0.005	0.007
Soda Ash	0.031	0.030	0.031	0.031	0.031	0.032	0.032	0.033	0.033	0.032	0.032	0.032	0.033	0.032	0.032
Ammonia & Urea	0.077	0.076	0.080	0.073	0.077	0.080	0.089	0.080	0.082	0.081	0.074	0.058	0.075	0.066	0.072
Iron & Steel Production	0.704	0.704	0.704	0.704	0.704	0.704	0.704	0.811	0.747	0.640	0.750	0.573	0.440	0.429	0.429
Waste Incineration	0.274	0.274	0.270	0.273	0.320	0.310	0.304	0.297	0.289	0.252	0.267	0.276	0.289	0.222	0.315
Liming of Agricultural Soils	0.030	0.025	0.027	0.029	0.031	0.033	0.035	0.038	0.040	0.042	0.044	0.038	0.033	0.034	0.039
Total Gross CO_2	**47.358**	**49.562**	**49.485**	**53.841**	**54.658**	**54.958**	**56.699**	**56.956**	**56.581**	**59.542**	**59.652**	**57.758**	**56.680**	**55.603**	**57.427**

Emissions ($MMTCO_2e$)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Methane (CH_4)															
Stationary Combustion	0.100	0.102	0.097	0.110	0.103	0.103	0.112	0.104	0.095	0.097	0.100	0.138	0.136	0.137	0.144
Mobile Combustion	0.057	0.056	0.057	0.056	0.054	0.052	0.049	0.050	0.048	0.044	0.041	0.038	0.035	0.031	0.031
Natural Gas and Oil Systems	0.576	0.582	0.588	0.595	0.601	0.607	0.614	0.620	0.626	0.633	0.639	0.647	0.654	0.662	0.671
Enteric Fermentation	1.998	2.016	1.999	1.983	2.118	2.211	2.271	2.249	2.200	2.185	2.133	2.020	2.113	2.049	2.203
Manure Management	0.257	0.257	0.266	0.256	0.272	0.276	0.268	0.276	0.281	0.287	0.306	0.313	0.365	0.407	0.409
Burning of Agricultural Crop Waste	0.003	0.003	0.003	0.004	0.003	0.003	0.004	0.004	0.003	0.002	0.003	0.002	0.002	0.003	0.003
Waste in Landfills	1.036	1.041	0.991	0.979	0.961	0.930	0.983	1.039	1.076	1.087	1.119	1.168	1.196	1.257	1.294
Municipal Wastewater	0.191	0.197	0.201	0.206	0.210	0.214	0.218	0.222	0.225	0.228	0.230	0.234	0.236	0.238	0.241
Fruits & Vegetables Wastewater	0.006	0.006	0.006	0.006	0.007	0.007	0.007	0.007	0.006	0.007	0.007	0.007	0.007	0.007	0.007
Red Meat Wastewater	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Poultry Wastewater	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Pulp & Paper Wastewater	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total CH_4	**4.229**	**4.264**	**4.211**	**4.199**	**4.334**	**4.408**	**4.530**	**4.574**	**4.565**	**4.574**	**4.582**	**4.570**	**4.748**	**4.794**	**5.005**
Nitrous Oxide (N_2O)															
Stationary Combustion	0.108	0.106	0.095	0.096	0.097	0.097	0.105	0.106	0.097	0.095	0.100	0.097	0.086	0.084	0.086
Mobile Combustion	0.516	0.529	0.582	0.617	0.616	0.621	0.619	0.650	0.657	0.631	0.603	0.544	0.509	0.470	0.436
Nitric Acid Production	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Manure Management	0.107	0.108	0.107	0.098	0.085	0.094	0.081	0.084	0.101	0.107	0.119	0.125	0.128	0.146	0.159
Agricultural Soil Management	2.063	1.961	1.908	2.248	1.841	2.082	2.302	2.134	2.231	1.899	1.965	2.008	2.076	2.038	1.987
Burning of Agricultural Crop Waste	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
N_2O from Settlement Soils	0.057	0.055	0.057	0.056	0.062	0.061	0.066	0.072	0.071	0.053	0.040	0.058	0.082	0.094	0.090
Waste Incineration	0.023	0.023	0.023	0.023	0.024	0.024	0.026	0.027	0.028	0.028	0.027	0.029	0.030	0.032	0.033
Municipal Wastewater	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Total N_2O	**2.877**	**2.785**	**2.775**	**3.142**	**2.728**	**2.984**	**3.204**	**3.078**	**3.188**	**2.817**	**2.858**	**2.865**	**2.915**	**2.867**	**2.795**

Emissions ($MMTCO_2e$)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
High GWP Gases – HFC, PFC, and SF_6															
Ozone-Depleting Substance Substitutes	0.004	0.007	0.034	0.090	0.179	0.385	0.541	0.696	0.795	0.889	0.986	1.083	1.186	1.289	1.405
Semiconductor Manufacturing	0.291	0.291	0.291	0.364	0.401	0.496	0.551	0.632	0.767	0.836	0.783	0.598	0.628	0.627	0.679
Electric Power Transmission and Distribution Systems	0.430	0.411	0.402	0.391	0.363	0.331	0.311	0.282	0.223	0.228	0.223	0.204	0.187	0.179	0.175
Aluminum Production	0.317	0.270	0.128	0.281	0.250	0.256	0.270	0.272	0.279	0.280	0.195	0.191	0.000	0.000	0.000
Total HFC, PFC, and SF_6	**1.042**	**0.980**	**0.855**	**1.126**	**1.192**	**1.468**	**1.673**	**1.882**	**2.064**	**2.234**	**2.187**	**2.076**	**2.002**	**2.095**	**2.260**
Gross Emissions, Consumption Basis	**55.506**	**57.591**	**57.327**	**62.309**	**62.913**	**63.817**	**66.107**	**66.491**	**66.399**	**69.167**	**69.279**	**67.270**	**66.344**	**65.360**	**67.487**

Inventory Notes:
Data generated from the EPA State Inventory Tool (SIT) except for electricity consumption (ODOE) and waste (ODEQ).
Zeroes in some columns may mask emissions that are in the hundreds of metric tons and thus don't show up above.

An emerging consensus is for greenhouse gas inventories to attribute energy emissions to the jurisdiction in which the energy is consumed. The Western Regional Air Partnership and the Western Climate Initiative use this convention. Counting only emissions attributable to in-state power generation (but not power consumption) is also done in some instances, and is done by the federal government for national data and state-level reports. For purposes of comparison those data are below:

Add In-state Electric Generation	1.795	3.610	4.513	4.309	5.453	2.725	3.197	2.700	6.189	6.221	7.339	8.520	6.375	8.048	8.029
Remove Electricity Consumption	(16.698)	(16.960)	(16.671)	(20.731)	(20.915)	(21.267)	(21.945)	(22.139)	(20.967)	(22.112)	(23.407)	(22.830)	(21.434)	(21.818)	(21.538)
Gross Emissions, Production Basis	**40.603**	**44.242**	**45.168**	**45.887**	**47.451**	**45.275**	**47.359**	**47.052**	**51.621**	**53.276**	**53.211**	**52.960**	**51.285**	**51.589**	**53.978**

However, by not counting energy consumption, roughly one-quarter of emissions directly attributable to the actions of Oregonians are not accounted for:

Consumption vs. Production Basis	14.903	13.349	12.159	16.422	15.462	18.542	18.748	19.439	14.778	15.891	16.069	14.310	15.059	13.770	13.508
Percentage of Gross Emissions Unaccounted for by Method	26.8%	23.2%	21.2%	26.4%	24.6%	29.1%	28.4%	29.2%	22.3%	23.0%	23.2%	21.3%	22.7%	21.1%	20.0%