Biennial Report to the Legislature 2015

KeepOregonCool
Oregon Global Warming Commission

Oregon Global Warming Commission

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*One voting member position of the Commission remains vacant at the time of this Report

OREGON GLOBAL WARMING COMMISSION

Biennial Report to the Legislature

September 2015

For more information on the Oregon Global Warming Commission please visit the Commission's website at www.KeepOregonCool.org.

KeepOregonCool
Oregon Global Warming Commission

For electronic copies of this Report visit the Commission's website or the Oregon Climate Change Portal at www.orclimatechange.gov. For printed copies of the Report please contact:

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Executive Summary

In this 2015 Biennial Report we describe two more years' worth of data from Oregon's emitting facilities and energy suppliers and confirm our previous finding that Oregon clearly met its 2010 GHG reduction goal – to arrest the growth of emissions and begin reducing them. We note that Oregon's GHG emissions are now nearly back to 1990 levels at 61 million metric tons of carbon dioxide equivalent (or million $MTCO_2e$). In addition, the combination of recently-enacted policies, including the Clean Fuels Program for vehicle fuels, expected utility Renewable Portfolio Standard (RPS) performance, and PGE's commitment to end coal combustion at the Boardman power plant, contribute to a GHG forecast that both begins at a lower level and holds projected future increases to a slower rate than previously predicted.

The less good news is that despite these successes, we project Oregon's 2020 emissions to be 11 million $MTCO_2e$ above the target level set by the Legislature for that year, with the gap between emissions and our goals widening each year to 2050 and beyond unless additional action is taken to contain and drive down emissions. Believing that the 2050 goal is too distant to plan for meaningfully, the Commission proposes an intermediate target year of 2035 which is identified simply as the level directly between our adopted 2020 and 2050 goals. This interim goal will help focus State and local efforts while being far enough in the future to allow the emissions-reducing impact of policy choices to materialize.

The majority of the analysis in this Report seeks to answer one question about the 2035 target: what combinations of emission reduction measures could be taken to help us achieve it? Rather than an exact depiction of a strategy or outcome, this analysis is illustrative of the diversity and scale of reductions that are available to Oregon. We examined measures that reduce emissions from buildings (commercial and residential), industrial processes, transportation (of people and freight), materials, agriculture, waste, and the generation of electricity. The combination of selected measures would result in roughly a 22 million $MTCO_2e$ emission reduction compared to business-as-usual in 2035, but would still leave Oregon about 10 million $MTCO_2e$ away from achieving the 2035 goal. We then analyzed the impact of implementing the same measures alongside a carbon pricing signal that gradually increases to $60/ton. We find that the combined approach results in greater emission reductions – 29 million $MTCO_2e$ in 2035 – and would likely put Oregon on track to achieve the interim goal. We recommend that both goal and strategies be revisited over time to ensure their continued applicability and efficacy.

We conclude with several recommendations for the state, and its policy leaders, specifically: set a 2035 interim goal; develop a strategy with interim benchmarks to achieve that goal; carefully consider cost and equity when setting the long-term strategy; encourage technological innovation when implementing the strategy; prioritize action from the largest emitters; support and leverage action at the federal level, and consider adopting parallel reduction goals for the emissions associated with Oregonians' consumption of goods.

Chair's Letter

Governor Kate Brown

President Peter Courtney

Speaker Tina Kotek

Members of the Oregon State Legislature

This is the fourth biennial Report to the Legislature from the Oregon Global Warming Commission and, predictably, we report again on incremental, encouraging but still insufficient progress toward Oregon's climate and greenhouse gas (GHG) reduction goals.

1. OREGON GHG EMISSIONS TRAJECTORY GOING FORWARD

Oregon's emissions continue their incremental decline from a peak of 72.5 MMTe[1] in 1999 to estimated 2012 emissions levels of ± 61MMTe[2], a drop of about 16% (and not far off Oregon's 1990 emissions of 56.9 MMTe). Continued gains on energy efficiency, renewables, more efficient vehicles and fewer miles driven (plus a little help from the recession) have combined to push Oregon's GHG emissions down over the last 15 years. The Legislature's extension of the vehicle Clean Fuels Standard, taken together with expected utility Renewable Portfolio Standard performance, continuing to press ahead on energy efficiency capture, and PGE's commitment to end coal combustion at its Boardman power plant, are projected to continue yielding reductions through the end of this decade.

That said, with new emissions sources offsetting these reductions (e.g., if gas generation replaces Boardman), and absent stepped up state and federal initiatives, we project Oregon's emissions in 2020 to be some 11 MMTe ***in excess of*** the 51 MMTe goal[3] that the Legislature has set for our state in that year, with the gap thereafter between performance and goals growing wider each year. By 2035, absent significant additional intervention, the gap (between business-as-usual emissions and a linear trajectory to the 2050 goal) is likely to exceed 30 MMTe. The current Administration's proposed new Federal power plant emissions rules and fuel efficiency standards for new vehicles, if fully implemented, could cut somewhat into that gap, but Oregon would still be left with a sizeable balance owing.

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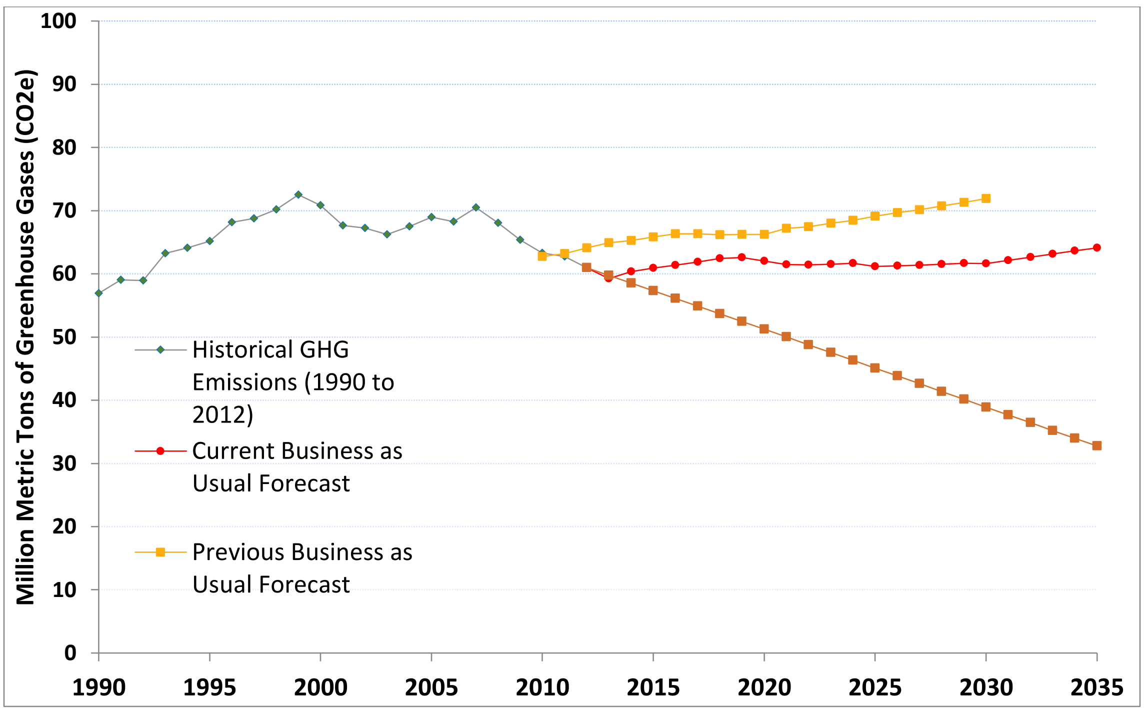
[1] "MMTe" means millions of metric tons of CO2 or its equivalent in other greenhouse gases. A metric tonne, the international unit of measurement, equals about 2200 pounds; a "short" ton, 2000 pounds.

[2] US emissions peaked at 7450 MMTe a decade later (in 2007, with the recession's onset) and have gone sideways since at about 6,700 MMTe (through 2012). Globally GHG emissions remained flat in 2014 despite 3% growth in global economic outpus, encouraging cautious predictions of decoupling emissions from economic growth.

[3] Equal to 10% below 1990 Oregon GHG emissions levels.

Our new trajectory for "business as usual" (BAU) emissions is shown in the figure below, in comparison to the Commission's previous BAU estimate. Our new forecast includes the following assumptions that are different from our last forecast:

- Implementation of Oregon's *Renewable Portfolio Standard*;
- Portland General Electric's planning assumptions about what will occur once *Boardman* ceases coal operations at the end of 2020[4];
- Projected business-as-usual *energy efficiency* achievements by the utilities;
- Extension and implementation of Oregon vehicle *clean fuels program*; and
- *Federal fuel economy* standards for heavy-duty trucks approved by EPA in 2011, and for light-duty vehicles approved in 2012.



In this 2015 Biennial Report, the OGWC proposes two responses to this challenge.

First, while currently on a path toward meeting the 2020 goal, recognizing that absent additional policy changes or unexpected reductions between 2015 and 2020, Oregon will not meet its 2020 goal, and believing that a 2050 goal is too far off to plan for meaningfully, we begin using a 2035 goal of 32.7 MMTe[5]. This emissions level is

[4] Note: these assumptions are taken from PGE's 2013 IRP, which indicate that the Company's preferred portfolio at the time included increasing renewable generation sufficient to meet RPS requirements, but no additional renewable or low-carbon generation beyond that amount to replace the generation occurring at Boardman. The Company may change this preferred approach in the future.

[5] Calculated by drawing a straight line projection between a 1990 emissions level of 56.177 MMTe and a 2050 goal of 14 MMTe; by 2035 Oregon should be 44% below 1990 levels.

simply a linear interpolation between Oregon's 2020 goal of 51 MMTe and our 2050 goal of 14.2 MMTe.

Second, we describe in this Report a scenario that could build on existing state and federal actions to reach this 2035 goal. This scenario – not the only possible one, certainly – gives us a frame of reference for the kinds of actions and degrees of progress that would need to be on our state's policy agenda. It relies upon analysis accessible to the State today, some of which was not available earlier, specifically:

- The second phase of analysis from the Oregon Greenhouse Gas Marginal Abatement Cost Curve project (MACC 2014; to 2035)
- The ODOT Statewide Transportation Strategy (STS, reported to OTC 2013; to 2050)
- "Economic and Emissions Impacts of a Clean Air Tax or Fee in Oregon" report submitted by the PSU Northwest Economic Research Center (NERC) in response to SB 306, 2013 Legislative Session (submitted to the Legislative Revenue Office December 2014; to 2034).

The three analyses and data sources are discussed at greater length in the body of this Report.

2. SCENARIOS

While it's possible to frame scenarios that rely entirely on either individually-targeted measures or a broader-based carbon price (or carbon cap) signal, the Commission felt it useful to describe a carbon reduction strategy that combines both approaches, and relies upon each to supplement and complement the other. In this way the effects of more targeted compliance obligations (e.g., on coal power plants and their customers) could be mitigated with broader tools (e.g., a carbon price that can influence emissions from more diffuse sources such as individually-owned cars and trucks). The other desired Commission outcome of this combined strategy approach was to limit the step up of a carbon price to a maximum level of $60/ton in 2035. Putting the entire burden on a carbon tax to reach targeted 2035 levels would have required a tax level close to the maximum $150/ton level studied by PSU[6].

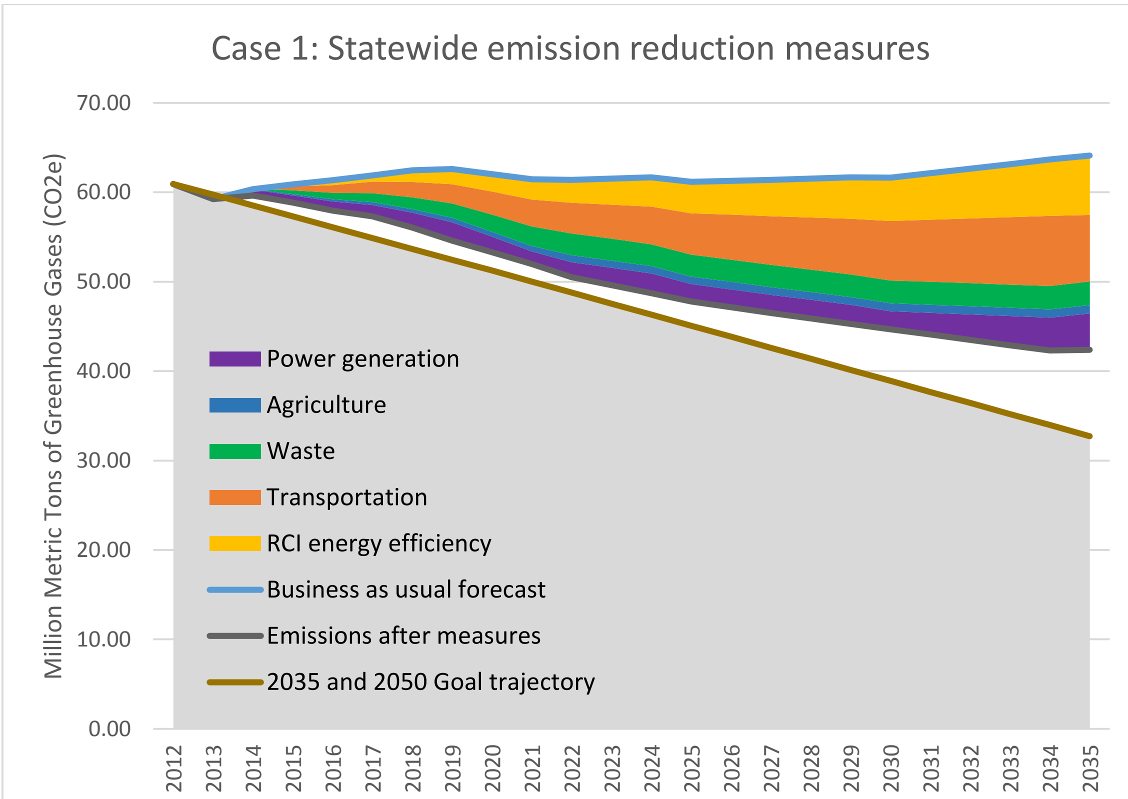
In exploring these scenarios, staff and researchers from PSU have made a diligent effort to understand the extent and distribution of costs – and benefits – of proposed emissions reductions. Two strategies in particular have been important.

First, staff identified the measures (and packages of integrated measures) that are the most cost-efficient means to reduce emissions (Case 1, as discussed below). The MACC

[6] Note that a similar CA study suggested a carbon tax level of $50/ton would be required for CA to reach a "10% below 1990" level by 2020. Current CA carbon prices under its cap and trade mechanism are closer to $13/ton but are supplemented by aggressive energy efficiency and renewable energy standards to make up the difference (per Sightline/Eberhard blog December 10, 2014).

analysis (which includes most STS transportation/land use measures) was built around this directive.

The combination of all of the measures analyzed results in a 2035 emission level of 42.4 MMT CO2e, a reduction of 22 MMT (34%) below where our business-as-usual forecast predicts we will be in 2035 (64.1 MMT). This would be a substantial reduction in emissions, but it would still leave Oregon 9.7 MMT from achieving the interim goal for 2035 of 32.7 MMT. Those measures are presented in the form of emission reduction wedges in the figure below.



To develop Case 2, we have assumed that the programmatic measures from Case 1 could be implemented alongside a carbon price that steps up to $60/ton. We enlisted the assistance of PSU researchers who utilized the carbon tax case that optimizes reinvestment of revenues in measures that support economic growth and employment. In Case 2, the programmatic measures, such as household energy efficiency improvements, are assumed to be implemented in the same way as Case 1, while the carbon price is applied in addition to those measures to achieve higher savings than either the measures or the price would achieve alone.[7] We note PSU's general conclusion that the overall economic and employment effects of a carbon tax at any of the levels PSU studied are either *slightly positive* or *slightly negative* relative to the size of Oregon's economy and

[7] See page 62 for a full explanation of Case 2 including results.

employment base[8]. Thus legislative discretion could allocate the largest share of revenues to reinvestment (e.g., in transportation facilities; in energy efficiency retrofits) while reserving a smaller allocation for targeted relief of Oregonians with the heaviest compliance burdens (e.g., businesses with large energy costs per unit of output; low income households).

3. FEDERAL CLEAN AIR ACT INITIATIVES: Vehicle Fuel Economy Standards + power plant carbon reduction standards

The two largest sector contributors of Oregon GHG's are transportation (39% in 2012) and use of electric power (30% in 2012). Overall, approximately 50% of our emissions derive from (1) cars and light trucks, and (2) coal combustion. Both sectors are primary targets of both federal and state GHG policies. In building state GHG compliance scenarios, this Report takes into account, and builds upon, the expected contributions from federal policies.

Since 1975, the federal government has set vehicle fuel economy standards and required auto manufacturers to meet these, on average across their new car fleets, for the vehicles they sell. The standards mandated new vehicle efficiency gains of almost 50% (from 18 mpg to 27.5 mpg) by 1985, then flatlined for the next 25 years. In 2010 and 2012, with new impetus from climate concerns, the Obama Administration set a new course for cars and light trucks to double their fuel efficiency to 54.5 mpg by 2025 (and issued parallel efficiency standards for over-the-road commercial trucks). The effect should be to nearly cut in half GHG emissions from these vehicles. The OGWC takes these effects into account in developing the transportation GHG reduction wedge.

In 2014 the Obama Administration proposed new GHG emissions reduction standards governing power plant emissions under Section 111(d) of the Clean Air Act and finalized these standards in August 2015. The stated intent is to reduce nationwide 2030 emissions from this sector by 32% from 2005 levels. As with other Clean Air Act actions, EPA gives states emissions reduction targets and defers to state authorities to devise and deploy acceptable compliance plans. EPA has proposed a "system" approach that enables states to assemble their preferred strategies, which may include energy efficiency, renewable energy, efficiency gains at existing power plants and shifting ("redispatching") generation from coal to gas plants. In the 2014 Draft Rule, EPA gave Oregon one of the more challenging reduction goals: a 48% reduction in the emission rate for our existing power plants by 2030. This was modified in the Final Rule to a much lower level, around 20% on a comparable rate-based standard. EPA also provided an alternative quantitative ("mass-based") standard in the Final Rule; that alternative would actually allow Oregon

[8] A similar look at the economic effects of a carbon charge in Washington came to similar conclusions: a consumer cost equal to about 0.3% of WA GDP, offset by reinvestment of the proceeds in WA schools and transportation facilities that actually results in higher jobs and GDP growth than without the carbon charge. See Sightline/Eberhard blog March 24, 2015

an increased emissions level of some 460,000 tons CO_2 by 2030. State agencies are beginning the work of developing an Oregon compliance plan for submission to EPA.

Under either the Draft or the Final Rule, Oregon's energy efficiency and renewable portfolio standard policies, combined with the commitment by PGE to end coal combustion at Oregon's only coal power plant in Boardman, OR, operate to help the state to meet its EPA target. As a result, some or all of the required emission reductions for Oregon due to the 111(d) regulations are likely part of our business-as-usual forecast. Because it remains unclear whether the EPA regulations will drive any net emissions reductions for Oregon beyond those already projected to occur, the business-as-usual charts included within this Report do not specifically include any further reductions attributable to 111(d).

However, no less important to Oregon is meeting its self-imposed targets which, unlike the EPA rule, include reducing power plant emissions that occur outside the state to deliver power to Oregon utility customers. Oregon's two largest electric utilities, PacifiCorp and Portland General Electric, both import substantial quantities of coal-generated electricity from plants in Montana, Wyoming and other mountain states. The state must reduce its dependence on this imported "coal-by-wire" to achieve its GHG reduction goals. The EPA 111(d) regulations are likely to require significant output and emissions reductions from mountain states' coal plants. Determining what reductions may ultimately result from EPA-approved compliance plans in these states, and which such reductions Oregon may be able to count toward its state targets, will await the filing of compliance plans from those states. That occasion is at least a year away and possibly three. Even then, it's unlikely the rule by itself will reduce emissions in the producing states as aggressively as Oregon's goals would require[9]. The task of filling in the gap between rule and goals will fall to us, and our serving utilities, in Oregon.

4. "FIRE AND WATER" – PREPARING OREGON FOR THE GROWING EFFECTS OF CLIMATE CHANGE

2015 looks to be another drought year – fourth in a row, and including 11 of the last 15 years of below normal water, if you're counting – for the western states. While California's plight gets most of the headlines[10], southern and eastern Oregon are suffering along with states of the American Southwest. The snowpack in the Oregon Cascades is ~75% below its long-term average, the result of average rainfall but winter and spring air

[9] There are other federal pollution control requirements in place, including those related to emissions of other pollutants, which may also act to shift generation sources, although the PacifiCorp and PGE Integrated Resource Plans on which this Report's projections are based take such existing regulations into account.
[10] and with a snowpack at 6% of historical average, deserves them

temperatures 15 degrees to 25 degrees above normal that prevented snow accumulation. The Governor has declared a 2015 drought "emergency" in 23 of Oregon's 36 counties.

Snowpack shortfalls mean summer water shortages for agriculture, for fish, for power generation, for recreation. And unless the state is unusually lucky, they mean another above-average wildfire season on top of bad years in 2013 and 2014; and not just for Oregon, but for most of the western states[11].

"Fire and water" is an easy shorthand for the onset of climate change effects in Oregon, but the list is longer. The recently released "Oregon Climate and Health Profile" report[12] documents growing risks from invasive tropical diseases like West Nile Virus, from heat-related effects especially on older Oregonians, from aggravated respiratory illnesses like asthma, and other public health concerns. In response to these growing health threats, the Oregon Health Authority is developing a new statewide plan to prepare Oregonians for emerging health threats from climate change.

Public infrastructure like roads and bridges are at risk from flooding and landslides. Public water supplies may dry up in some years (as they have for many California towns). Forest ecosystem health – forests, fish, and other species – is threatened.

In 2010, the State adopted a "Climate Change Adaptation Framework," the product of deliberations among state agency heads and staff. The State Climatologist, Dr. Phil Mote, and I also participated. The Framework identified eleven areas of serious risk, and suggested responses for each. It was an admirable piece of work for its time and place. It was also limited by assumptions of near-term affordability (Oregon was in deep recession) and political viability. It has also suffered from neglect since 2010. Individual state agencies have pursued adaptation elements, and several communities have actively identified their own priority tasks, but the state as a whole has not dealt with climate risk systematically.

In discussions with the Governor's Office, the Commission has considered whether the Framework needs revisiting especially in light of accumulating evidence of risk and better definition of its distribution across Oregon's landscape and communities. The Commission is considering undertaking this review, in consultation with the Governor's Office, with State agencies that share the responsibility, and with the many Oregon communities that have already begun to document their vulnerabilities and identify their strategies to cope.

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[11] A University of Utah study documented seven more wildfires on average per year since 1984 across the western states, burning 90,000 acres more each year.

[12] Prepared by the Oregon Health Authority Public Health Division

5. GLOBAL WARMING COMMISSION EFFECTIVENESS RECOMMENDATIONS

Just as Oregon needs to improve its strategies and tools for dealing with greenhouse gas reductions and climate risk, so this Commission needs to revisit its current practices and authorities to better serve the State government and Oregonians. We are addressing this task in at least two areas: (1) GHG inventory management; and, (2) usefulness and timing of the Commission's Report to the Legislature.

Inventory Management: Oregon has greatly improved on its tracking and attributing GHG emissions since its benchmark year of 1990. Some data points are derived, by formula, from the measured consumption of fossil fuels for direct consumption as vehicle fuels (gasoline; diesel) or space heating (natural gas). In the last several years, DEQ has made an important shift to requiring and receiving direct reports from single large Oregon producers of GHG's such as industries and businesses with more complicated profiles than process heat or transportation of goods. In important cases, some manufacturers produce significant quantities of lesser known GHG gases, such as flourocarbons, that molecule for molecule can have very large climate change multiplier effects. Agencies have also developed new tools to assess emissions from Oregon's consumption of goods and services in addition to our traditional production-based inventories.

The Commission, working with ODEQ and ODOE, is also seeking more timely availability of these data. In the past, policymakers seeking to shape climate policy could find themselves working with inventory data from three or four years earlier, with no way to verify suspected shifts in trend lines over more recent years. With this Biennial Report we hope to provide Oregon policymakers and citizens with data for major GHG sources – transportation and electricity generation at least – that can be updated annually and will not be allowed to fall even two years behind. The tradeoff for timeliness may be a degree of precision. The strategy we are pursuing will likely require periodic updating of preliminary numbers[13] but not, we hope, revisions substantial enough to drive different policy outcomes.

Timing of the Biennial Report: The OGWC Biennial Report to the Legislature and Governor is required under the statue establishing the Commission, and is due March 31 of odd-numbered years[14]. Among other directions in the statute, the Commission "may recommend statutory and administrative changes, policy measures and other recommendations . . . ." But recommendations that arrive at the Legislature in mid-

[13] Thus we may have to deliver preliminary numbers subject to later revision, as the Federal Government now does with monthly economic and employment numbers subject to revision to reflect more complete data.
[14] Our last Report did not arrive by March 31; it will be delayed again this year.

session are unlikely to have much effect in that session and are less likely still to be remembered by the next one, two years later.

The Commission is considering changing its target date for the next Report to the summer prior to the next session in 2017; that is, to submit the next Report next summer (in 2016). This would enable us, in a timely way, to either offer legislative actions or speak to those likely to be offered. Thus if the proposed review of the State's climate change preparation/adaptation strategies this year suggests legislative action for the 2017 session, the recommendations will be timely and can access the legislative process. This change would also have the effect of ensuring the Report arrives in compliance with the law (e.g., arriving in advance of March 31, 2017).

I. Oregon's Greenhouse Gas Emissions: Updated Inventories

Oregonians contribute to greenhouse gas emissions in a variety of ways, spanning nearly all of the activities that we engage in. Having a solid understanding of these emissions, including those that occur both in-state and out-of-state and from both production and consumption, is the first step to analyzing what sorts of actions might be required for us to meet our long-term emission reduction goals. Prior to 2010, Oregon's GHG inventory was constructed in a "top-down" fashion, using an inventory tool published by the U.S. Environmental Protection Agency (EPA). Beginning in 2010, Oregon's largest emitters of GHGs began reporting their emissions to the Oregon DEQ as part of the mandatory GHG reporting program. In 2013, the Oregon Departments of Environmental Quality, Energy, and Transportation produced a technical report[15] which utilized both the "top-down" method and the reported data, and represented the first attempt by a state government to provide a greenhouse gas inventory using multiple emission accounting methodologies.

The report analyzed data up to the year 2010 and described three inventories: in-boundary emissions, which are those that occur within Oregon's borders plus emissions associated with the use of electricity within Oregon; consumption-based emissions, which are those global emissions associated with satisfying Oregon's consumption of goods and services, including energy; and expanded transportation sector emissions, which evaluated the full life-cycle emissions from fuel use by ground and commercial vehicles, freight movement of in-bound goods, and air passenger travel.

The 2013 effort to construct the three inventory methods was extensive. This Oregon Global Warming Commission (OGWC) Biennial Report to the Legislature contains the first update to the in-boundary emissions and consumption-based emissions inventories that were constructed in 2013. It does not contain a full report on those inventories as was done in 2013. The updated data years of 2011 and 2012 in the in-boundary inventory were constructed using a similar methodology to the 2010 data year: data reported to DEQ's greenhouse gas reporting program is the primary basis for measuring emissions, and the state inventory tool developed by the US EPA is used to further refine these data and fill gaps where reported data do not exist. The updated data years of 2011 and 2012 in the consumption-based inventory were constructed using a "light touch" model update, as described in the section below.

The OGWC is working with state agencies to decrease the time lag between the current year and when full inventory data is available. A significant source of the current delay is the gap between the US EPA's publication of the state inventory tool (the 2012 version was released at the start of 2015). With this in mind, we may begin to work with agencies to construct "hybrid" inventories using the most recently reported GHG data that ODEQ collects along with slightly

[15] http://www.oregon.gov/deq/AQ/Documents/OregonGHGinventory07_17_13FINAL.pdf

older GHG data for other sectors available through the EPA's tool. The data that comprise the in-boundary inventory are contained in the Appendix to this Report.

In-Boundary Emissions Inventory

Inventory Overview

Oregon's in-boundary inventory estimates greenhouse gas emissions that occur within the State's jurisdictional boundary and that are associated with the generation of electricity used by Oregonians within that boundary. This inventory includes emissions from the combustion of fuel used in Oregon, the processing and disposal of waste and other materials, the generation and transmission of electricity used in Oregon, agricultural and industrial operations, and a variety of other processes. Most of these emissions occur within the State, though a substantial share of the electricity used by Oregonians is generated out of state, and the emissions from this out of state generation are included in this inventory. Likewise, emissions from electricity generation occurring in Oregon that is used out of state are presented separately and not included in the statewide emission totals of this inventory.

Total Emissions

Following is a discussion of the 2012 inventory, how it compares with prior years, and how the estimates of prior year emissions have changed slightly since the last inventory[16]. Key economic sectors and their trends are presented, followed by an examination of those sectors in greater detail.

Table 1: Oregon Emissions by Sector, 1990-2012 (Million MT CO2e)

	1990	*1995*	*2000*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*
Transportation	20.9	22.5	24.2	24.7	25.3	25.8	24.0	24.2	22.9	22.5	23.9
Residential & Commercial	16.8	20.1	23.3	24.2	22.8	24.6	24.7	23.9	23.0	22.5	20.5
Industrial	14.0	16.9	17.8	14.1	14.0	14.1	13.6	11.9	11.7	12.0	11.2
Agriculture	5.2	5.7	5.6	6.0	6.1	6.0	5.7	5.4	5.7	5.8	5.4
Total	**56.9**	**65.2**	**70.8**	**69.0**	**68.2**	**70.5**	**68.1**	**65.4**	**63.3**	**62.7**	**60.9**

Table 1 summarizes greenhouse gas emissions by economic sectors since 1990. Transportation remains the largest contributor to the State's in-boundary emissions, and has increased its share of overall emissions in recent years. Residential and commercial activity continues to be the second largest contributor. The industrial sector is the third largest contributor, with about half as much emissions as the transportation or the residential and commercial sectors. Finally, agricultural activity is a distant fourth. Overall, emissions declined approximately 12 percent (8

[16] We endeavor to work with state agencies to reduce the time to 1-2 years between when raw data is reported and when the updated state inventory is available.

million $MTCO_2e$) between 2005 and 2012. A more detailed analysis of what this trend means for the achievement of our GHG reduction goals is presented below in Section II.

Figure 1: Oregon Emissions by Sector, 1990-2012 (Million Metric Tons of Carbon Dioxide Equivalent)

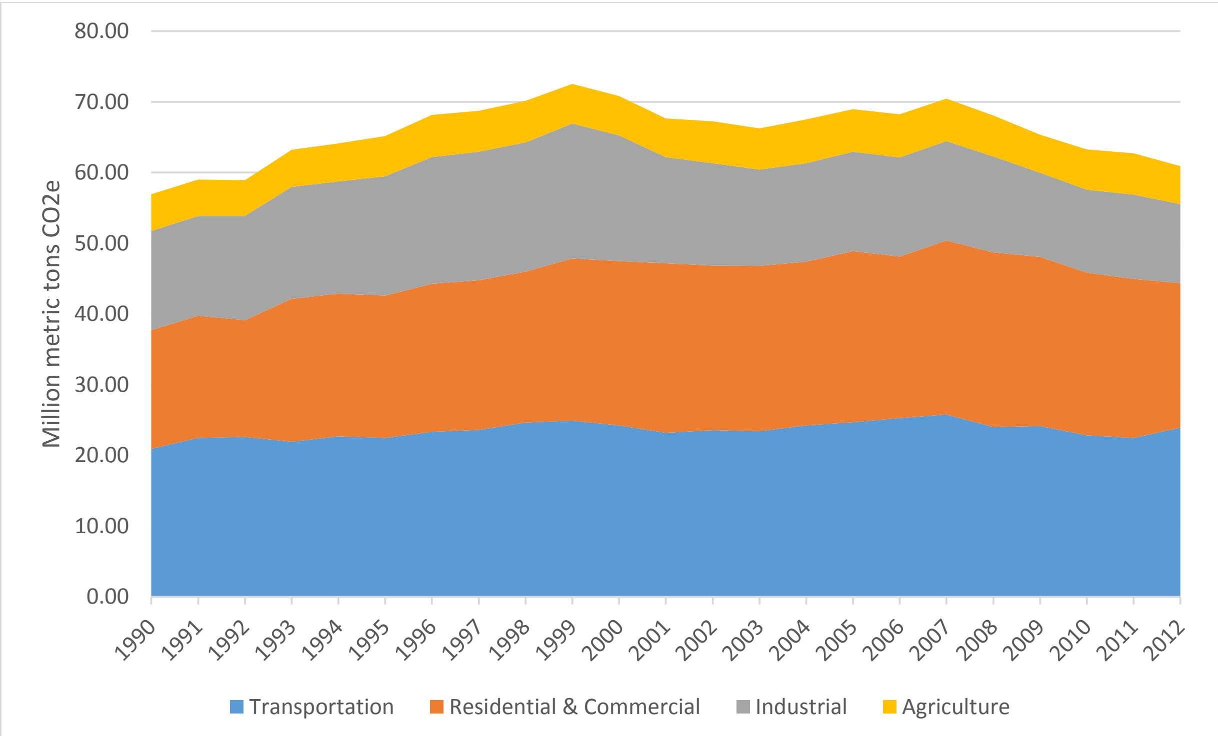


Figure 2 illustrates how the state's emissions have changed in each economic sector since 1990. Emissions from agriculture have been relatively constant, at slightly above 5 million $MTCO_2e$ each year. The transportation sector has failed to show needed emissions reductions, remaining mostly flat since 1990 at just above 20 million $MTCO_2e$. The residential and commercial sector grew through the 1990s, in part due to the retirement of GHG free Trojan Nuclear Plant, but has since declined to approximately 1993 emission levels, likely due to the drop in emissions associated with electricity use over that time. The industrial sector's emissions rose gradually through the 1990s to a peak in 1999 of 19.3 million $MTCO_2e$, and declined most years since then, and were just 11.2 million $MTCO_2e$ in 2012.

Different Types of Data – A Different Light on our Emissions

In addition to our overall emissions, we should consider how our emissions per capita and per dollar of state GDP have changed over time. Looking at this data can help us be sure that recent declines in our in-boundary emissions are not due to the effects of net migration out of the state or loss of economic activity. The table below indicates that while in-boundary emissions have declined since 2000, per capita emissions and the carbon intensity of our economy have also declined, while our state population and GDP have risen over the same time period. These are not perfect indicators that the policies we have in place are responsible for falling emissions, but they are helpful for informing the direction we are headed and another useful way to compare Oregon's emissions to other states and countries.

The data also show that Portland and Multnomah County have outpaced the state's reductions in per capita emissions. Multnomah County's per capita emissions have gone down by 34% from 1990-2012, while the state as a whole reduced by 22% during that time period. Meanwhile, the region has grown more quickly than the state overall between 2000 and 2013 – 19% population growth verses 15% in the state as a whole. This indicates that the overall state reduction in per capita emissions is disproportionately due to efforts implemented under the County's climate action plans.

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012
Total emissions (MMT)[1]	56.9	65.2	70.8	69.0	68.2	70.5	68.1	65.4	63.3	62.7	60.9
Statewide per capita emissions (MT)[1,3]	20.0	20.5	20.6	19.0	18.5	18.9	18.0	17.1	16.5	16.3	15.7
Multnomah Cty. per capita emissions (MT)[4]	15.4	15.3	15.5	12.9	13.2	12.5	11.9	11.3	10.6	10.6	10.1
Carbon intensity (MT/ $2009 million GDP)[1,3]	877.0	795.9	535.9	447.5	406.5	407.4	375.6	363.0	332.9	316.9	296.0
State GDP ($2009 Billion)[3]	64.8	81.9	132.1	154.2	167.8	173.1	181.3	180.2	190.1	197.8	205.7

Sources: 1. Oregon GHG Inventory; 2. U.S. Department of Commerce (http://bea.gov/iTable/index_regional.cfm); 3. Portland State University Population Research Center (http://www.pdx.edu/prc/annual-oregon-population-report); and 4. Portland Bureau of Planning and Sustainability

While the carbon intensity data are a useful comparison to our inventory data, it is important to note that solving the problem of climate change will require absolute reductions in GHGs, not only reductions in emissions per person or per unit of output. It is for this reason that GHG reduction goals, targets and mandates around the world – including ours – are expressed in absolute terms.

Nonetheless, we endeavor to present these additional data points wherever possible.

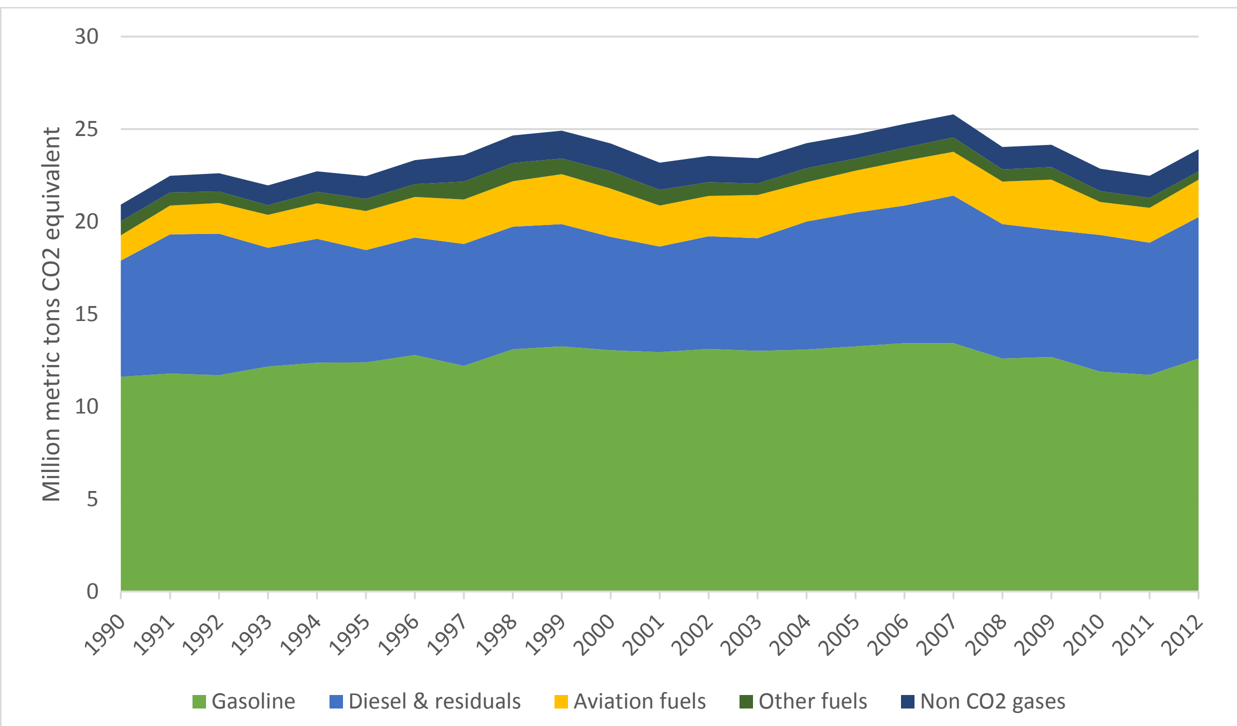
Transportation Sector Emissions

Emissions attributed to transportation are primarily from fuel used by on-road vehicles, including passenger cars and trucks, as well as freight and commercial vehicles. This sector also includes aviation fuel and off-road transportation such as farm vehicles, locomotives, and boats.

Figure 3 illustrates how the state's emissions from transportation fuel have changed since 1990 by the relative contribution of each fuel type. Non-CO_2 gases include methane and nitrous oxide that are byproducts of fuel combustion and fluorinated gases with high global warming potential from air conditioning and other auxiliary systems on vehicles. The other fuels category includes propane, natural gas, lubricant emissions and electricity. Aviation fuels include kerosene jet fuel, aviation-grade gasoline, and naphtha jet fuel. Diesel & residuals include all distillate and residual fuels used for transportation.

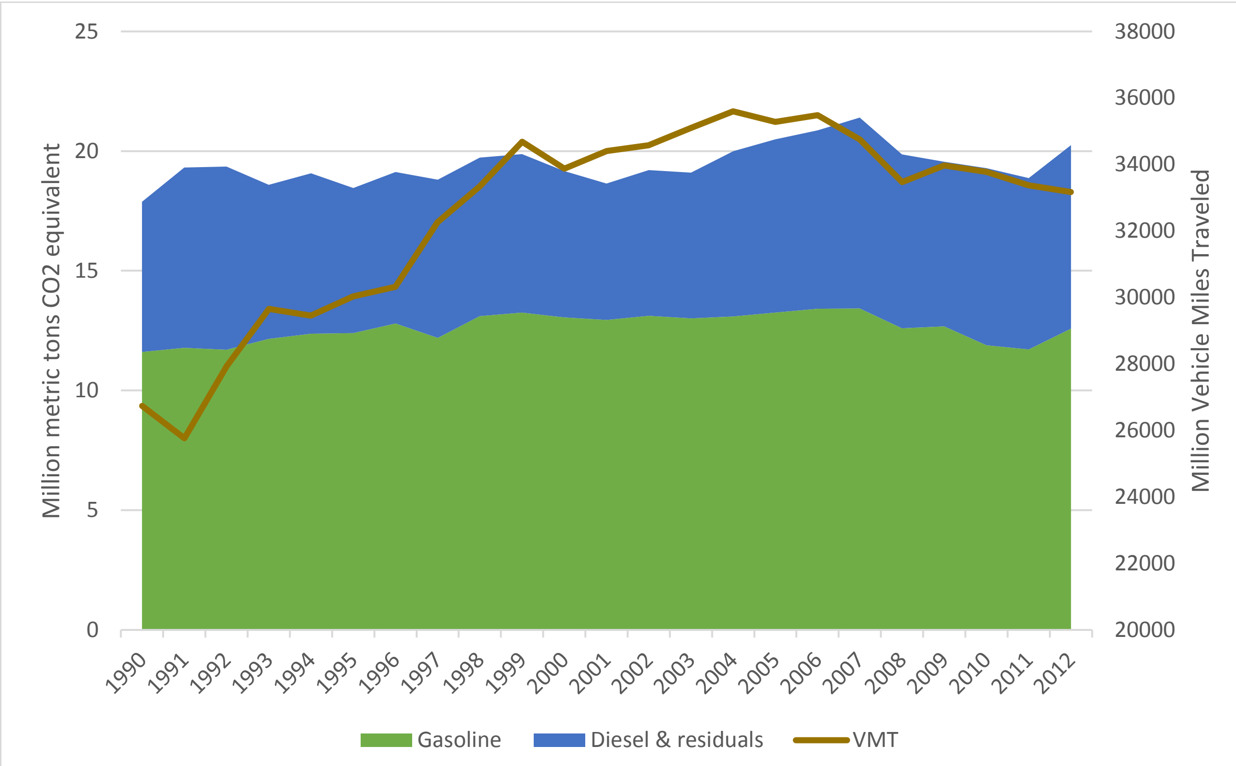
Total emissions from transportation have fluctuated since 1990 rather than declining consistent with Oregon goals, ending slightly higher in 2012. During this period, emissions peaked in 2007 at 25.8 million $MTCO_2e$, and have since declined 7 percent to 23.92 million $MTCO_2e$ in 2012. There is a noticeable uptick in emissions from motor gasoline and diesel use in 2012 which is somewhat difficult to diagnose given the lack of additional years to establish any trends. It is possible that this is a reflection of the economy rebounding from the recession, and the corresponding increase in driving and purchases of goods.

Figure 2: Oregon Emissions from Transportation Fuel Use (Million Metric Tons of Carbon Dioxide Equivalent)



When we look at just the emissions from burning gasoline and diesel for purposes of light-duty and heavy-duty vehicle travel alongside our state's overall vehicle miles traveled (VMT), some other interesting trends emerge. In the late 1990s and early 2000s, our state VMT increased before hitting its most recent peak in 2006. At the same time, emissions from these two fuel sources increased but only very slightly, likely illustrating the improvements in vehicle efficiency occurring over those years. Emissions hit their peak around the same time as VMT (2007) and have been mostly declining since then. We would expect to see a continuation of this trend going forward as efforts to reduce VMT and improve efficiency continue. This is a trend which needs several more years of data to verify, however.

Figure 3: Oregon Emissions from Motor Gasoline and Diesel (Million Metric Tons of Carbon Dioxide Equivalent) and Total Statewide Vehicle Miles Traveled (Million)



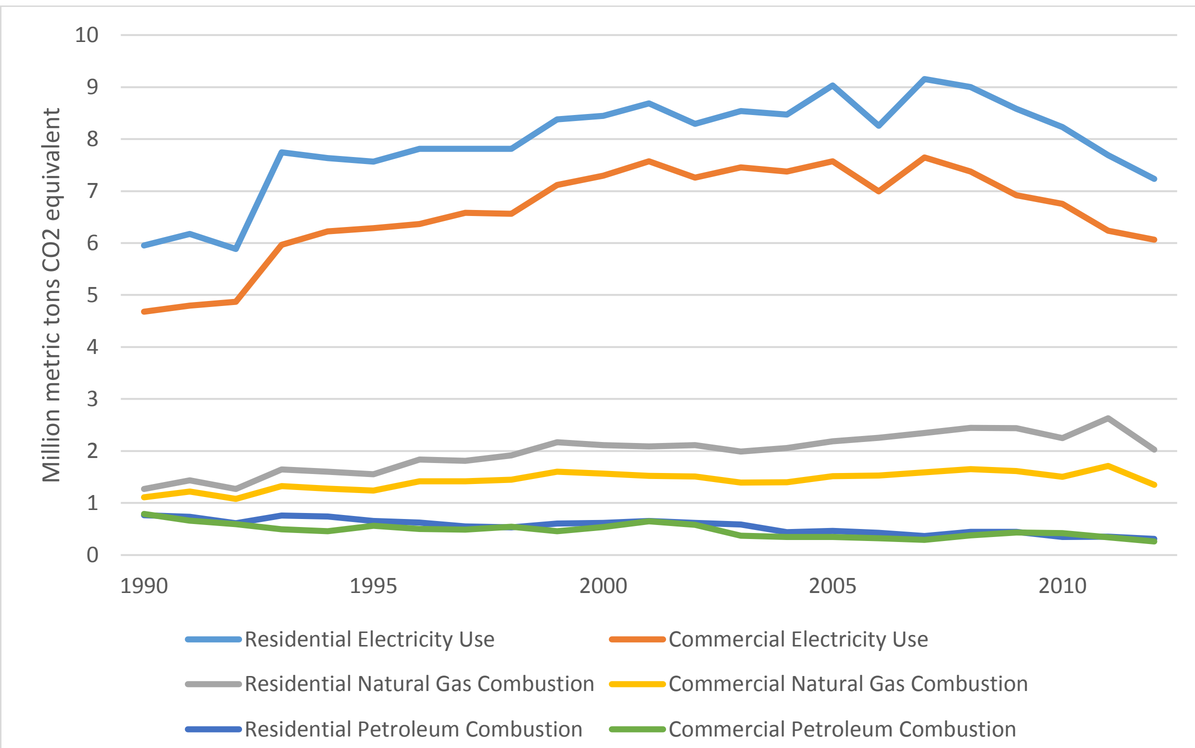
Residential and Commercial Emissions

Emissions from residential and commercial activities come primarily from generation of electricity and natural gas combustion to meet the energy demand from this sector. Other sources of emissions from this sector include small amounts of petroleum fuels burned primarily for heating, decomposition of waste in landfills, waste incineration, wastewater treatment, fugitive emissions associated with the distribution of natural gas, and from the fertilization of landscaped areas. Fluorinated gases from refrigerants, aerosols, and fire protection are also a small but increasing source of emissions from this sector.

Figure 4 illustrates how the state's emissions from electricity, natural gas, and petroleum use in residential and commercial activities have changed since 1990. Emissions from residential and commercial electricity use have followed a similar trend during this period, with residential use consistently between one and two million $MTCO_2e$ higher than commercial use each year. Annual variation in weather influences both electricity demand and the supply of renewable energy from wind and hydroelectric sources. Emissions associated with natural gas direct use in residential and commercial applications have increased steadily since 1990, showing only a recent decline in the last year. This is a trend which needs several more years of data to verify, however.

The annual emissions intensity of Oregon's electricity is influenced by weather and hydrological conditions that affect hydroelectric generation. The less power that is available from dams, the more electricity Oregon utilities must acquire from other sources, much of which is generated with fossil fuels. So, changes in annual emissions from various uses within each sector may have as much or more to do with annual differences in the emissions intensity of Oregon's electricity as with changes in demand. Emissions associated with electricity use rose during the 1990s, leveled off around 2000 with annual fluctuation, and have shown a downward trend in recent years, particularly 2012 which was a better-than-average year for hydroelectric production.

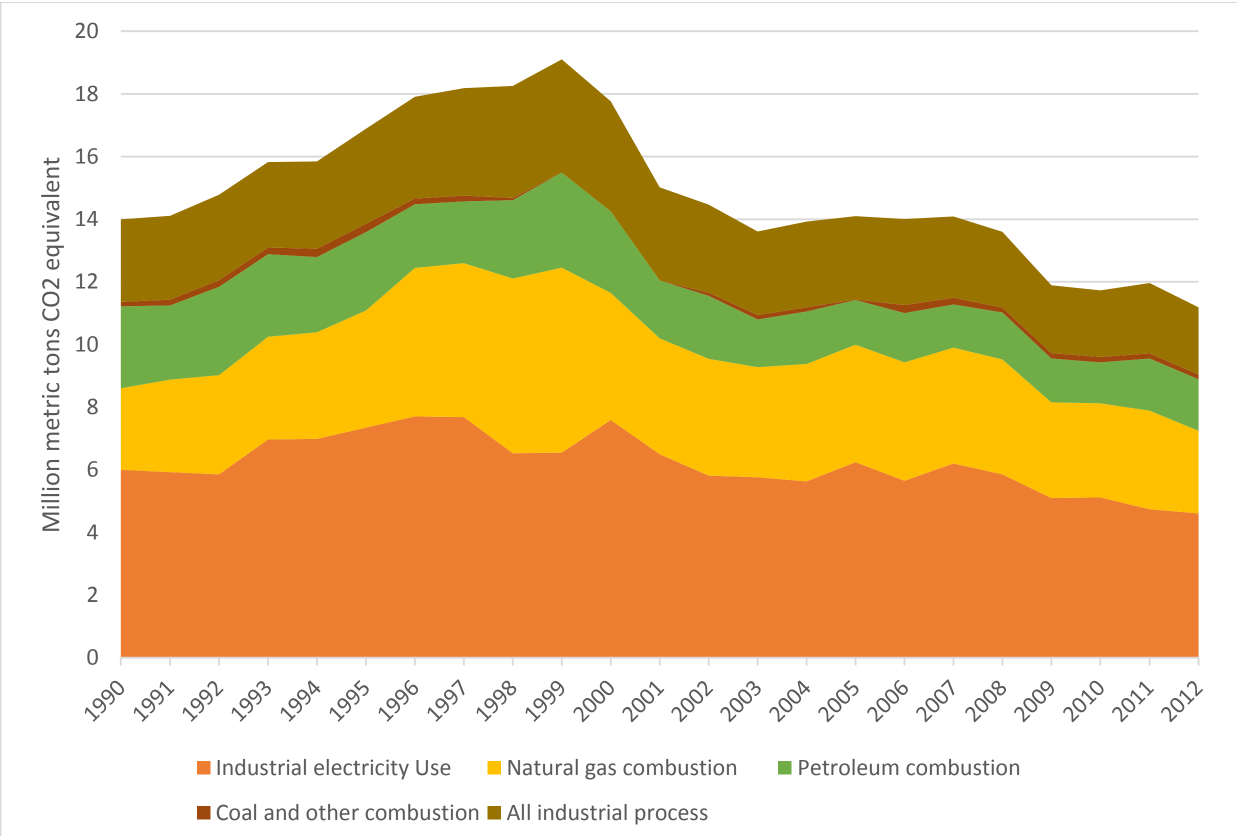
Figure 4: Oregon Residential and Commercial Emissions from Electricity, Natural Gas, and Petroleum Use (Million Metric Tons of Carbon Dioxide Equivalent)



Industrial Emissions

Similar to residential and commercial activities, emissions from the industrial sector come primarily from electricity generation and natural gas combustion. Emissions from petroleum combustion have declined since the late 1990s largely because many facilities transitioned from distillate fuels to natural gas and from structural changes in Oregon's industrial base. Emissions from coal combustion are nominal as there are very few industrial facilities in Oregon using coal onsite.

Figure 5: Oregon Emissions from Industrial Processes and Fuel Use (Million Metric Tons of Carbon Dioxide Equivalent)



Certain industries emit greenhouse gases from processes other than fuel combustion. In Oregon, these industrial processes are chiefly cement manufacturing, pulp and paper manufacturing, and semiconductor manufacturing. Emissions from these processes collectively account for approximately 2.15 million $MTCO_2e$ in 2012, which is about four percent of Oregon's total in-boundary emissions. Table 2 lists these emission categories.

Table 2: Oregon Emissions from Industrial Processes (Million Metric Tons of Carbon Dioxide Equivalent)

Industrial process	1990	1995	2000	2005	2010	2011	2012
Aluminum Production	0.31	0.26	0.27	0.09	0.00	0.00	0.00
Ammonia and Urea Production	0.08	0.08	0.07	0.07	0.13	0.15	0.13
Cement Manufacture	0.22	0.21	0.44	0.44	0.46	0.46	0.45
Combustion Byproducts	0.08	0.06	0.06	0.05	0.05	0.05	0.06
Food Processing Wastewater	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Industrial Landfills	0.09	0.11	0.14	0.17	0.26	0.26	0.27
Iron & Steel Production	0.70	0.70	0.75	0.34	0.03	0.03	0.04
Lime Manufacture	0.09	0.16	0.14	0.09	0.05	0.05	0.05
Limestone and Dolomite Use	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Natural Gas Distribution & Production	0.33	0.41	0.33	0.30	0.24	0.30	0.26
Pulp & Paper Wastewater	0.32	0.32	0.32	0.32	0.32	0.32	0.31
Refrigerant, Foam, Solvent, Aerosol Use	0.00	0.06	0.14	0.19	0.15	0.10	0.13
Semiconductor Manufacturing	0.29	0.50	0.77	0.51	0.36	0.44	0.38
Soda Ash Production & Consumption	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Waste Incineration	0.07	0.12	0.02	0.03	0.05	0.03	0.02

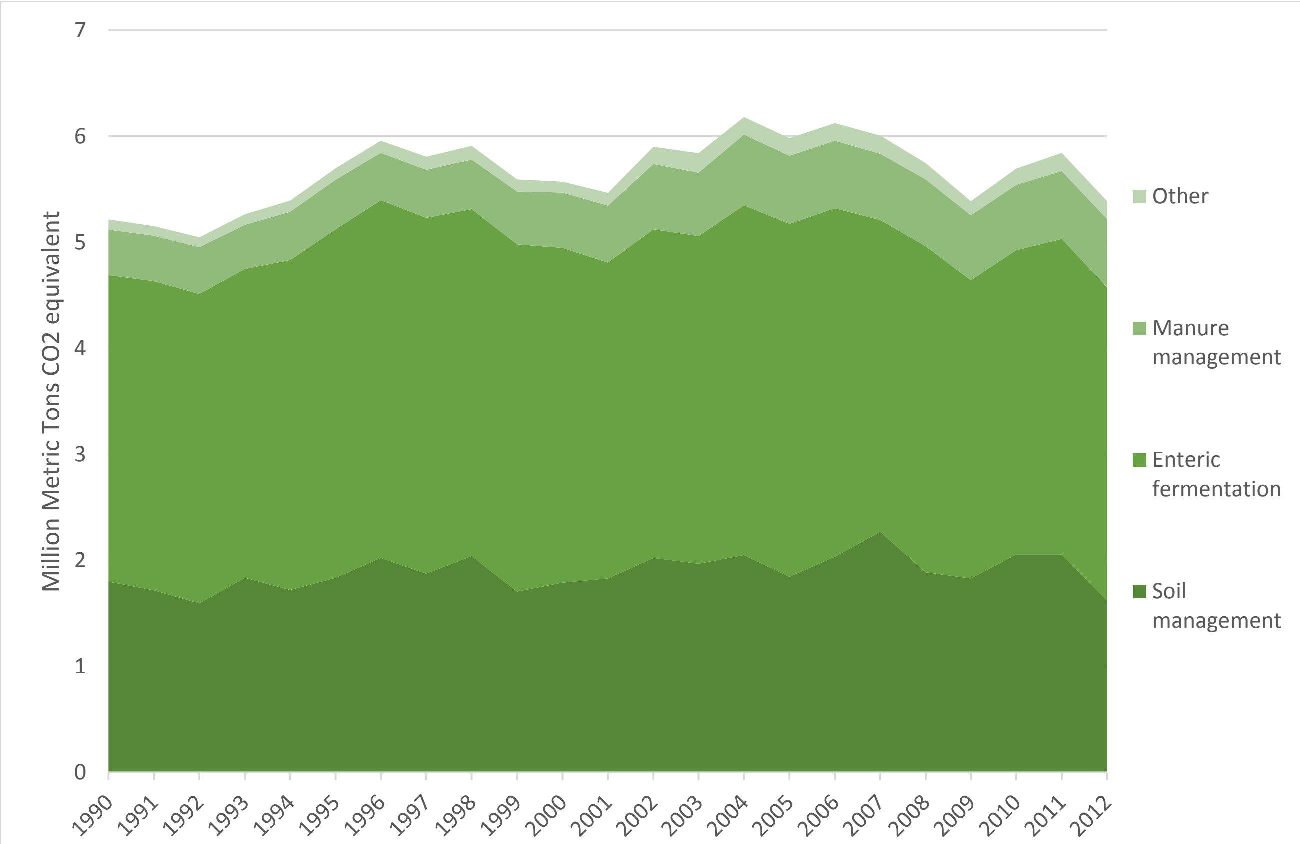
Agriculture Emissions

Agricultural activities have consistently accounted for approximately 5.5 million $MTCO_2e$ since the mid-1990s. In contrast to other sectors, most of these greenhouse gas emissions are from methane and nitrous oxide rather than carbon dioxide. Slightly more than 2 million $MTCO_2e$ is from methane that results from enteric fermentation (i.e. digestion of feed from livestock). About 2 million $MTCO_2e$ is from nitrous oxide, estimated from nitrogen-based fertilizers used for soil management. Methane and nitrous oxide from management of livestock manure have accounted for roughly 0.5 million $MTCO_2e$ since 2000. Other agricultural sources of emissions, including urea fertilization, liming of soils, and residue burning, produce less than 0.2 million $MTCO_2e$.

Black Carbon – Important Warming Agent?

Black carbon (BC) is a solid form of mostly pure carbon that is formed by the incomplete combustion of fossil fuels, biofuels and biomass. It is a significant part of particle pollution and absorbs solar radiation at all wavelengths. Recent research indicates that BC may play an important role in climate change and has been linked to a range of climate impacts, including increased temperatures, accelerated ice and snow melt and disruptions to precipitation patterns. BC is emitted directly to the atmosphere in the form of fine particulates (PM2.5) and is emitted along with other particles and gases. Its short atmospheric lifetime (days to weeks) combined with its strong warming potential make it a good target for reduction strategies that will provide climate benefits within the next several decades. In addition, emissions of BC and its effects are more localized than other greenhouse gases, meaning that mitigation actions will produce different climate results depending on the region, season, and sources in the area. Oregon does not yet track or attempt to directly mitigate our emissions of BC, largely due to the remaining scientific uncertainty about the particular global and regional climate effects and a lack of information and inventory protocols for doing so. However, given its potential importance for short-term climate change, the OGWC will track action at the federal level (via the US EPA) and may explore making recommendations about this pollutant in the future.

Figure 6: Oregon Emissions from Agriculture (Million Metric Tons of Carbon Dioxide Equivalent)



Updates to Previous Years

The process of analyzing emissions for an updated inventory involves revisiting previous years' data with some slight adjustments up or down in emissions for some of those years. That was the case when agency staff constructed this 2012 inventory. For example, the 2010 emissions level as reported in the previous inventory report has been adjusted upward by roughly 0.5 million MTCO2e of CO2e. Prior years' emissions are also adjusted slightly upward in the 2012 update.

The adjustments are caused primarily by an important update in greenhouse gas accounting methodology. The Intergovernmental Panel on Climate Change (IPCC), the UN-convened body that provides the most comprehensive review of climate science, released its Fifth Assessment report (also known as "AR5") in late 2013 and in it updated its understanding of the global warming potential (GWP) of methane. All inventory numbers have been updated to reflect this new scientific understanding, and thus we see increases in our emissions in all categories that emit methane[17]. In addition to this update, some of the inputs to DEQ's reporting program

[17] AR5 contained information indicating that methane emissions should be analyzed with a GWP of 28, meaning it has 28 times the warming forcing of carbon dioxide. This was increased from the previous Report which included a

were updated in the years following the completion of the 2010 inventory, which is the source of a few other adjustments upward.

Consumption-based Inventory

Oregon's consumption-based emissions inventory estimates the global emissions of greenhouse gases associated with satisfying Oregon's consumption of goods and services (including energy). Consumption is defined in economic terms consistent with "final demand" of goods and services by Oregon households, government (federal, state, and local) facilities located in Oregon, and one small but important category of business expenditures: investment (including capital and goods inventory formation). This inventory includes global emissions associated with the wide range of "stuff" that Oregonians purchase, including food, vehicles, appliances, furnishings, and electronics, as well as services, fuels and electricity. Greenhouse gas emissions are included in this inventory regardless of whether they physically originate in Oregon or elsewhere.

Understanding how Oregon contributes to global greenhouse gas emissions requires looking at more than one type of GHG inventory – no single accounting method adequately captures the full picture. Considering both the in-boundary and consumption-based inventories allows us to present a more comprehensive perspective of our emissions and think through possible methods for reducing them. It enables us, if we choose to do so, to develop emissions reduction goals keyed to consumption inventory amounts in lieu of, or in parallel with, our current goals tied to the historical inventory. Whether we do this or not, the consumption-based inventory invites us to develop emissions reduction recommendations that address the added emissions driven by Oregonians' consumption and waste management practices. The Commission may consider either or both of these options in the future.2012 Model Updates

The consumption-based emissions inventory is built using a model that draws data from multiple sources, including the US and Oregon in-boundary inventories, ODOT's expanded transportation sector inventory, international emissions datasets, and datasets of Oregon and US consumption, production and trade flows. The inventory is described in greater detail in the 2010 inventory report (published 2013).

Oregon's consumption-based emissions were first estimated for calendar year 2005 and then 2010. DEQ has committed to a full update every five years (2015, 2020, etc.) with "light touch" updates in intervening years as resources allow.

For 2012 DEQ has undertaken an estimate of 2012 consumption-based emissions, making the following significant updates to the model:

- Oregon consumption (final demand) data for 2012 replaces 2010.

GWP of 25. When analyzed on a shorter timescale, for example 25 years instead of 100 years, the GWP of methane is even higher than 28.

- Emissions intensities (emissions per dollar of economic output) for each of 440 producing sectors in 3 geographic regions are drawn directly from the 2010 model and adjusted uniformly to 2012 dollars using the CPI-U. All Oregon, US, and foreign emissions intensities are then further adjusted by a geographic-specific constant representing real (not inflation adjusted) reductions in emissions intensities for that region as a whole.
- Most emissions from the direct use phase (e.g. the point at which the products are used by Oregonians) are drawn directly from the Oregon 2012 in-boundary inventory (with adjustments consistent with the 2010 inventory). In the case of transport-emissions that in 2012 were drawn from the ODOT expanded transportation sector inventory, the 2010 ODOT results were adjusted proportionately based on changes in in-boundary emissions for specific fuel types (gasoline, etc.).
- Waste disposal emissions were updated using 2012 disposal tonnage.
- As with the in-boundary inventory, global warming potentials for all years were updated using the most recently updated IPCC values.

Because the 2012 update is not as detailed and complete as the full 2010 inventory, results for 2012 are presented only at a more aggregated level. Additional detail can be viewed in the 2010 inventory report (published 2013).

Updated Results

Table 3: Oregon Consumption-Based Emissions by Life-Cycle Stage (Million Metric Tons of Carbon Dioxide Equivalent)

	2005	*2010*	*2012*
Total	**75.4**	**75.2**	**77.0**
Pre-Purchase	*45.5*	*46.7*	*49.3*
Use	*28.9*	*27.9*	*27.1*
Disposal	*1.0*	*0.6*	*0.5*

Consumption-based emissions were essentially flat between 2005 and 2010 and then rose slightly from 2010 to 2012. This increase in emissions is a result of increases in consumption as Oregon recovered from the recession. Indeed, real (inflation-adjusted) consumption increased by a much higher percentage, but the emissions that would have resulted from this increase in consumption were somewhat (although not entirely) obviated by efficiency gains and, specific to 2012, a reduction in the carbon intensity of Oregon electricity due to high hydroelectric production.

Emissions upstream from the consumer (in production, wholesale and retail activities) continue to dominate Oregon's consumption-based emissions. Many although not all of these emissions occur outside of Oregon. These emissions have continued to rise. As described above, many use-phase emissions (such as the emissions associated with driving cars or running furnaces) have flat-lined or fallen, reflecting the results of policies and programs such as those incentivizing energy efficiency. Disposal-phase emissions are small and decreasing, a result of reductions in waste disposal, and improvements in methane gas capture at landfills.

Table 4: Oregon Consumption-Based Emissions by Type of Consumption (Million Metric Tons of Carbon Dioxide Equivalent)

	2005	*2010*	*2012*
*Total**	**75.4**	**75.2**	**77.0**
Vehicles and parts	15.6	13.9	15.0
Appliances	11.9	12.4	11.1
Food and beverages	9.5	10.5	10.1
Other manufactured goods	5.3	4.6	7.7
Services	5.6	6.9	6.3
Construction	5.3	5.4	4.8
Healthcare	4.0	5.0	4.6
Transportation services	3.4	3.7	4.4
Electronics	3.5	2.8	2.6
Furnishings and supplies	3.1	2.8	3.1
Retailers	2.1	2.3	2.2
Lighting and fixtures	2.9	1.9	1.7
Clothing	1.8	1.4	1.6
Wholesale	0.8	0.6	0.6
Water and wastewater	0.3	0.4	0.3
Other	0.5	0.6	0.7

**Results may not total exactly due to rounding.*

As in prior years, close to half of all consumption-based emissions in 2012 are associated with just three categories of consumption: vehicles and parts, appliances, and food and beverages. Emissions associated with vehicles and appliances are primarily (roughly 90 percent) associated with fuel and electricity use, although emissions associated with the production of vehicles are not insignificant. In contrast, emissions associated with food and beverages primarily occur during production.

Categories of emissions with the most significant changes between 2010 and 2012 include

- A decrease in emissions associated with "appliances", likely due to a combination of efficiency improvements and 2012's low carbon intensity for electricity (which was due to high hydroelectric use that year).
- A decline in emissions between 2005 and 2010 from "other manufactured goods", followed by a sharp increase between 2010 and 2012, reflecting post-recession investments in machinery and other large capital investments by businesses.
- An increase in emissions from "transportation services", driven by increases in airline travel and truck transport of finished goods.

- Sustained declines in emissions from "electronics" and "lighting and fixtures". Emissions reductions from "electronics" are primarily due to computers, peripherals and other hardware becoming smaller (and less material intensive) and reduced power demand during the use phase of consumer electronics. Emissions reductions for "lighting and fixtures" are in the use (not production) phase resulting from sustained improvements in lighting energy efficiency coupled with the low carbon intensity of electricity in 2012.

II. Oregon's Greenhouse Gas Reduction Goals

Thanks to DEQ's mandatory reporting program, Oregon is able to refine our understanding of what our GHG emissions have been and what they are likely to be in the future. Through this program and by using tools available to Oregon and other states through EPA, we can make sound judgements about whether or not we are meeting our statutorily required emission reduction goals, and where the best opportunities lie for the most efficient reductions. This section examines what the data tell us about whether we met our 2010 goal, and whether we are on track to meet our 2020 and 2050 goals.

2010 Reduction Goal: Arrest Emissions Growth by 2010

The law that established Oregon's greenhouse gas reduction goals (ORS 468A.205) directs the state to arrest the growth of emissions and to begin reducing those emissions by 2010. In the Commission's last Report, we noted that, despite the lack of specific standard by which to judge whether emissions growth has been arrested by 2010, it seems logical to assume that holding emissions more or less level over a reasonable period of time by 2010 should suffice as "arresting" those emissions. With the data available to us at the time, we concluded that emissions had remained fairly level for the 2000's decade, and had begun to decline measurably after 2008. In this Report we are able to confirm that the updated in-boundary emissions inventory described above continues to support that earlier conclusion. Emissions remained fairly level for the years 2000-2007, and began to decline in 2008. 2009 and 2010 represent the lowest two levels of emissions for the decade at 65.4 and 63.3 million $MTCO_2e$.

Data for 2011 and 2012 seem to indicate that Oregon's emissions are now reliably in the low 60 million $MTCO_2e$ range. With these numbers we can report with continued confidence that Oregon likely did meet its first greenhouse gas reduction goal of arresting emissions growth and beginning to reduce emissions after 2010. This conclusion is a positive one, but we must temper it with a few possible caveats: 2009 and 2010 emissions were likely suppressed by continued effects of the recession, and 2011 and 2012 emissions seem to have benefited from the availability of above-average hydroelectric power. Thus, we must continue to monitor trends in our 2013 and 2014 emissions to confirm these conclusions.

2020 and 2050 Reduction Goals: 10% and 75% below 1990 Levels

To evaluate Oregon's path to meeting our more ambitious 2020 and 2050 goals, we need to make an estimation of the trajectory of our emissions post-2012. This Report utilizes the same methodology as our last Report, but with updated data and a more sophisticated projection for the electric sector. As with our last Report, we use a forecasting tool available from the US EPA and calibrate it to Oregon's actual 2012 emissions data[18]. Doing so we can get a sense of the direction the state's emissions are headed in the absence of additional policy intervention. From this starting point, we can also outline some steps the state can take to ensure the emissions trajectory is headed toward our GHG goals, as we do in Section V below.

Figure 7 shows the current "business as usual" (BAU) forecast in comparison to the Commission's previous estimate of BAU. Our new forecast for BAU includes the following assumptions[19] that are different from our last forecast:

- Oregon's Renewable Portfolio Standard (RPS): we now have the ability to more accurately forecast load requirements for the state's utilities. From their 2013 Integrated Resource Plans (IRPs), we also have information on the investor-owned utilities' own estimates of the sources from which they will procure power in order to comply with policies currently in place. Thus, we have a way to incorporate Oregon's current RPS policy into the forecast.
- Boardman: the new forecast includes Portland General Electric's assumptions about what will occur once Boardman cease's coal operations at the end of 2020[20], which are more accurate than previous staff estimates on Boardman.
- Energy efficiency: similarly to the estimates of the RPS, our new forecast benefits from the more precise load projections for each utility, supported by Energy Trust of Oregon analysis, which take into account their estimate of how much efficiency will be achieved on their systems due to policies currently in place.
- Clean Fuels: with the passage and signature of the Clean Fuels bill in the 2015 session, we now have the ability to include the emission reduction projections that could accrue to that program in our estimate of BAU.

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[18] The EPA's projection tool uses our historical emissions data and estimates of future energy demand to forecast state-level emissions in various sectors. For the most part, it uses national or regional-level growth estimates and scales or prorates them to Oregon based on population or some other variable. While this is an imperfect method, it is the primary source for projecting overall statewide emission and is the tool used by most states that create such projections.

[19] This forecast does not include the effects of the recently-finalized federal Clean Power Plan.

[20] Also from the 2013 IRP which indicated that the company did not, at that time, plan to replace Boardman with new renewable generation.

- Fuel economy: the projection tool incorporates fuel economy standards for heavy-duty trucks[21] and light duty vehicles[22] approved by EPA and the National Highway Traffic Safety Administration.

Interaction with Federal Policies

Many aspects of Oregon's emissions will be influenced by federal regulatory action (or inaction) that alters energy demand or types of fuel used. This is most obviously the case for the fuel efficiency of passenger cars and trucks and heavy-duty commercial vehicles, as well as emissions standards for power plants that affect the type of fuel burned or the efficiency of the power plant. The federal government has promulgated rules for the fuel efficiency of passenger cars and trucks out to model year 2025 and heavy-duty trucks out to model year 2018. There are several air quality rules, including the Mercury and Air Toxics (MATS) rule and the Regional Haze rule, that do not directly regulate CO2 emissions from power plants but that will ultimately have an impact on those emissions through their implementation (utilities may elect to shut down older, less carbon-efficient power plants, for example, rather than pay for costly air quality retrofits; as PGE chose to do with its Boardman, OR coal plant).

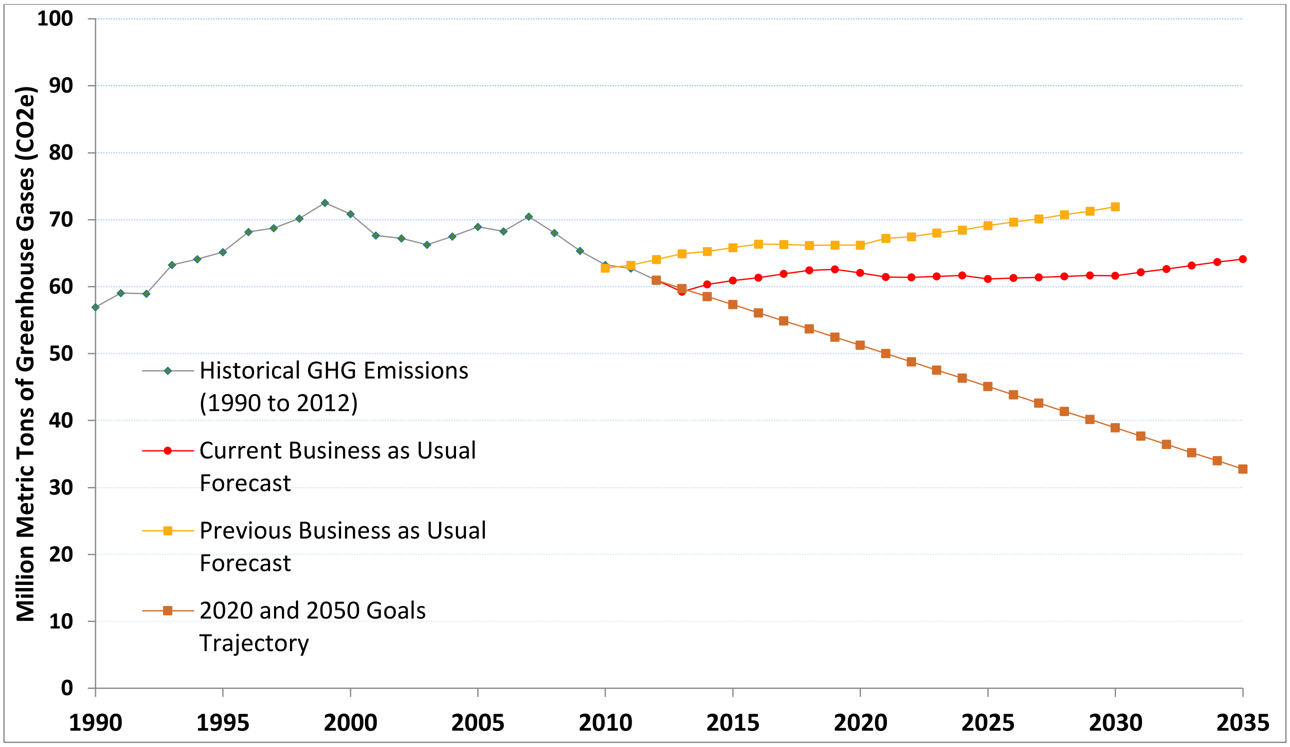
Recently, in June 2015, EPA and NHTSA announced proposed rules for heavy-duty trucks beyond model year 2018. And in summer of 2016, EPA is expected to finalize rules explicitly regulating carbon emissions from new and existing power plants, using authority under Sections 111(b) and 111(d), respectively, of the Clean Air Act.

The EPA's projection tool for states uses the Energy Information Administration's (EIA) Annual Energy Outlook for the estimate of future energy demand, which takes into account federal policies and programs. However, in the projection used in this Report, neither the effects of the recently-announced heavy-duty truck standards nor the forthcoming Section 111 power plant regulations are estimated because of the recent nature of these rules. We discuss potential interactions between these policies and our scenarios in the sections below.

The new forecast indicates that in the absence of new policies greenhouse gas emissions are expected to remain at or below 2012 levels for a couple of years and begin to slowly rise starting in 2016. Despite the likely rise in emissions, there's some positive news in this forecast: through 2013, Oregon appears to have brought emissions down to a level that could be considered on a linear path to our 2020 and 2050 goals. This is coupled with a business as usual forecast that we now expect to have a slower rate of increase than previously projected.

[21] http://www.gpo.gov/fdsys/pkg/FR-2011-09-15/pdf/2011-20740.pdf
[22] http://www.gpo.gov/fdsys/pkg/FR-2012-10-15/pdf/2012-21972.pdf

Figure 7: Current and Previous Business as Usual Forecasts



Now for the less positive news: despite an overall lower forecast than previously reported thanks to the implementation of Oregon's RPS and other policies, that forecast is not expected to come within striking distance of our 2020 and 2050 emission reduction goals. Rather, with 5 years left to go we appear to be on track to miss our 2020 goal by just over 11 million MTCO2e. That gap widens to 32 million MTCO2e in 2035 on a linear path to our 2050 goal.

The temporal nature of our 2020 and 2050 goals – one being so close it is hard to see how we could meet it, and the other being so far away it is difficult to imagine what policies and technologies might get us there – leads us to suggest two things in the sections that follow: first, Oregon needs an interim target between our current two to help ensure that we do not defer meaningful actions until it is too late. And second, in order to meet that interim target and put Oregon on a sustainable path to meeting our 2050 goal, we must immediately begin taking more ambitious action than what we have seriously contemplated as a state historically. We elaborate on what some of these actions could be in Section V below.

III. A 2035 GHG Reduction Goal for Oregon

In December 2004, Oregon's Advisory Group on Global Warming submitted its recommendations to Governor Kulongoski. The emissions reduction goals it proposed, subsequently adopted by the 2007 Oregon Legislature, included: a near-term (2010) goal of arresting emissions creep upwards; and a 2050 end goal for achieving a sustainable emissions level, estimated at the time by climate scientists to be at least 75% below 1990 levels.

The Advisory Group, aware that a goal set for as far away as 2050 could be shouldered aside with relative ease by more immediate demands, also recommended an intermediate 2020 goal to give greater focus and immediacy to state reduction efforts. There was no scientific rationale for proposing a "10% below 1990 levels by 2020." The date seemed far enough away to allow meaningful emissions reduction policies to be adopted, investments to be made, regulatory actions to be designed and implemented, so that measurable emissions reductions were plausible. It also seemed near enough to lend State greenhouse gas reduction efforts a degree of urgency.

That date is now only five years away. Oregon, and the nation, have taken some meaningful policy steps (Federal vehicle efficiency standards; a US-China climate accord; Oregon's utility efficiency and renewable energy initiatives), and we've benefited from serendipitous events (lower cost gas; rapidly declining wind and solar costs) that are delivering near-term lower emissions. But neither the country nor Oregon is on track for 2050. [23] Neither has adopted the necessary systemic regulatory, taxation and infrastructure investment policies that would put us on a dependable trajectory to 2050. Without an intermediate check point, we risk deferring meaningful actions to much later, much closer to 2050, when such actions would be less effective, and would have to achieve unrealistically steep and costly reductions.

The Oregon Global Warming Commission is therefore recommending that the State identify and commit to a new intermediate target that will be: (a) near enough to focus State and community efforts without having to assume "silver bullet" technological bailouts; and, (b) far enough in the future to allow choices to be made and consequences to be realized.

The Commission will begin using an intermediate 2035 emissions reduction goal of 32.7 million MTCO2e. This target was identified simply as the intermediate 2035 level the state would achieve if it drew a line between our adopted 2020 and 2050 goals. Figure 7 above shows the 2035 goal along the trajectory between 2020 and 2050 in comparison to our projected emissions forecast for that year.

It's a target that will be more challenging to achieve if, as expected, we fail to meet our 2020 goal and have that additional ground to make up.

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[23] We should note that overall US emissions are down from their 2007 peak (as Oregon's are down from its 1999 peak). Some of this is displacement of older coal-fired electric generation by newer, more carbon efficient gas, some is recession effect, and some may be systemic and durable. But an economic rebound coupled with locked in emissions from the new generation of gas plants will challenge further progress. We should also note that Oregon's 2020 goal was aggressive when adopted, was arbitrary by its nature as an intermediate benchmark, and was made more challenging given the closure, in the early 1990's, of PGE's near-zero GHG Trojan nuclear power plant.

2035 recommends itself for other reasons:

- 2035 presents a 20 year planning horizon that is consistent with how Oregon's electric and gas utilities look forward, allowing us to compare the carbon outcomes of the utility Integrated Resource Plans with the State's 2035 goal;
- Oregon mandates the Portland-area Metropolitan Planning Organization (Metro MPO) to adopt light-duty vehicle emissions goals and strategies for achieving a 20% per capita reduction by 2035 (the state's five other urban-area MPO's are encouraged to develop and implement such plans as well, with the same target date).
- EPA's Clean Power Plan targets a 2030 date for states meeting their emissions targets for existing power plants, which is within the window that the new goal would establish for Oregon.
- The GHG scenario(s) developed for this Report rely on data sets (e.g., MACC) that projected possible emission reductions for the year 2035, allowing us to use the data available from that analysis rather than needing to scale it to a different year (such as extrapolating to a more distant one).

The new 2035 target, along with the legislatively-set ones, can be useful for planning and accountability purposes. The new goal will have no force of law or imprimatur from the Legislature until and unless that branch acts on the recommendation. But since the targets earlier adopted by the Legislature are already aspirational this presents no compelling reason for the Commission to defer.

For these reasons, the Commission adopts the proposed intermediate 2035 GHG reduction goal with its adoption of this Report and its transmittal to the Governor and Legislature.

Analytical Approach for 2035 Reduction Scenarios

Were Oregon to achieve the 2035 reduction goal described above, we would be able to say with some confidence that we were on track to meet our 2050 goals. Though additional measures would likely be necessary post-2035, achievement of this goal would be not only impressive in its own right, but many of the major transformations required for achievement of the 2050 goal would be underway as a result. For the rest of this Report, we discuss some of the possible measures that Oregon could implement to begin making that transformation, and we describe a scenario in which the state could achieve this ambitious interim target.

To construct our emission reduction scenario analysis, we followed a process common to other similar analyses.[24] The basic steps we undertook are described below. More detail about the

[24] For example, Pacala and Socolow's analysis of stabilization wedges, published in *Science* in 2004. (http://www.pdx.edu/prc/annual-oregon-population-report).

sources of information on emission reduction measures and opportunities is described below in Section V.

First, we constructed our best estimate of Oregon's future GHG emissions given current trends and existing policies. This projection process is described above and relies partially on a tool for projecting emissions available from the US EPA. We then compiled analyses on measures Oregon could implement to reduce GHG emissions in the future. This involved a careful assessment of research and modeling already done by various entities in the state and includes measures that reduce electricity and natural gas use in the residential, commercial and industrial sectors, fossil fuel use in transportation, and measures that reduce emissions and energy use in the agriculture and waste sectors.[25] In our assessment, we included the most cost-effective reduction measures from these sectors and excluded some because of potential overlap with others. With the exception of measures that reduce emissions due to changes in our electricity resource mix, we did not include measures specifically designed to reduce out-of-state emissions because these emissions are not included in the forecast. However, we intend to explore methodologies to include these measures in future analyses.

It is important to note that while we are confident in the relative size of the reductions implied in our assessment of the measures, we are not implying that the state will, or should, implement these measures in any particular order or implement the exact combination of measures we include. The analysis is intended as illustrative, to demonstrate what could be achieved if these or a comparable suite of measures were implemented and the magnitude of the effort required, not to recommend the best strategy or provide a thorough evaluation of priorities.

With an assessment of the available measures complete, we constructed a scenario demonstrating the GHG emissions that could be expected for the years 2015-2035. The scenario that resulted is discussed and elaborated more in Section V below. Finally, we enlisted the assistance of Portland State University researchers who updated their analysis of a carbon tax in Oregon (discussed more below in Section IV) to take into account interaction between the measures identified and a $60/ton carbon price in the state. The GHG emission reduction scenario that resulted from this analysis is also elaborated in Section V.

IV. Recent Analysis on Oregon's Emission Reduction Options

Before we present our analysis of emission reduction scenarios, we summarize key outcomes from recent analytical work done by various entities in the state that, over the last biennium, have expanded our understanding of climate mitigation opportunities. These analyses informed our emission reduction scenarios, and thus warrant a detailed discussion here. We go into further detail on the various measures that comprise our scenarios in Section V.

[25] The sources of information for these analyses are described further in in the next two Sections.

Emission Reduction Measures – Updates to Marginal Abatement Cost Curve Analysis

In our last Report, we described a 2012-2013 research and modeling effort conducted by the Oregon Department of Energy and a team of consultants to evaluate a suite of measures that Oregon could undertake to reduce emissions in all sectors. Over 200 measures were rigorously analyzed under different assumptions of federal and state climate policy ambition. The data produced by this analysis provides a means of comparing the emission reduction potential and cost-effectiveness of policy and technology options available to the state. A key takeaway from the first phase of this study was that "low hanging fruit" – also known as no-regrets options – exist in every sector, not just with energy efficiency. Indeed, economically beneficial measures were uncovered across Oregon's economy.[26]

Several important updates were made to this analysis since our last Report that have increased its usefulness. To address stakeholder suggestions from the original project and to improve the analytical rigor, ODOE reengaged with contractors to improve the analysis in the latter half of 2013. With the limited funds available, the primary goals of the second phase of the project were twofold: (1) better integrate the power supply and demand measures in order to reduce "double counting" where emission reductions were being credited to both energy efficiency and power generation measures, making the measures more accurate, and (2) update the transportation measures with new modeling results from ODOT's STS analysis and fill gaps related to vehicle technologies. These updates are described in further detail below.[27]

An integration tool was developed to combine the measures in electricity demand and supply. This tool now provides users an easy interface with which to examine six integrated scenarios that combine the demand and supply side options that were set out in the original analysis. The effect of this integration work is that users can now more accurately predict the GHG reduction impact of measures undertaken in the power sector because emission reductions attributable to energy efficiency measures are being accounted for[28].

Secondly, the transportation strategies that appear in the original analysis were updated and revised to varying degrees by one of the contractors that helped ODOT complete the Statewide Transportation Strategy (STS) in 2013. This was done to better align the assumptions and results from the original MACC study with the results from the STS, particularly around vehicle and fuel strategies, light-duty travel reduction and efficiency strategies, and transit strategies. Additional strategies were eliminated because they were redundant.

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[26] These are measure that could be implemented at "negative cost", that is, the savings that accrue due to the measures outweigh the costs of installing and operating them.

[27] The full results of both phases of the MACC analysis are available on ODOE's website, here: http://www.oregon.gov/energy/GBLWRM/pages/ghg-macc.aspx

[28] Note: the updated integration scenarios did not include any assumptions about specific federal policies to reduce emissions from the power sector, such as the Clean Power Plan.

Note that the MACC approach, which ranked measures by the cost-effectiveness with which they achieve carbon reductions, may not result in a proportional application of Oregon's GHG reduction goal to all sectors.[29] Depending on how the MACC measures were to be implemented in practice, some sources and sectors could achieve more or earlier reductions than other sources and sectors. Neither does the MACC analysis schedule reductions to reflect the practical or political difficulties of capturing reductions (e.g., it's easier to regulate a few large emissions sources than to regulate the carbon decisions of individuals), while these considerations will certainly be consulted in shaping public policies. Indeed, there will be many other criteria aside from a simple cost of abatement measure to consider when evaluating GHG reduction options, including environmental, economic, and social co-benefits, absolute magnitude of GHG reductions, feasibility, and timing. The underlying analysis of the abatement measures is nevertheless useful for purposes of constructing our emission reduction scenarios.

Analysis of a Carbon Tax in Oregon

In December 2014, the Legislative Revenue Office completed a study it had been directed to undertake by SB306 (2013), of the economic and greenhouse gas emissions impacts of implementing a carbon tax in Oregon. The study was conducted by Portland State University's Northwest Economic Research Center (NERC), and the researchers involved have since presented their findings to the Legislature and discuss the results at length in their final report.[30] We highlight some of the key features of their analytical approach here.

For the economic aspects of their modeling, NERC used the Regional Economic Modeling Inc (REMI) software, which was customized to fit six Oregon regions. The basic input to this model was the deviation in fuel prices from the expected baseline (business as usual) prices due to the application of the carbon tax. Changes in demand for different fuels due to the carbon tax were then used to update the results for expected future emissions. Future emissions were used to estimate the total revenue that would result from the tax. The NERC team also examined a range of options for how the carbon tax revenue could be used, and used those options to inform the economic model creating a dynamic feedback between emissions and key economic variables throughout their scenarios.[31]

The study analyzed a large number of possible scenarios, including different levels of carbon tax and methods for repatriating the revenue (e.g. investing in energy efficiency, reducing other taxes, etc). The results of the study include estimated emissions, carbon tax revenues, and employment and output impacts under the range of scenarios analyzed. The researchers found that in all cases, emissions decrease shortly after the introduction of a tax and continue to fall until approximately one year after the maximum tax rate is reached and stabilize thereafter. The amount of emission reductions depends on the carbon tax rate, and were found to scale linearly with the size of the tax up to approximately $45/ton. Above this level, emissions

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[29] We also did not rely exclusively on the MACC analysis when selecting measures for our GHG reduction scenarios.
[30] http://www.pdx.edu/nerc/sites/www.pdx.edu.nerc/files/carbontax2014.pdf.
[31] May include more detail in appendices.

reductions continue but grow at a slower pace indicating some diminishing returns in the amount of reductions achievable at higher tax rates. In addition to these emission reduction impacts, the study found that when revenue is repatriated back to the economy there are relatively small impacts – either gains or losses – on employment and output, though benefits and costs vary across geographic regions, income levels and industries.

V. 2035 Emission Reduction Strategies for Oregon

Utilizing the analyses discussed above, the Commission has constructed an illustrative estimate of the emission reductions possible in 2035 assuming ambitious but plausible implementation of policies to promote these measures. This illustrative analysis is intended to give guidance to the Governor and Legislature in their choice of measures and tools for achieving Oregon's greenhouse gas reduction goals. Specific measures, and the mix of programmatic and tax (or cap) strategies, are not Commission recommendations but are indications, to lawmakers, of the extent and seriousness of the commitment required to attain Oregon's goals.

The results of implementation of the programmatic measures alone in Oregon is presented in Case 1. As we explain below, despite the reductions possible with those measures the 2035 goal would still not be achieved. As such, we were fortunate to receive the help of Portland State University's NERC to analyze a combined scenario that would include the programmatic measures we identified plus the implementation of a carbon price to further reduce emissions not already captured in an effort to attain the reductions needed to reach the estimated 2035 reduction goal. The process of constructing this scenario is described further below in Case 2.

Case 1: Implement Oregon Programmatic Measures

To compile the GHG reduction programmatic measures that are available to Oregon for purposes of this analysis, we utilized the various analytical and research results available to the state. The updated MACC analysis was used to construct bundles of measures in residential, commercial and industrial energy efficiency, as well as the agriculture and materials and waste sectors. Ground transportation measures are taken from the MACC, but have been updated to match the STS results. The STS outputs were used to compile freight and air travel emission reduction measures. Power generation emission reduction options were constructed in a more top-down fashion, as described below. In this section we describe in a bit more detail the types of measures included from each sector, and the source of the data.

It is important to note that in compiling these measures we intended to include the most cost-effective options we could glean from the available analyses. In addition, cost-effectiveness was a primary criteria for measure inclusion in the original source analyses, which gives us confidence that these measures are the right ones for Oregon to look to for near-term emission reduction.[32] However, we also note that many measures have other merits[33] that should be considered in addition to the efficiency with which they reduce emissions, and that some currently more expensive measures may also need to be implemented in order for us to achieve our long term goals. The cost of some measures may be more significant upfront or could result in an inequitable distribution of costs and benefits over the course of implementation, which is a particular concern with respect to low income households. These are issues policymakers will want to consider when reviewing this analysis.

Residential, Commercial, and Industrial (RCI) Energy Efficiency

Measures that promote energy savings in the residential, commercial, and industrial sectors represent some of the most cost-effective options for reducing statewide emissions. These measures have the effect of reducing both electricity and natural gas use and thus reduce GHG emissions from more than one fuel type. We used the underlying measure data from the updated MACC results to assemble our estimate of the possible reductions. In general, the measures included here were developed by reviewing a range of available data sources on technologies or methods for decreasing energy use in a particular segment or sector (e.g. Residential weatherization and lighting). The costs and energy savings of implementing a new measure were compared with the technologies currently in-use to establish estimates for the impacts of the measures. The majority of the measures included are based on analysis from the Northwest Power and Conservation Council Regional Technical Forum and the Energy Trust of Oregon[34]. We also included one measure that is an estimate of the additional savings possible by aggressively implementing building codes and incentives to move construction of new buildings toward achievement of net-zero energy status[35].

For all measures in this category, we assumed that a more supportive state and federal policy environment is in place than currently exists, which makes some measures achievable that would not be under the less supportive options. For RCI measures, this generally means that we are assuming additional federal and state action occurs such that we acquire 80% of the

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[32] See the Commission's website for electronic resources detailing the full suite of measures included in Case 1, including best available estimates of their cost-effectiveness. www.keeporegoncool.org

[33] Such as reduction in other pollutants, expansion of access to energy, enhanced mobility and community connectedness, increased productivity, reduced congestion, among others.

[34] Northwest Power and Conservation Council – Regional Technical Forum (2009), *6th Power Plan, Conservation Supply Curve Files.* Downloaded 6/2012 from http://www.nwcouncil.org/energy/powerplan/6/supplycurves/default.htm; Stellar Processes and Ecotope on behalf of Energy Trust of Oregon (2011). *Energy Efficiency and Conservation Measure Resource Assessment for the Years 2010-2030.* Downloaded 6/2012 from http://energytrust.org/library/reports/021611_ResourceAssessment.pdf.

[35] This measure was estimated by staff at Oregon DEQ, with efforts made to eliminate overlap between this measure and other energy efficiency measures. It estimates the effects of increasing codes and incentives gradually over time to begin achieving net-zero energy status in some new buildings. When a building is net-zero energy, it consumes only as much energy as it produces over the course of a year. This measure assumes that 10% of new construction will be 80% less energy-consuming than a building built to code, another 10% of new construction will be 50% less energy-consuming than a building built to code, and the rest of new buildings will range from 0-25% less energy-consuming than buildings built to code.

"achievable potential" of those measures[36]. Thus, we are illustrating the reductions possible if the state and federal governments were to take additional policy steps to incentivize or enable these technologies or practices while we are attempting to account for the fact that some of these savings are already expected to occur thanks to the implementation of utilities' energy efficiency programs. For all the RCI measures, this "policy support" assumption is that additional funding for state energy efficiency programs becomes available such that additional energy savings are realized beyond what would occur in the less supportive scenarios. A brief description of a sample of the types of measures included in the RCI sectors is included below[37].

- Residential HVAC, Weatherization, and Lighting: includes improvement of the efficiency of residential heating, ventilation, air conditioning (HVAC), building envelopes, and lighting systems through the installation of higher-than-standard efficiency technologies. Measures can be implemented through a variety of policies and programs, ranging from utility/ETO programs to low-income weatherization assistance, equipment installer incentives and/or tax incentives.
- Commercial Lighting, Daylight, and Lighting Controls: includes improvement of the efficiency of lighting systems through equipment and controls upgrades and the effective utilization of daylight, through the installation of higher-than-standard technologies and daylighting systems in new or replacement installations.
- Commercial Appliance and Non-HVAC Equipment: includes improvement of the efficiency of appliances and equipment in the commercial sector, such as refrigerators, computers/servers, cooking/food service equipment, wastewater treatment and water supply equipment, and heat pump water heaters.
- Industrial Industry Specific Measures: includes an examination of different industry sub-sectors and the specific equipment and processes that lend themselves to particular measures for reduction of energy use. The industry types included are: electronic chip fabrication, food processing and storage, metal foundries, wood products, and agriculture.

This case results in statewide load growth that is *reduced* annually by more than 0.10% for the years up until 2030, with the efficiency benefits declining thereafter. By 2035, load growth has once again risen above 0%. This is in comparison to a business-as-usual load growth forecast of roughly 1.2% per year over the course of the time period. This policy case results in a statewide load roughly 1.7 million MWh lower in 2035 than one that simply holds the 2015 load forecast constant through to 2035 – a 4% reduction from that 2015 statewide load. These comparisons indicate the ambitiousness of the energy efficiency measures included in this policy case. Indeed, the 2035 cumulative electricity savings in our scenario are roughly double the ETO's

[36] In the MACC analysis, this is known as Scenario 3. "Achievable potential" is defined by the Northwest Power and Conservation Council's Regional Technical Forum (RTF) as 85% of Technical Potential. This scenario therefore assumes 80% of 85% of estimated technical potential for each measure is achieved.
[37] A full list of measures is available on the Commission's website.

projections of cost-effective savings, meaning that in order for these savings to be realized there would need to be an increase in funding for energy efficiency measures across the state (including for ETO), an identification of more savings than we currently know about, measures that are not currently cost-effective will need to become so through technical or production cost gains or by pricing carbon through a tax or cap, or (most likely) some combination of all of these. Given the broadly cost-effective nature of energy efficiency measures, it seems appropriate to assume that we place a high priority on achieving as much as possible through these measures in our illustrative case[38].

Transportation

As described above, measures that reduce emissions from the transportation sector were updated to calibrate them to the results of the STS analysis. They were also updated to reflect the fact that new federal policies have come into place for light-duty vehicle fuel efficiency, meaning the measures themselves would achieve slightly less greenhouse gas reduction than perhaps was previously deemed feasible. The difference in reduction amounts would not go away, but would instead be attributable to the federal standards.

Ground Transportation

Measures in this category help to reduce emissions from individual ground travel needs, separate from moving goods or air travel. In general, the underlying MACC analysis values updated to reflect STS assumptions or new federal policies were used to estimate the reductions for these measures (e.g. transit, advanced vehicles). Using the measure data from the MACC analysis produces a smaller estimate of the reductions that are feasible in this category than using the full results of the STS. This is due to the fact that (as noted above) federal fuel economy standards for light-duty vehicles have come into effect since the STS analysis was completed. The measure data also contains a smaller assumption about the reduction in the GHG intensity of the grid[39] and the omission of all carbon pricing mechanisms[40].

The measures in this category include:

1. Increased investment in and availability of public transportation and the associated land use changes necessary,
2. Implementation of pay-as-you-drive insurance,
3. Mode shifting from single-occupancy vehicle trips,
4. Intelligent transportation systems and transportation demand management,
5. Parking management

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[38] See the Commission's website for more detailed information about the measures included.

[39] STS assumed power sector hit 75% below 1990 levels by 2050; MACC assumes power sector only achieves 25% RPS and declines in emission *intensity* – but not necessarily absolute emissions – slowly thereafter.

[40] STS included carbon pricing, we omit it in this analysis because it would overlap with the carbon pricing scenario we include in Case 2.

6. Improvements to light-duty fuel economy for vehicles with internal combustion engines, and
7. Increased deployment of electric and plug-in hybrid electric vehicles.

Many of these measures are highly cost effective – 6 out of 10 of the least cost (on a dollars-per-ton of reduction basis) measures in the MACC analysis are in this category. However, a few others further up the cost-effectiveness ladder[41] are included here as well for two reasons. First, transportation sector emissions may be difficult to bring down through currently available technology and policy, and thus we determined that all measures should be considered for this sector despite currently higher costs (on a dollars-per-ton of reduction basis). In addition, some of the costs of those measures could be expected to come down over time, particularly as battery technologies improve and costs of advanced vehicles reflect that. Secondly, these measures have other significant benefits to society, such as reducing other air pollutants from conventional vehicles and expanding access to public transportation to more communities (especially improving mobility and access to employment for low income households), which are not captured by the simple "dollars-per-ton" analysis.

Though we have included all MACC ground transportation options, our emission reduction estimates are more conservative than what the STS analysis found. Acquiring more emission reductions from ground transportation will require altering some of the key assumptions used here, including a more significant electrification of passenger vehicles. As the STS analysis pointed out, in order for electrification of transportation to achieve the maximum reductions possible, it will need to be accompanied by decreasing levels of carbon intensity on the grid.

Freight

Emission reduction opportunities in this category include those that impact emissions from moving goods within Oregon. The measures in this section reflect similar freight strategies to those analyzed in the STS, but unlike the STS, these measures do not include emission reductions that occur out of state (or across an ocean, or in another country)[42]. The measures in this section were also examined for possible double counting, and some were eliminated due to this concern. For example, both the STS and the MACC analyzed the potential emission reductions that could occur due to the introduction and penetration of advanced fuels, such as renewable natural gas, but those measures were left out of this assessment due to the potential overlap with the effects of Oregon's Clean Fuels Program[43]. The measures and their potential emission reductions represent a scenario in which federal and state policy are strengthened to encourage these reductions.

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[41] Namely electric vehicles, plug-in hybrid electric vehicles, and public transit expansion.

[42] We may develop a methodology to capture those emission reductions in a future report.

[43] Significant potential exists for biofuels and other advanced fuel technologies to reduce emissions from freight travel. Analyzing the potential interaction and overlap between the Clean Fuels Program and additional policies or incentives for these fuels was outside the scope of this Report, however it may be a useful process to undertake as the state moves to implement measures in the Statewide Transportation Strategy.

The measures in this category include:

1. Land Use Policy Changes, which assumes that the last 50 miles of goods movement in Portland is shifted to electric trucks,
2. Urban Traffic Congestion Relief, which includes measures such as bottleneck removal to improve system management on congested freight routes;
3. Idling Reduction Strategies, which includes the installation of ground-based power at truck stops and port facilities,
4. More Energy Efficient Transporter Operations, which assumes 50 mph speed limit for trucks,
5. Mode Shift in Response to Higher Fees, which is an estimate of commodity flows and application of elasticities and ton-mile costs by mode from literature to encourage mode shifting for freight, and
6. Truck Engine Fuel Efficiency, which assumes incremental improvement in the fuel efficiency of truck engines beyond the EPA's current requirements for 2014-2018 model years[44].

Air Travel

Emission reduction opportunities in the air travel sector were taken directly from the STS analysis. The opportunities in this category include those that impact emissions associated with Oregonians' air travel, including the emissions from airplane fuel, ground service equipment for airport operations, and ground access vehicles to and from the airport. Emission reductions from these measures needed to be adjusted in a similar way to the adjustments made for the freight measures in order to attempt to estimate (as best as possible) the reductions that would occur to our in-state emissions. Similar to freight vehicle technology measures, some of the air emission reduction measures will be difficult for Oregon to influence on its own but the measures seek to estimate the reductions possible from an ambitious increase in action at the state and federal level[45].

The measures include:

1. Passenger rail improvements, which would help shift passenger travel in the Eugene to Vancouver, BC corridor to rail,
2. Improved aviation system optimization, entailing increased efficiency in all airport terminal access activities and deploying efficient operation and maintenance practices for all airport service operations, and
3. Improved aircraft engine technology and fuel carbon intensity.

[44] Note: this does not include the recently proposed fuel economy standards for the later model years.

[45] Note: the federal government is now preparing regulations for greenhouse gas emissions from aircraft. The EPA issued a proposed rule in June 2015, but a final rule will likely take several years of negotiating with international partners.

Agriculture

Agriculture measures were analyzed using the results of the original MACC work. There was no need to assume that additional changes should be made to the results of that analysis.

Three measures are included:

1. Development of dairy anaerobic digestion and methane utilization projects,
2. Increasing co-digestion of dairy manure and food processing waste, and
3. Improved nutrient management through precision agriculture.

The first two measures are assumed to be implemented together, increasing the use of anaerobic digestion of manure at large dairies and co-digesting an additional 10% of organic waste from nearby food processors, providing a carbon neutral energy source for producing electricity or thermal energy. The third measure examines an increase in the practices known collectively as precision agriculture for nutrient management in all crop production where the farm is at least 500 acres.

Materials and Waste

Several categories of measures that reduce emissions from materials and waste were analyzed for purposes of this Report. The primary source of data was the original MACC work, which was augmented by additional estimates of GHG savings provided by Oregon DEQ staff.

This wedge includes:

1. Increasing biogas energy production from municipal solid waste and at wastewater treatment plants,
2. Installing landfill gas collection and destruction systems at landfills where they do not already exist,
3. Reducing the embedded carbon emissions within new building materials, and
4. Prevention of food and packaging waste.

The materials and waste measures reduce emissions from within Oregon's borders (e.g. methane emitted from landfills) but also from outside Oregon's borders (e.g. avoided manufacture of cement or other raw materials). For many of the measures, the out-of-state reductions can be orders of magnitude larger than the in-state reductions. For purposes of our in-boundary emissions inventory and GHG reduction goals, only those emission reductions that occur within Oregon are included. However, just as the state keeps track of estimates of consumption-based emissions, we should not lose sight of the many measures that we can implement in Oregon that have a positive ripple effect on emissions elsewhere. For a future Report, we may attempt to build on the analysis done in our 2020 Roadmap and the work of state agencies to better understand and report on measures Oregon should take to reduce such upstream emissions.

Power Generation

Rather than use the MACC analysis for power generation emission reduction measures, which were specific to types of generation technology instead of utility-wide reduction strategies, we are including overall emission rate reduction assumptions for the two largest utilities in the state commensurate with a reduction proportionate to the statewide 2050 GHG goal. We then extrapolate that 2050 goal for PGE and PacfiCorp linearly back to today, using the most current information we have from DEQ on reported emissions by these two utilities. This exercise allows us to demonstrate the gap between electric sector emissions currently and where they need to be in 2035 to be roughly on the path to achieving that 2050 goal. This exercise does not take into account precisely how policy changes over the next 20 years will affect emissions. For example, it does not account for the fact that when emission reductions occur in the electricity sector, they may not occur gradually, but instead quite suddenly, as when a coal plant is retired.

We are not recommending a particular policy prescription by which to achieve these goals, although we do discuss some of the implications in Section VI. We also note that the State's GHG reduction goals do not provide for or require proportional emissions reductions by sector or source, only overall State emissions, thus this proportional application is for illustrative purposes for one possible scenario. However, if these goals are met, the utilities responsible for 92% of 2012 statewide electricity emissions will be on a path toward a large emission reduction by 2050. As briefly mentioned above, their achievement of reductions of something like this magnitude is essential to the achievability of other significant emission reductions, particularly in the transportation sector.

Setting the 2050 target for PGE and PacifiCorp

Rather than a simple application of the statewide target of 75% below 1990 levels by 2050, we have made a few adjustments to the goals we assume for these two utilities. Because of the impact of the closure of the Trojan nuclear facility in 1993 on the emission rate for PGE, basing the utilities' emission reduction goals on 1990 levels of emissions is not realistic or fair. We are therefore choosing a more recent year, and another that is frequently used in emission reduction goal setting, by which to estimate the utilities' "base year" emissions: 2005. And because utility emissions fluctuate from year to year due to hydro generation resource availability and other factors, we use a 5 year average around the year 2005 (2003-2007) to set the original base year emissions for both utilities.[46] Because the starting year is later than 1990 and emissions grew substantially between 1990 and the new base period, we are using an "80% below base period" reduction goal in lieu of the "75% below 1990" target in the statute.

In the scenario for statewide emission reductions we present here, the emissions from these two utilities are first reduced by a proportionate amount of the quantity of emission reductions achievable through energy efficiency, as found in the analytical process described above. Beyond what the energy efficiency measures can do, we assume that the utilities will take

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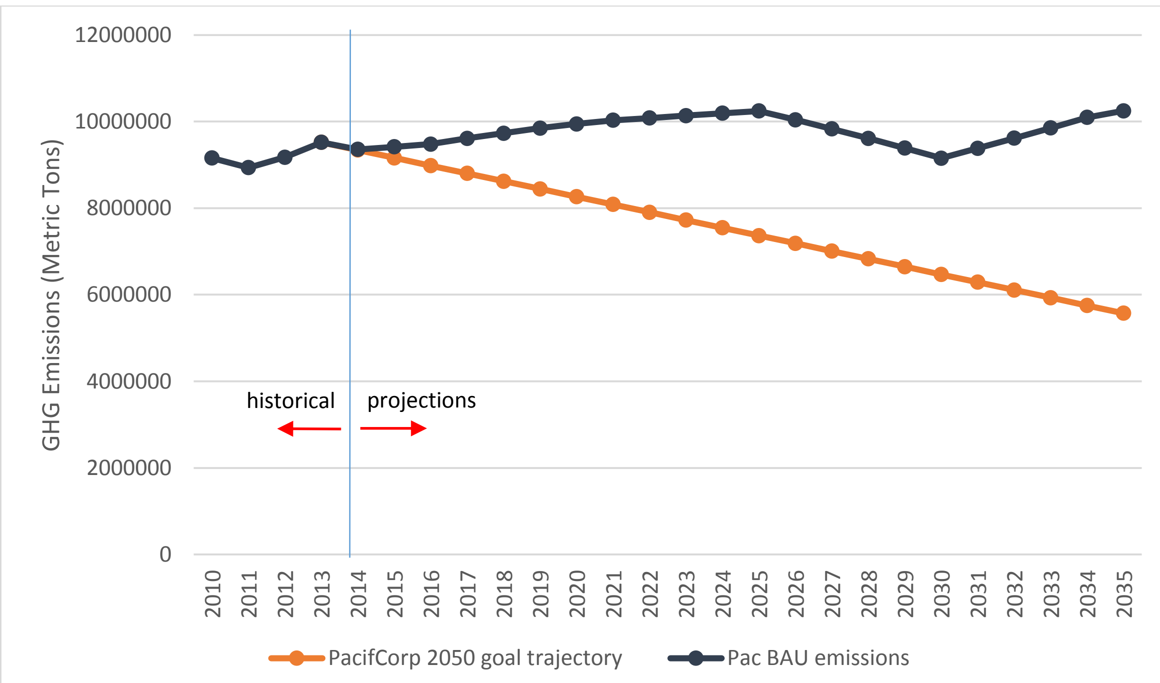
[46] This approach is consistent with our recommendations to the US EPA on how to set baselines for emission reductions from power generation.

actions to modify their generating resource portfolio – reducing reliance on the most carbon-intensive units and bringing on greater quantities of renewable generation – to bring their emissions down to achieve the goal we have set here.

Scenario Results for PGE and PacifiCorp

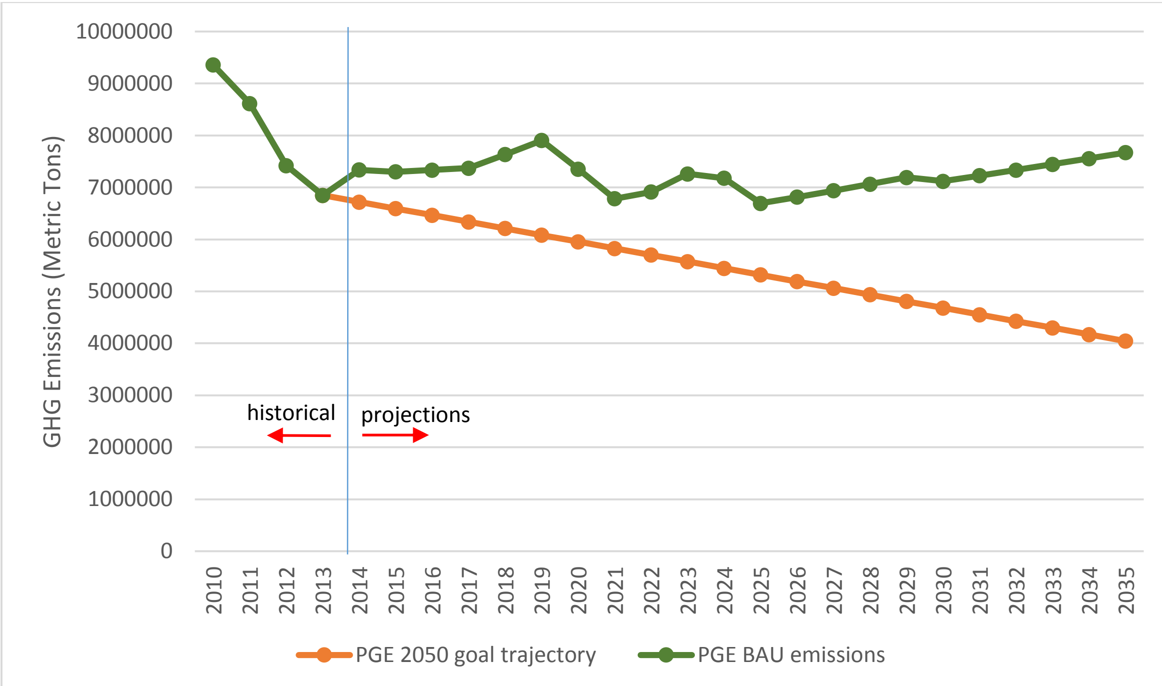
This exercise results in 2050 emission goals for the two utilities of 2.0 million MTCO2e and 2.7 million MTCO2e for PGE and PacifiCorp, respectively, down from a 2005 average amount of 10.0 and 13.5 million MTCO2e, respectively. These reduction values are extrapolated linearly back to 2035, resulting in targets for that year of 4.0 million MTCO2e for PGE and 5.6 million MTCO2e for PacifiCorp. Figures 8 and 9 show business-as-usual (BAU) forecasts for the two utilities' emissions out to 2035 as compared with the linear trajectory of the 2050 and 2035 emission goals.[47]

Figure 8: PacifiCorp Projected Emissions and 2035/2050 Goal Trajectory



[47] BAU forecasts for the utilities were compiled using 2013 IRP information on emissions rates and load forecasts.

Figure 9: PGE Projected Emissions and 2035/2050 Goal Trajectory



The figures above show absolute quantities of emissions, but the implied emission rates for each utility that emerge from this analysis are also informative about what would be necessary to achieve the overall reduction goals. If PGE and PacifiCorp are successful in reducing their load requirements commensurate with the energy efficiency measures we have included, then they must subsequently also achieve a 33% and 29% reduction in their emission rates, respectively, by 2035 from what their 2013 IRPs projected for 2035.

Hypothetically, both utilities could more than achieve this by switching the percentages of their Oregon load served with coal-fired power to natural gas-fired power by 2035. Using the percentages of Oregon load served by various resources as reported to DEQ in 2013, we estimate that if PacifiCorp shifted the entire percentage of coal to natural gas by 2035 (and achieved the aggressive reductions in load growth assumed in our energy efficiency measures) they would reduce emissions to roughly 3.3 million MTCO2e, which is below the interim 2035 target of 5.6 million MTCO2e. A similar shift for PGE would result in roughly 2.8 million MTCO2e in 2035, also below the interim target of 4 million MTCO2e. Both of these estimates also assume that the utilities are successful in increasing the share of RPS-eligible power supplied to Oregon sufficient to meet the policy goal of 25% by 2025. However, this shift alone would not be enough to put the utilities on a path to meeting the proportional 2050 goals of 2.0 million MTCO2e and 2.7 million MTCO2e for PGE and PacifiCorp, respectively. Load is likely to grow between 2035 and 2050, which would increase emissions if generating mix remained the same. Perhaps more importantly, using investments in solely natural gas-fired power to eliminate coal from the mix would lock in investments that could put our 2050 goals out of reach (or could require stranding investments in those facilities before their useful life expires).

Does Case 1 achieve 2035 target?

The combination of all of the measures discussed above results in a 2035 emission level of 42.4 million MTCO2e, a reduction of 21.7 million MTCO2e below what our business-as-usual forecast predicts we will be in 2035 (64.1 million MTCO2e). This would be a substantial reduction in emissions, but would still put Oregon 9.7 million MTCO2e from achieving the interim goal for 2035 of 32.7 million MTCO2e. Table 6 shows the emission reductions that are achievable by the various sectors, the total reductions, and the gap to meet our 2035 goal trajectory for 5 year increments starting in 2015. Figure 8 demonstrates these measures as emission reduction wedges, showing the cumulative reductions possible in the years 2015-2035.

Table 5: Case 1 Emission Reductions Compared to Goal (Million Metric Tons of Carbon Dioxide Equivalent)

	2015	*2020*	*2025*	*2030*	*2035*
BAU forecast	60.9	62.0	61.2	61.6	64.1
Emissions after measures	58.9	53.3	47.8	44.7	42.4
Emission reduction measures:					
Transportation	0.5	2.6	4.6	6.6	7.5
RCI energy efficiency	0.2	2.0	3.5	4.9	6.6
Power generation	0.8	1.7	1.9	2.0	4.1
Agriculture	0.2	0.5	0.8	0.9	0.9
Waste	0.4	1.9	2.5	2.6	2.6
Total Reductions	2.1	8.8	13.4	17.0	21.7
2035 Goal Trajectory	57.3	51.2	45.1	38.9	32.7
Gap to meet goal	1.6	2.0	2.7	5.8	9.7

Figure 10: Case 1 Emission Reduction Wedges

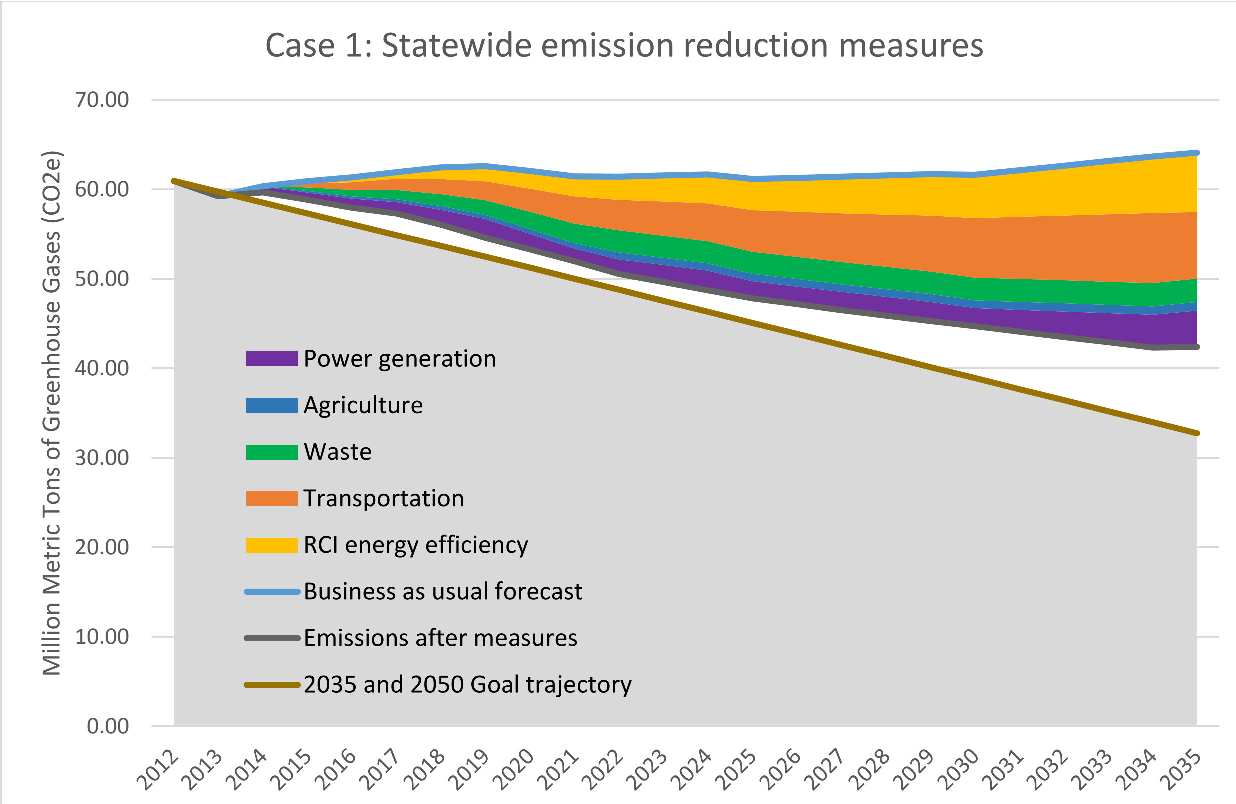


Figure 7 demonstrates at least two noteworthy things. First, it shows that if Oregon begins taking some of these actions now, the state can achieve very substantial emission reductions, bringing the level down to within striking distance of the interim 2035 goal. However, it also demonstrates that even with more ambitious policy and technology actions, it will still be difficult for the state to achieve the 2035 target with these measures alone. In Case 2, we explore how and whether Oregon could use a form of carbon pricing to help drive emissions down a bit more and make the 2035 goal achievable[48].

Case 2: Oregon programmatic measures plus carbon pricing

In order to estimate and illustrate the possible emissions effect of implementing a carbon price in addition to the programmatic measures described above, we sought the expertise of

[48] With both of our Cases, we recognize that there is a possibility of outside forces, such as additional federal action or technological breakthroughs, boosting our reductions between now and 2035. Beyond the assumptions that are inherent in our ambitious policy and technology measures discussed above, we have not included any additional assumptions about these types of outside forces because we do not believe that Oregon should rely on hypothetical future reductions to achieve our goals. However, we should be prepared to capitalize on such regulatory or technological changes by putting in place favorable policies that reward moves toward low carbon solutions and by actively seeking out those solutions within our own borders.

Portland State University's Northwest Economic Research Center (NERC). NERC and PSU researchers completed a legislatively-mandated study of the effects of an Oregon carbon fee at the end of 2014 and presented their findings to the legislature[49]. The Commission requested the assistance of these researchers in estimating the interaction between the emission reduction measures and a carbon price, understanding that the relationship between the two would not simply be additive. In the sections below, we briefly describe the process of evaluating the interaction and the resulting emission reductions we could possibly expect to see in this case.

Methodology

The basic methodology used by the NERC team for purposes of this analysis was very similar to the approach used in the original study, however for our purposes the geographic area of interest was the entire state of Oregon rather than six sub-regions as was the case with the original study. The primary modeling inputs were the forecast of Oregon's energy-related greenhouse gas emissions, the baseline fuel prices (which then deviate due to the assessment of the carbon price), and carbon intensities of fuel used in Oregon. Changes in demand for different fuels resulting from the increase in prices under a carbon price informs the results for overall state-wide emissions reductions attributable to the carbon price. The analysis did not determine how or whether the application of a carbon price would shift the resource choices made by electric utilities and relied exclusively on consumer demand reduction for the carbon savings calculated from the electric sector[50].

The tax level and resulting fuel consumption determine how much revenue is generated by the tax. In the original analysis, the study team also examined a wide range of options for how the state could use the revenue generated. The choice of what to do with the revenue is an important policy question that we do not grapple with in this Report. The different revenue repatriation schemes were found to have very similar emissions impacts at various levels of a tax. Therefore, for purposes of our analysis we only examine the effects on emissions rather than the economic effects of different revenue schemes. In addition, in our analysis the tax level is kept below the level that would generate enough revenue to require factoring in the use of the revenue in order to accurately estimate emission reductions.

In order to estimate the interaction between the programmatic measures and a carbon price, changes were made to the primary modeling inputs described above prior to applying the carbon price to the baseline fuel prices. Essentially, the study team tried to first estimate what Oregon's emissions, fuel use, and fuel price future would be under Case 1 (where all programmatic measures are implemented from 2015-2035, as described above) and use this

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[49] http://www.pdx.edu/nerc/sites/www.pdx.edu.nerc/files/carbontax2014.pdf

[50] In addition, the analysis did not make clear whether natural gas would be effectively taxed twice for electricity generation, and if so, whether there would be additional cost impacts of taxing natural gas at the point of importation into the state and at its use to generate electricity.

future as the new "baseline" against which to apply the carbon price. Including information about the measures in Case 1 allowed the study team to update the emissions and economic baseline in their model, which means the carbon price is added to a new baseline that includes policies that have already altered behavior to a certain degree, and the carbon price builds upon the outcomes of those policies and measures.

Ask An Economist…

Q: How does the economic model ensure that emission reductions from a carbon price are above and beyond the reductions that occur due to the programmatic measures?

A: "We used the updated fuel prices and overall emissions that result from the programmatic measures and updated both our economic and emissions forecast. When we then add in the carbon tax, the economy is already experiencing higher fossil fuel prices and has gone through an adjustment period away from those fuels. By adding an additional price increase on top of that (the carbon tax), the economy is reacting to those prices after having already adjusted to the earlier price changes. Some of the easy fossil fuel reductions or behavior changes have already occurred, so the impact of the tax is smaller."

-Jeff Renfro, Senior Economist,
Northwest Economic Research Center, Portland State University

Results

Several similarities and some differences occur between this analysis and the original study of a standalone Oregon carbon tax. As in the original study, we find that emissions begin to decline immediately after application of the carbon price, and at a faster rate than with just the programmatic measures by themselves. Similarly, higher tax rates generate greater emission reductions.

While the overall effectiveness of the carbon pricing mechanism is smaller in our analysis than in the original study – a $60 tax reduces 2035 emissions by just 7.2 million MTCO2e in this analysis, compared with 14.5 million MTCO2e in the original study – this would be an expected outcome of the fact that the programmatic measures are already reducing fossil fuel demand and emissions substantially over the 20 year period. In reality, the two types of approaches (a carbon pricing mechanism and programmatic measures) would complement one another, making the overall reductions greater than either approach by itself[51]. The application of a carbon price results in additional actions being realized beyond those we have identified in Case

[51] It is important to note that future fuel prices (for electricity, natural gas, petroleum, etc) will play an essential role in determining whether measures, such as those depicted in Case 1, will have their desired outcomes. Low energy costs

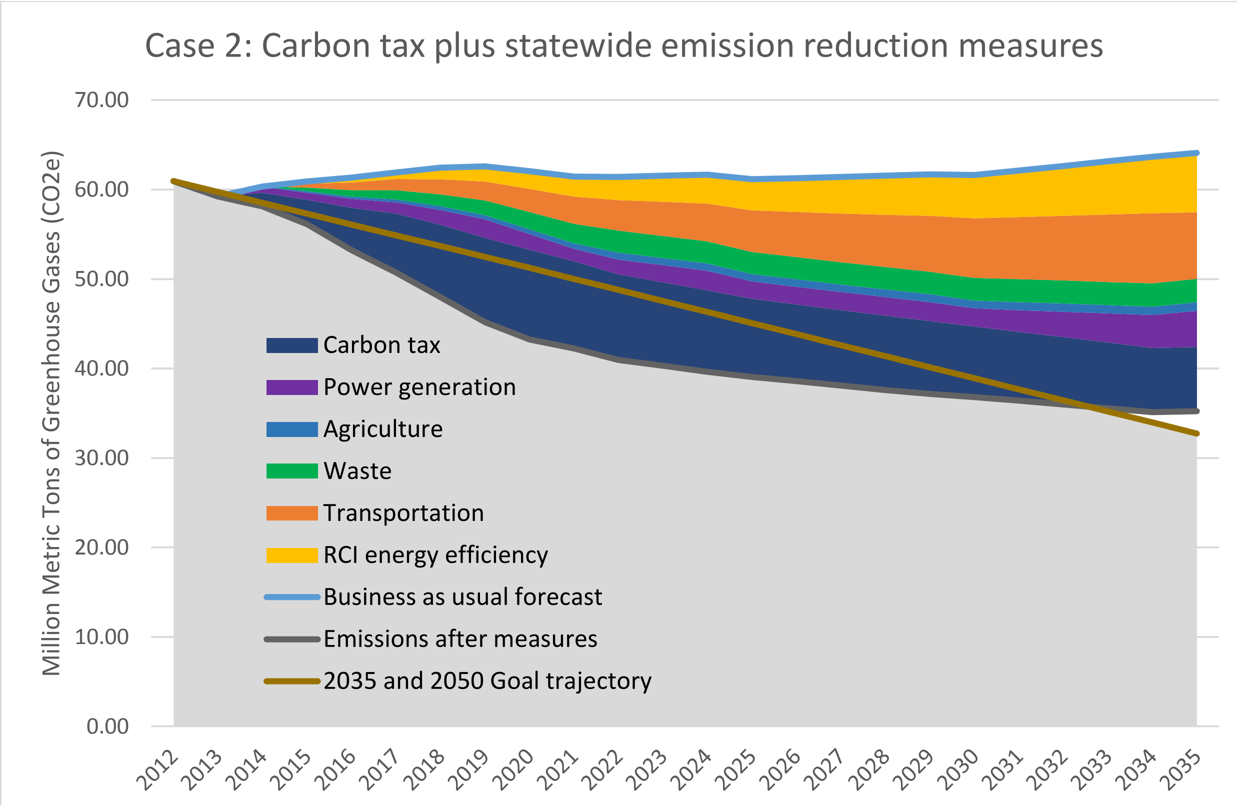
1 because such additional actions become cost-effective. Indeed, this is what we find when we compare our full Case 2 results with the results of the original study – Case 2 reduces 2035 emissions by 28.9 million MTCO2e compared with 14.5 million MTCO2e with a carbon price alone.

In the original study, annual reductions from the baseline due to the tax remain fairly constant once they reach their peak yearly level. This means that the tax succeeds in dropping emissions down to a certain level, and then overall emissions level off or begin increasing slightly with projected growth while the tax achieves roughly the same reduction in emissions per year. In our modified analysis, once the annual reductions due to the tax reach their peak annual level, the reductions per year begin decreasing until the end of the time period. However, because the programmatic measures are also in place to drive down emissions, overall emissions continue to decline despite the decreasing effectiveness of the tax. Intuitively this makes sense – as the baseline emissions fall due to the measures, the effectiveness of a carbon tax held steady at $60 (nominal) at reducing the next unit of emissions should also decline. This may argue for increasing the level of the carbon tax in the later years (or indexing it to inflation) if additional programmatic measures are not implemented sufficient to achieve the desired total reductions.

Does Case 2 achieve the 2035 target?

For purposes of this Report, we present the results of a $60 carbon price applied along with the programmatic measures from Case 1. Just as in the original study, the price is phased in beginning at $10 per ton, increasing by $10 per year until it reaches the final level. As figure 8 demonstrates, a carbon price at this level is effective at bringing emissions down below the linear trajectory to our 2035 goal for much of the 20-year time period. For the last 3 years of the time period, statewide emissions appear to be just above the linear trajectory and in 2035 would be above the state target by a small amount. As with Case 1, this is not meant to be an exact depiction but rather illustrative of the magnitude of emissions reductions that could be achieved with this combination of policies and programs.

Figure 11: Case 2 Emission Reduction Wedges



In addition, we should note that a carbon price was modeled for purposes of this Report as an Oregon-only policy, and because the legislatively-authorized NERC analysis was available to us; but Case 2 could be illustrative of a number of different policy options. For example, a cap on emissions that declines over time would create an implied carbon price in the market that could have a very similar effect. This is the case with the implementation of California's climate policy program – though an overall cap on emissions is in place, programmatic measures are expected to drive the bulk of the state's actual reductions. A national-level policy could also create this price signal.

Several conclusions could be drawn from this analysis. First, it seems that if implemented with other ambitious measures to drive down emissions, a carbon tax could be phased in more gradually than a $10 per year increase and Oregon would still be on track to hit its longer term targets. It is also clear that by 2035 the marginal emission reductions from the $60 tax are not able to drive statewide emissions all the way to the interim goal (although it does appear that such a tax would be effective at getting us within striking distance, and we acknowledge that this analysis is best viewed as illustrative rather than precise). This could suggest a carbon price trajectory that is phased in more gradually but reaches a slightly higher 2035 level. Perhaps more plausibly, it could suggest that Oregon would need to revisit both programmatic and pricing tools again, probably more than once, between now and 2035.

VI. Conclusions and Recommendations

By its self-imposed deadline of 2010, Oregon had met its first legislatively-adopted greenhouse gas (GHG) reduction goal of arresting emissions growth and beginning to reduce emissions. In fact our emissions peaked in 1999, and are now almost 16% below that peak (and almost back to 1990 levels)[52]. However, we are still not on track to meet our 2020 goal; based on present projections we'll miss it by around 11 million metric tons of CO2e, with the gap widening thereafter (see page 32, above). As this Report demonstrates, we have to add substantially to our actions to date, considering both programmatic measures (e.g., mandating more utility renewable energy) and incentives (e.g., a carbon tax or cap).

Many Oregonians like to think of our state, and way of life, as exemplifying how prosperity can be reconciled with a light environmental footprint[53]. And indeed there is statistical support for that perspective (although our statistical bragging rights are bulked up by choices made in the last century to develop the region's hydropower potential).

Above all, we use gas and electric energy far more efficiently than we did even one generation – 20 years – ago; and more efficiently than in most other states. And while hydropower now only provides 40% of our electricity[54] (many Oregonians mistakenly believe it still meets all our power needs), that hydro base is still a first critical building block in any Oregon GHG strategy.

Oregon's Renewable Portfolio Standard is now adding a first tranche of new wind and solar energy to utility generating profiles. At the same time, Portland, Eugene and other Oregon communities have successfully stepped up local efforts to manage their own emissions down, leveraging local government authorities and voluntary community efforts to improve carbon efficiency.

There's no more hydropower of any significance to be developed, and without a strong partnership with the State and Federal governments, Oregon's communities are limited in what local authority can accomplish. The next low carbon power generation will have to come from stepped up investments in wind, solar and other renewables, and in energy efficiency; while lower emissions from our cars and trucks will depend on successful biofuels development, and on low carbon electricity to power a new fleet of electric vehicles.

How do we get from here to there? Generally, the analysis in this Report supports the following recommendations:

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[52] Overall US emissions also have peaked, but not until 2009 and in large part due to recession-driven economic weakness. Thus far in the recovery, however, emissions have remained down as more efficient vehicles have entered the national fleet and a mix of gas, renewables and efficiency has replaced retiring coal plants.

[53] The Global Footprint Network ranked Oregon fifth best among all states in sustainable use of our resources (although it may not have recognized the carbon burden of the coal-generated electricity we import from other states).

[54] Another 40% of our electricity comes from fossil fuels: coal and gas.

- **Set a 2035 Goal**: Given the gap between Oregon's 2020 and 2050 emissions reduction goals, and the fact that we are not likely to meet the 2020 goal, the Commission and Legislature should set a plausible intermediate goal for 2035, and a plausible menu of measures that can attain it. In light of technology and policy changes, the Commission will revisit this target every 5 years to evaluate progress and ensure it continues to be an appropriate one for the state, as well as consider additional interim targets.
- **Develop a long-term strategy, with interim benchmarks and specific measures, to meet our goals**: As this Report demonstrates, a combination of strengthened programmatic measures – energy efficiency, stronger utility renewable energy commitments, low carbon vehicle and fuel incentives – and an economy-wide carbon signal (carbon tax or carbon cap) that starts modestly and builds over time, can put us on our trajectory[55]. There are other combinations of measures and signal than the one offered in this Report that can accomplish this end; the important thing is to settle on a realistic strategy and revisit it periodically to ensure effectiveness and cost-efficiency.
- **Carefully consider cost and equity in setting Oregon's long-term strategy:** Many of the potential strategies for reducing emissions will ultimately save consumers and businesses money in the long-term, particularly as the external incentives for using lower-carbon energy grow stronger. However, some may either involve significant upfront costs or could result in an inequitable distribution of costs and benefits over the course of implementation. We are particularly concerned about these equity considerations with respect to low income Oregon households and many rural Oregon communities, which are likely to be more vulnerable to both the costs of measures to contain emissions, and to costs of our failure to contain the effects of climate change. While this Report does not seek to advise the Legislature on precisely how the measures contained herein could or would be implemented in practice, we consider addressing cost and equity to be an urgent priority in policy design.
- **Encourage technological development to help meet our goals**: It will be critical to keep abreast of new technologies and ensure that Oregon's strategy incentivizes adoption of the best choices for the state. For example, battery technologies and applications will materially affect both electric utility and electric vehicle potentials and GHG outcomes. But the strategy we adopt today needs to depend only on technologies we can see today as practical contributors. Wishing for a technological get-out-of-jail-free card is not a strategy.
- **Begin with targeted emissions reductions from our biggest contributors**: The wedge analysis in this Report indicates that reductions will need to occur from all sectors in

[55] Descriptions of California's so-far-successful carbon strategy often begin and end with its AB 32 carbon cap-and-trade. But programmatic measures collectively play a larger role than the cap.

order for us to meet our long-term goals. However, the biggest reductions will be needed from the biggest contributors, and it therefore makes sense to prioritize actions that begin to make the necessary changes in those sectors. "Light Duty Vehicles" (cars and light trucks) are about 25% of Oregon's emissions. GHG's from coal combustion at power plants is another 25%. These are the two priority areas for early action, especially since they interact with each other (Electric Vehicles powered from a renewable energy-dominant electric grid equals progress in both sectors).

- **Set state and local policies to support and leverage federal action**: By 2025, Federal vehicle fuel economy standards will double new car and truck carbon efficiencies. But state and local incentives for families and businesses to trade up on the efficiency scale are needed for these vehicles to more rapidly displace older, less efficient vehicles. Local incentives and enabling regulation are also needed to deploy refueling infrastructure, accelerate transit/bike/pedestrian investments, and support efficient land use planning that creates options to driving. Equally, the proposed Federal carbon emissions limits on new and existing power plants will help Oregon to meet its adopted state goals. Oregon needs to participate in shaping these new rules to be both cost-efficient and carbon-effective. At the same time, without strengthened state and local commitments to renewables and energy efficiency, Oregon could find itself trapped in a future where gas-fired generation has replaced coal and locked us onto a GHG plateau that has reduced emissions near-term but is blocking progress toward our 2050 goal.
- **Consider adopting consumption-based GHG goals**: One of the ways advanced economies manage GHG emissions is by "off-shoring" them to countries that make the goods we consume. There is a good argument that Oregonians are still responsible for the emissions associated with those imported goods (e.g., flat-screen televisions; smart phones; athletic shoes). Oregon now has a "consumption-based" inventory of these kinds of GHG emissions (Oregon and Portland have been leaders in doing this analysis) and we need to consider whether we should adopt a parallel set of consumption-based emissions reduction goals.

Today, greenhouse gas emissions are an embedded part of Oregon's economy and infrastructure; of our mobility for work or recreation; of our food supply; and of the gas and electricity that warm and cool and light our homes and businesses. Preserving what we most value about our lives and our state, while systematically reducing the GHG content of the goods and practices on which those values are constructed, is the great challenge of our times.

Oregon has taken the first steps in rising to that challenge, and we are well positioned to take the next ones. The State occupies a critical space between local communities and Federal Government efforts. State authorities are essential to many strategies, from utility regulation to transportation investments. What is most important is that our state commits to developing those new strategies, and begins taking meaningful action on them without delay.

Appendix: Oregon "In-Boundary" Greenhouse Gas Emission Data, 1990-2012

Note: All emissions data are expressed in million metric tons of carbon dioxide equivalent (MMTCO2e)

Table 6: Total Oregon Gross GHG Emissions, Including Emissions Associated with the Use of Electricity

1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
56.9	59.0	58.9	63.2	64.1	65.2	68.2	68.8	70.2	72.5	70.8	67.7	67.2	66.3	67.5	69.0	68.2	70.5	68.1	65.4	63.3	62.7	60.9

Figure 12: Oregon Historical Total Gross GHG Emissions, Including Emissions Associated with the Use of Electricity

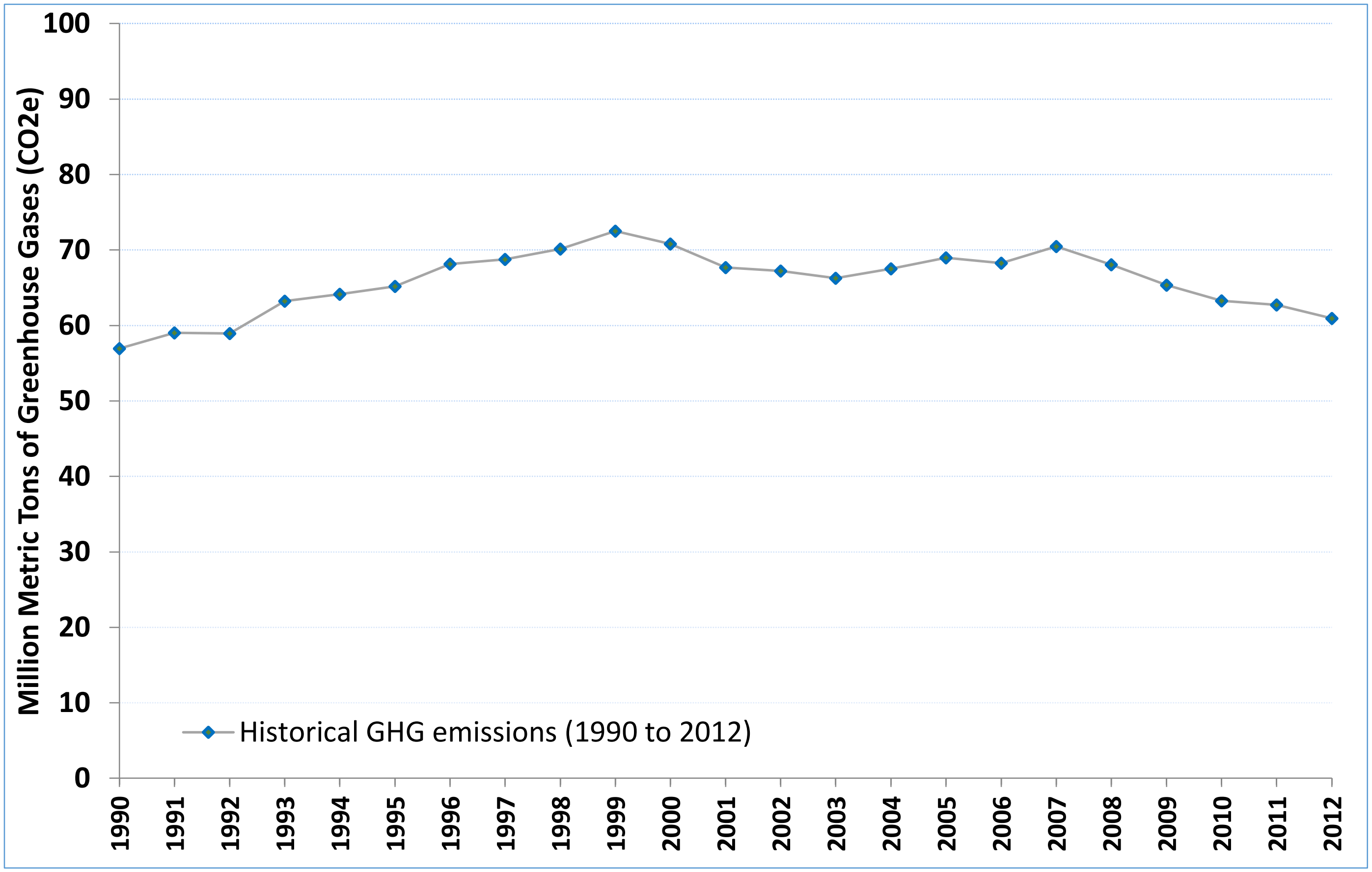

Table 7: Oregon Greenhouse Gas Emissions, Proportions by Economic Sector and by Type of Greenhouse Gas

	Proportion by Key Sector				Proportion by Greenhouse Gas			
	Transportation	Residential & Commercial	Industrial	Agriculture	Carbon Dioxide (CO2)	Methane (CH4)	Nitrous Oxide (N2O)	High Global Warming Potential Gases
1990	37%	30%	25%	9%	83%	11%	5%	1%
1991	38%	29%	24%	9%	84%	10%	5%	1%
1992	38%	28%	25%	9%	84%	10%	5%	1%
1993	35%	32%	25%	8%	84%	10%	5%	1%
1994	35%	31%	25%	8%	84%	10%	4%	1%
1995	34%	31%	26%	9%	84%	10%	5%	2%
1996	34%	31%	26%	9%	84%	10%	5%	2%
1997	34%	31%	26%	8%	83%	10%	5%	2%
1998	35%	30%	26%	8%	83%	9%	5%	3%
1999	34%	32%	26%	8%	84%	9%	4%	3%
2000	34%	33%	25%	8%	84%	9%	4%	3%
2001	34%	35%	22%	8%	83%	10%	4%	3%
2002	35%	35%	22%	9%	83%	10%	5%	3%
2003	35%	35%	21%	9%	82%	10%	5%	3%
2004	36%	34%	21%	9%	82%	10%	5%	3%
2005	36%	35%	20%	9%	83%	10%	4%	3%
2006	37%	33%	21%	9%	83%	10%	4%	3%
2007	37%	35%	20%	9%	83%	10%	4%	3%
2008	35%	36%	20%	8%	83%	10%	4%	3%
2009	37%	37%	18%	8%	83%	10%	4%	3%
2010	36%	36%	19%	9%	82%	11%	4%	3%
2011	36%	36%	19%	9%	81%	11%	4%	3%
2012	39%	34%	18%	9%	82%	11%	4%	3%

Table 8: Emissions from the Transportation Sector, Carbon Dioxide Only

	Carbon Dioxide									
	Motor Gasoline	Distillate Fuel	Jet Fuel, Kerosene	Natural Gas	Residual Fuel	Lubricants	Aviation Gasoline	LPG	Light Rail Electricity Use	Jet Fuel, Naphtha
1990	11.61	4.53	1.25	0.49	1.75	0.22	0.04	0.04	0.00	0.08
1991	11.78	4.85	1.39	0.48	2.69	0.20	0.04	0.04	0.00	0.11
1992	11.70	4.93	1.52	0.38	2.72	0.20	0.05	0.03	0.00	0.10
1993	12.16	4.66	1.66	0.27	1.77	0.22	0.04	0.03	0.00	0.07
1994	12.37	4.88	1.87	0.32	1.82	0.23	0.05	0.05	0.00	0.00
1995	12.39	4.57	2.05	0.40	1.50	0.23	0.05	0.03	0.01	0.00
1996	12.80	4.90	2.14	0.44	1.43	0.22	0.07	0.02	0.00	0.00
1997	12.20	5.07	2.34	0.71	1.53	0.24	0.06	0.02	0.00	0.00
1998	13.11	4.89	2.40	0.75	1.73	0.25	0.05	0.00	0.01	0.00
1999	13.25	5.50	2.64	0.58	1.13	0.25	0.06	0.01	0.02	0.00
2000	13.05	5.52	2.57	0.65	0.60	0.25	0.05	0.01	0.02	0.00
2001	12.95	5.15	2.14	0.60	0.55	0.22	0.08	0.01	0.02	0.00
2002	13.13	5.51	2.12	0.50	0.58	0.22	0.05	0.01	0.02	0.00
2003	13.01	5.37	2.29	0.38	0.72	0.21	0.05	0.02	0.01	0.00
2004	13.09	6.10	2.09	0.52	0.81	0.21	0.04	0.02	0.01	0.00
2005	13.25	6.36	2.21	0.41	0.88	0.21	0.05	0.04	0.01	0.00
2006	13.42	6.71	2.36	0.46	0.74	0.20	0.07	0.03	0.01	0.00
2007	13.43	6.94	2.31	0.53	1.03	0.21	0.07	0.02	0.01	0.00
2008	12.60	6.57	2.24	0.41	0.70	0.19	0.06	0.05	0.01	0.00
2009	12.68	6.51	2.67	0.45	0.36	0.17	0.05	0.04	0.01	0.00
2010	11.90	6.67	1.72	0.36	0.72	0.19	0.05	0.04	0.01	0.00
2011	11.72	6.71	1.84	0.29	0.43	0.18	0.05	0.04	0.01	0.00
2012	12.59	7.24	1.99	0.22	0.41	0.18	0.03	0.04	0.01	0.00

Table 9: Emissions from the Transportation Sector, Methane, Nitrous Oxide, and HGWP Gases (Million Metric Tons of Carbon Dioxide Equivalent)

	Methane				Nitrous Oxide			HGWP
	Passenger & Light Vehicles	Non-Road Vehicles & Equipment	Heavy-Duty Vehicles	Natural Gas Distribution (sector share)	Passenger & Light Vehicles	Non-Road Vehicles & Equipment	Heavy-Duty Vehicles	Refrigerants, A/C, Fire Protection Use
1990	0.11	0.01	0.01	0.06	0.67	0.03	0.02	0.00
1991	0.10	0.01	0.01	0.05	0.68	0.03	0.02	0.00
1992	0.10	0.01	0.01	0.04	0.75	0.04	0.02	0.01
1993	0.11	0.01	0.01	0.03	0.82	0.03	0.02	0.04
1994	0.10	0.01	0.01	0.03	0.82	0.03	0.02	0.08
1995	0.10	0.01	0.01	0.04	0.83	0.04	0.02	0.19
1996	0.09	0.01	0.01	0.04	0.83	0.04	0.02	0.26
1997	0.09	0.01	0.01	0.06	0.87	0.04	0.03	0.34
1998	0.08	0.01	0.01	0.05	0.88	0.04	0.03	0.38
1999	0.08	0.01	0.01	0.04	0.86	0.04	0.03	0.43
2000	0.07	0.01	0.01	0.05	0.83	0.04	0.03	0.48
2001	0.07	0.01	0.00	0.05	0.77	0.03	0.02	0.52
2002	0.06	0.01	0.00	0.04	0.69	0.04	0.02	0.55
2003	0.05	0.01	0.00	0.03	0.63	0.04	0.02	0.58
2004	0.05	0.01	0.00	0.04	0.58	0.04	0.02	0.61
2005	0.05	0.01	0.00	0.03	0.51	0.04	0.02	0.64
2006	0.04	0.01	0.00	0.04	0.46	0.04	0.01	0.68
2007	0.04	0.01	0.00	0.04	0.39	0.04	0.01	0.72
2008	0.03	0.01	0.00	0.03	0.33	0.04	0.01	0.76
2009	0.03	0.01	0.00	0.03	0.28	0.04	0.01	0.81
2010	0.03	0.01	0.00	0.03	0.24	0.03	0.01	0.85
2011	0.03	0.01	0.00	0.03	0.21	0.04	0.01	0.88
2012	0.03	0.01	0.00	0.02	0.18	0.04	0.01	0.91

Table 10: Emissions from the Residential and Commercial Sectors, Carbon Dioxide Only

	Carbon Dioxide								
	Residential Electricity Use	Commercial Electricity Use	Residential Natural Gas Combustion	Commercial Natural Gas Combustion	Commercial Petroleum Combustion	Residential Petroleum Combustion	Waste Incineration	Residential Coal Combustion	Commercial Coal Combustion
1990	5.96	4.68	1.27	1.11	0.79	0.76	0.17	0.00	0.00
1991	6.18	4.80	1.44	1.22	0.66	0.73	0.17	0.00	0.00
1992	5.89	4.87	1.27	1.08	0.59	0.61	0.16	0.00	0.00
1993	7.74	5.96	1.64	1.33	0.49	0.76	0.17	0.00	0.00
1994	7.64	6.23	1.60	1.27	0.46	0.74	0.16	0.00	0.00
1995	7.57	6.29	1.55	1.24	0.56	0.65	0.16	0.00	0.00
1996	7.82	6.37	1.84	1.42	0.50	0.62	0.16	0.00	0.00
1997	7.82	6.58	1.81	1.42	0.49	0.55	0.16	0.00	0.00
1998	7.81	6.56	1.92	1.45	0.54	0.53	0.16	0.00	0.00
1999	8.38	7.12	2.17	1.60	0.46	0.60	0.15	0.00	0.00
2000	8.45	7.30	2.12	1.56	0.54	0.62	0.15	0.00	0.00
2001	8.69	7.58	2.09	1.52	0.65	0.65	0.15	0.00	0.00
2002	8.29	7.26	2.11	1.51	0.58	0.62	0.15	0.00	0.00
2003	8.54	7.46	1.99	1.39	0.37	0.58	0.14	0.00	0.00
2004	8.47	7.37	2.06	1.40	0.35	0.44	0.14	0.00	0.00
2005	9.03	7.57	2.19	1.52	0.34	0.46	0.14	0.00	0.00
2006	8.25	7.00	2.25	1.53	0.32	0.43	0.14	0.00	0.00
2007	9.16	7.65	2.35	1.59	0.29	0.36	0.14	0.00	0.00
2008	9.00	7.38	2.45	1.65	0.38	0.44	0.13	0.00	0.00
2009	8.58	6.92	2.44	1.62	0.43	0.44	0.13	0.00	0.00
2010	8.23	6.75	2.25	1.50	0.42	0.35	0.13	0.00	0.00
2011	7.69	6.24	2.63	1.71	0.34	0.35	0.12	0.00	0.00
2012	7.23	6.06	2.03	1.35	0.26	0.31	0.13	0.00	0.00

Table 11: Emissions from the Residential and Commercial Sectors, Methane, Nitrous Oxide, and HGWP Gases (Million Metric Tons of Carbon Dioxide Equivalent)

	Methane						Nitrous Oxide					HGWP
	Municipal Solid Waste Landfills	Natural Gas Distribution (sector share)	Municipal Wastewater	Residential Combustion Byproducts	Commercial Combustion Byproducts	Waste Incineration	Fertilization of Landscaped Areas	Residential Combustion Byproducts	Waste Incineration	Commercial Combustion Byproducts	Municipal Wastewater	Refrigerants, Aerosols, Fire Protection Use
1990	1.29	0.30	0.26	0.07	0.02	0.00	0.05	0.01	0.01	0.00	0.07	0.00
1991	1.30	0.30	0.26	0.07	0.02	0.00	0.05	0.01	0.01	0.00	0.07	0.00
1992	1.23	0.28	0.27	0.07	0.02	0.00	0.05	0.01	0.01	0.00	0.07	0.01
1993	1.21	0.33	0.27	0.09	0.02	0.00	0.05	0.01	0.01	0.00	0.07	0.03
1994	1.18	0.30	0.28	0.09	0.02	0.00	0.05	0.01	0.01	0.00	0.07	0.06
1995	1.14	0.30	0.28	0.09	0.02	0.00	0.05	0.01	0.01	0.00	0.07	0.13
1996	1.20	0.29	0.29	0.09	0.02	0.00	0.06	0.01	0.01	0.00	0.08	0.18
1997	1.27	0.29	0.29	0.08	0.02	0.00	0.06	0.01	0.01	0.00	0.08	0.24
1998	1.31	0.25	0.29	0.07	0.02	0.00	0.06	0.01	0.01	0.00	0.08	0.27
1999	1.32	0.27	0.30	0.07	0.02	0.00	0.05	0.01	0.01	0.00	0.08	0.30
2000	1.36	0.29	0.31	0.08	0.02	0.00	0.03	0.01	0.01	0.00	0.08	0.34
2001	1.42	0.28	0.31	0.12	0.03	0.00	0.05	0.02	0.01	0.00	0.08	0.36
2002	1.46	0.32	0.32	0.12	0.03	0.00	0.07	0.02	0.01	0.00	0.09	0.39
2003	1.53	0.29	0.32	0.13	0.03	0.00	0.08	0.02	0.01	0.00	0.09	0.41
2004	1.57	0.27	0.32	0.13	0.03	0.00	0.08	0.02	0.01	0.00	0.09	0.43
2005	1.56	0.29	0.32	0.09	0.02	0.00	0.07	0.01	0.00	0.00	0.09	0.45
2006	1.53	0.31	0.33	0.08	0.02	0.00	0.07	0.01	0.00	0.00	0.09	0.47
2007	1.63	0.29	0.33	0.08	0.02	0.00	0.07	0.01	0.00	0.00	0.09	0.50
2008	1.79	0.29	0.34	0.09	0.02	0.00	0.06	0.01	0.00	0.00	0.09	0.53
2009	1.81	0.31	0.34	0.13	0.02	0.00	0.06	0.02	0.00	0.00	0.09	0.57
2010	1.80	0.29	0.34	0.12	0.02	0.00	0.07	0.02	0.00	0.00	0.09	0.60
2011	1.67	0.41	0.35	0.12	0.02	0.00	0.07	0.02	0.00	0.00	0.10	0.61
2012	1.47	0.33	0.35	0.11	0.02	0.00	0.05	0.01	0.00	0.00	0.10	0.64

Table 12: Emissions from the Industrial Sector, Carbon Dioxide Only

	Carbon Dioxide											
	Industrial Electricity Use	Natural Gas Combustion	Petroleum Combustion	Cement Manufacture	Coal Combustion	Ammonia Production	Urea Consumption	Waste Incineration	Iron & Steel Production	Soda Ash Production & Consumption	Limestone and Dolomite Use	Lime Manufacture
1990	6.00	2.60	2.62	0.22	0.14	0.07	0.01	0.07	0.70	0.03	0.01	0.09
1991	5.92	2.95	2.37	0.23	0.18	0.07	0.01	0.07	0.70	0.03	0.01	0.11
1992	5.86	3.16	2.82	0.23	0.22	0.07	0.01	0.07	0.70	0.03	0.01	0.12
1993	6.96	3.28	2.63	0.20	0.21	0.06	0.01	0.07	0.70	0.03	0.01	0.14
1994	6.99	3.40	2.40	0.21	0.27	0.07	0.01	0.07	0.70	0.03	0.01	0.15
1995	7.35	3.74	2.50	0.21	0.27	0.07	0.01	0.11	0.70	0.03	0.01	0.16
1996	7.70	4.75	2.03	0.36	0.19	0.07	0.01	0.05	0.70	0.03	0.01	0.17
1997	7.68	4.92	1.97	0.38	0.19	0.07	0.01	0.03	0.81	0.03	0.01	0.16
1998	6.53	5.58	2.50	0.40	0.07	0.07	0.01	0.03	0.75	0.03	0.01	0.17
1999	6.54	5.91	3.03	0.46	0.00	0.07	0.01	0.01	0.64	0.03	0.01	0.16
2000	7.59	4.06	2.60	0.44	0.00	0.07	0.01	0.02	0.75	0.03	0.01	0.14
2001	6.49	3.71	1.84	0.43	0.00	0.05	0.01	0.01	0.57	0.03	0.01	0.10
2002	5.81	3.73	2.01	0.43	0.10	0.06	0.02	0.01	0.44	0.03	0.01	0.07
2003	5.76	3.52	1.52	0.37	0.14	0.05	0.02	0.01	0.43	0.03	0.00	0.08
2004	5.63	3.75	1.68	0.42	0.13	0.06	0.02	0.01	0.43	0.03	0.01	0.10
2005	6.25	3.75	1.43	0.44	0.02	0.06	0.02	0.02	0.34	0.03	0.01	0.09
2006	5.65	3.78	1.58	0.45	0.25	0.06	0.02	0.01	0.36	0.03	0.01	0.08
2007	6.20	3.70	1.38	0.45	0.22	0.06	0.02	0.01	0.37	0.03	0.01	0.07
2008	5.85	3.67	1.50	0.32	0.16	0.06	0.01	0.03	0.37	0.03	0.01	0.06
2009	5.10	3.06	1.39	0.31	0.18	0.06	0.01	0.05	0.23	0.03	0.01	0.05
2010	5.12	3.00	1.31	0.46	0.17	0.11	0.02	0.04	0.03	0.03	0.01	0.05
2011	4.74	3.15	1.67	0.46	0.17	0.13	0.02	0.02	0.03	0.03	0.01	0.05
2012	4.61	2.64	1.65	0.45	0.15	0.11	0.02	0.01	0.04	0.03	0.01	0.05

Table 13: Emissions from the Industrial Sector, Methane, Nitrous Oxide, and HGWP Gases (Million Metric Tons of Carbon Dioxide Equivalent)

	Methane						Nitrous Oxide			HGWP		
	Pulp & Paper Wastewater	Natural Gas Distribution & Production	Industrial Landfills	Combustion Byproducts	Food Processing Wastewater	Waste Incineration	Combustion Byproducts	Waste Incineration	Nitric Acid Production	Semiconductor Manufacturing	Refrigerant, Foam, Solvent, Aerosol Use	Aluminum Production
1990	0.32	0.33	0.09	0.04	0.01	0.00	0.05	0.00	0.00	0.29	0.00	0.31
1991	0.32	0.34	0.10	0.03	0.01	0.00	0.04	0.00	0.00	0.29	0.00	0.32
1992	0.32	0.38	0.10	0.03	0.01	0.00	0.04	0.00	0.00	0.29	0.00	0.31
1993	0.32	0.37	0.10	0.02	0.01	0.00	0.03	0.00	0.00	0.36	0.01	0.28
1994	0.32	0.36	0.10	0.03	0.01	0.00	0.03	0.00	0.00	0.40	0.03	0.25
1995	0.32	0.41	0.11	0.03	0.01	0.00	0.03	0.00	0.00	0.50	0.06	0.26
1996	0.32	0.43	0.11	0.03	0.01	0.00	0.04	0.00	0.00	0.55	0.08	0.27
1997	0.32	0.44	0.12	0.03	0.01	0.00	0.04	0.00	0.00	0.58	0.10	0.27
1998	0.32	0.42	0.13	0.03	0.01	0.00	0.04	0.00	0.00	0.77	0.11	0.28
1999	0.32	0.44	0.13	0.03	0.01	0.00	0.03	0.00	0.00	0.84	0.13	0.28
2000	0.32	0.33	0.14	0.03	0.01	0.00	0.04	0.00	0.00	0.77	0.14	0.27
2001	0.32	0.30	0.15	0.03	0.01	0.00	0.03	0.01	0.00	0.58	0.16	0.19
2002	0.32	0.34	0.15	0.02	0.01	0.00	0.03	0.01	0.00	0.60	0.17	0.08
2003	0.32	0.31	0.15	0.02	0.01	0.00	0.02	0.01	0.00	0.58	0.17	0.08
2004	0.32	0.30	0.16	0.02	0.01	0.00	0.03	0.01	0.00	0.54	0.18	0.09
2005	0.32	0.30	0.17	0.02	0.01	0.00	0.03	0.01	0.00	0.51	0.19	0.09
2006	0.32	0.32	0.18	0.03	0.01	0.00	0.03	0.01	0.00	0.53	0.20	0.09
2007	0.32	0.28	0.20	0.03	0.01	0.00	0.03	0.01	0.00	0.48	0.22	0.00
2008	0.32	0.26	0.22	0.02	0.01	0.00	0.03	0.01	0.00	0.43	0.23	0.00
2009	0.32	0.24	0.23	0.02	0.01	0.00	0.03	0.01	0.00	0.31	0.24	0.00
2010	0.32	0.24	0.26	0.02	0.01	0.00	0.03	0.01	0.00	0.36	0.15	0.00
2011	0.32	0.30	0.26	0.02	0.01	0.00	0.03	0.01	0.00	0.44	0.10	0.00
2012	0.31	0.26	0.27	0.03	0.01	0.00	0.03	0.01	0.00	0.38	0.13	0.00

Table 14: Emissions from the Agriculture Sector (Million Metric Tons of Carbon Dioxide Equivalent)

	Carbon Dioxide		Methane			Nitrous Oxide		
	Urea Fertilization	Liming of Agricultural Soils	Enteric Fermentation	Manure Management	Agricultural Residue Burning	Agricultural Soil Management	Manure Management	Agricultural Residue Burning
1990	0.06	0.03	2.89	0.34	0.00	1.80	0.09	0.00
1991	0.06	0.02	2.92	0.34	0.00	1.72	0.09	0.00
1992	0.06	0.03	2.92	0.35	0.00	1.59	0.09	0.00
1993	0.07	0.03	2.92	0.34	0.00	1.83	0.08	0.00
1994	0.07	0.03	3.11	0.36	0.00	1.72	0.10	0.00
1995	0.07	0.03	3.29	0.36	0.00	1.83	0.10	0.00
1996	0.07	0.04	3.38	0.35	0.01	2.02	0.10	0.00
1997	0.08	0.04	3.36	0.36	0.00	1.87	0.10	0.00
1998	0.08	0.04	3.27	0.36	0.00	2.04	0.11	0.00
1999	0.07	0.04	3.28	0.38	0.00	1.70	0.11	0.00
2000	0.05	0.04	3.16	0.40	0.00	1.79	0.12	0.00
2001	0.08	0.04	2.98	0.41	0.00	1.83	0.13	0.00
2002	0.13	0.03	3.10	0.48	0.00	2.02	0.13	0.00
2003	0.14	0.03	3.09	0.47	0.00	1.97	0.13	0.00
2004	0.12	0.04	3.30	0.53	0.00	2.05	0.14	0.00
2005	0.12	0.04	3.33	0.52	0.00	1.85	0.12	0.00
2006	0.12	0.04	3.29	0.51	0.00	2.03	0.13	0.00
2007	0.13	0.04	2.94	0.50	0.00	2.27	0.12	0.00
2008	0.11	0.04	3.08	0.50	0.00	1.89	0.12	0.00
2009	0.10	0.03	2.81	0.50	0.00	1.83	0.12	0.00
2010	0.12	0.03	2.87	0.50	0.00	2.06	0.12	0.00
2011	0.13	0.04	2.98	0.53	0.01	2.05	0.11	0.00
2012	0.12	0.04	2.95	0.53	0.00	1.62	0.11	0.00

Table 15: In-State Electric Power Generation Emissions and Derivation of Production-Based Emissions Inventory

	Carbon Dioxide			**Methane**	**Nitrous Oxide**	**HGWP**	**In-State Electric Power Generation Sub-total**	**Add In-State Electric Power Generation Sub-Total to Statewide Emissions Total**	**Production-Based Emissions Calculation Adjustment**	
	OR Power Plant Natural Gas Combustion	OR Power Plant Coal Combustion	OR Power Plant Petroleum Combustion	OR Power Plant Combustion Byproducts	OR Power Plant Combustion Byproducts	Transmission and Distribution Systems			**Remove Total Electricity Use Emissions**	**Gross Emissions, *Production Basis***
1990	0.40	1.37	0.02	0.00	0.01	0.44	2.25		-16.64	42.56
1991	0.62	2.98	0.01	0.00	0.02	0.42	4.06		-16.90	46.19
1992	0.79	3.71	0.01	0.00	0.02	0.41	4.95		-16.62	47.27
1993	0.93	3.36	0.02	0.00	0.02	0.40	4.74		-20.67	47.31
1994	1.43	4.01	0.00	0.01	0.02	0.37	5.85		-20.86	49.13
1995	1.05	1.67	0.01	0.01	0.01	0.34	3.08		-21.21	47.06
1996	1.42	1.77	0.00	0.01	0.01	0.32	3.54		-21.89	49.80
1997	1.30	1.39	0.01	0.00	0.01	0.29	3.01		-22.08	49.69
1998	2.86	3.31	0.03	0.01	0.02	0.23	6.45		-20.91	55.70
1999	2.68	3.54	0.01	0.01	0.02	0.24	6.48		-22.06	56.95
2000	3.75	3.55	0.05	0.01	0.02	0.23	7.59		-23.35	55.07
2001	4.47	3.98	0.08	0.01	0.02	0.20	8.75		-22.77	53.65
2002	3.01	3.36	0.01	0.01	0.02	0.18	6.58		-21.38	52.45
2003	4.03	3.98	0.04	0.01	0.02	0.17	8.25		-21.76	52.74
2004	4.80	3.21	0.02	0.00	0.02	0.16	8.21		-21.48	54.25
2005	4.76	3.25	0.04	0.01	0.02	0.15	8.22		-22.86	54.32
2006	4.08	2.22	0.00	0.01	0.02	0.13	6.47		-20.91	53.81
2007	5.56	3.95	0.00	0.01	0.03	0.12	9.67		-23.01	57.13
2008	6.31	3.64	0.01	0.01	0.02	0.12	10.10		-22.24	55.92
2009	5.89	2.86	0.00	0.01	0.02	0.10	8.88		-20.61	53.64
2010	6.05	4.04	0.00	0.00	0.05	0.09	10.24		-20.11	53.40
2011	3.31	3.32	0.00	0.00	0.03	0.10	6.77		-18.67	50.85
2012	4.50	2.65	0.00	0.00	0.04	0.08	7.26		-17.91	50.30