Oregon Global Warming Commission

Report to the Legislature

2011

Including Key Actions and Results from the Commission's Interim Roadmap to 2020

February 2011

KeepOregonCool
Oregon Global Warming Commission

Oregon Global Warming Commission

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[1] One voting member position remains vacant.

* Commission member for most of the Biennium, but no longer a member.

Report to the Legislature:

OREGON GLOBAL WARMING COMMISSION

State of Oregon, February 2011

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

KeepOregonCool
Oregon Global Warming Commission

The Oregon Department of Energy has published this report on behalf of the 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

Oregon continues to make progress toward meeting its legislated climate change goals (*ORS 468A.205*). Based on the most recent data available (for 2008) greenhouse gas emissions have oscillated in recent years around a flat emissions trajectory. This flat emissions trajectory trend is expected to continue through 2010. Therefore, it is expected that future data will demonstrate that emissions will have been "arrested" by 2010, meeting the first part of Oregon's greenhouse gas reduction goal for 2010. The second part of the 2010 reduction goal – to begin reducing greenhouse gas emissions – is less clear. Greenhouse gas emissions are expected to begin a downward emissions trajectory by 2012 based on the predicted impacts of several key policies and programs. There may be a larger than average oscillation in emissions before that downward trend begins. The key point is that the general emissions trend through 2010 should be flat, with downward sloping emissions following a few years thereafter.

Progress toward Oregon's 2020 and 2050 goals – to reduce greenhouse gas emissions by 10 percent and at least 75 percent below 1990 levels, respectively – remains challenging. Rising to this challenge the Commission initiated a "Roadmap to 2020" project. Six technical committees were convened to work on sector-based strategies for meeting these two emission reduction goals. These committees represented stakeholders and other experts from the energy, land use & transportation, industrial, agricultural, forestry, and materials management sectors. As a first step these committees envisioned what their sector might look like in 2050 in an Oregon that had met its long-term reduction goal. The committees then worked backward from these visions to 2020 by brainstorming, sorting through, and highlighting key actions to help meet the 2020 and 2050 reduction goals. These key actions are listed on the next page. The "Roadmap to 2020" will be refined, based on a public comment process planned for 2011 and by integrating results from ongoing processes (e.g., the transportation greenhouse gas planning work from SB 1059 in the 2010 session).

Oregon made substantial progress this past biennium in its planning work to prepare for and adapt to the impacts of climate change. The first Oregon-specific assessment of climate change impacts was released by the Oregon Climate Change Research Institute (OCCRI) in December of 2010. In addition, State agencies collaborated with each other and OCCRI to produce, with Commission input, the first comprehensive Oregon policy framework for climate change adaptation planning in December of 2010.

The Commission acted on other fronts as well, working with State agencies and local governments to implement existing policies, and commenting on federal climate policy choices. To meet its public education responsibilities the Commission designed and launched its www.keeporegoncool.org website. The site serves as the administrative home for the Commission as well as a key outreach and education tool. The electronic version of this report is available from this site, as well as the full version of the *Interim Roadmap to 2020* report and numerous other resources for Oregonians on climate change.

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FROM THE CHAIR

“Global warming is not just another environmental issue.”

Oregon Strategy for Greenhouse Gas Reductions

Governor’s Advisory Group on Global Warming, December 2004

The Good News

The good news, in the six years since that line was written in an earlier State climate “roadmap” report, is that Oregon is on a greenhouse gas (GHG) emissions trajectory to meet its 2010 goal – to arrest GHG emissions growth and position ourselves to begin making real reductions. The 2010 emissions goal, and subsequent goals for 2020 and 2050, were recommended by the Governor’s 2004 Advisory Group on Global Warming, and adopted by the 2007 Legislature in HB 3543.

There is other encouraging news. By the end of 2020 we will end coal operations at PGE’s Boardman power plant. Wind energy now contributes 4.4 percent of Oregon’s electricity, up from less than one percent in 2004. Megawatt-sized solar systems are proposed or under construction. Oregon has a Renewable Portfolio Standard and our utilities are on their compliance paths. New technologies and ideas for managing the power grid are creating opportunities to re-imagine the electricity system as one in which high reliability service, reasonable cost and low carbon peaceably co-exist.

New energy efficiency finance and delivery tools (like Portland’s CleanEnergyWorks) are being deployed to capture deep residential and commercial sector savings. Oregon has become the national leader in green building techniques and their application in both new structures and retrofits. The Northwest Power and Conservation Council projects some 6000 average megawatts (aMW) of additional regional electric energy conservation savings in the next 20 years, to go with the nearly 4000 aMW already realized since 1980 – in aggregate, about five Grand Coulee Dams’ worth of avoided new energy generation.

In 2004 “low carbon vehicle fuels” seemed synonymous with bio-diesel in Oregon. Such fuels still figure in our strategies, but by 2010 Oregon had become one of the favored markets in the U.S. for deployment of electric vehicle technologies by car companies across the globe.

Portland and Multnomah County were among the many Oregon local governments taking the initiative to curb GHG emissions. Oregon’s most populous city and county have reduced their emissions back to and even below 1990 levels despite a 24 percent population gain over the period while maintaining a vigorous economy (at least until all economies sagged in the current global slump). State and local government transportation and land use planning efforts are paying off, with more compact urban areas that require less energy per person while accommodating economic growth and individual choice. These outcomes have won recognition for Oregon nationally and globally.

The 2020 Challenge

Getting to our 2010 goal wasn't easy, and it wasn't accomplished by operating the State on autopilot. We have mobilized in many ways over the last six years. The Renewable Portfolio Standard, auto tailpipe emissions standards and other initiatives from state and local governments, utilities, businesses and private citizens were all essential.

Getting to our 2020 goal – 10 percent below 1990 levels – is a heavier lift still. It's the equivalent of a nearly 30 percent reduction from the emissions levels of the last several years. And since some choices made in 2011 may not generate carbon savings for years – closing a coal plant in 2020, for example – Oregon can't delay choosing the actions and investments that will be needed. Infrastructure investments – in transportation and in electric and gas transmission – have lengthy lead-times to construction before savings can begin to accumulate.

It is also important to acknowledge the thin revenues with which the State begins this decade.

The Oregon Global Warming Commission's (OGWC) *Interim Roadmap to 2020* recognizes both of these considerations – lead-time and cost – by offering recommendations that mix near-, mid- and long-term action timelines, that include research and regulatory as well as investment actions, and that propose new funding mechanisms. Six work groups, comprised of technical and policy experts in their fields, developed recommendations in the areas of energy; transportation and land use; industrial emissions; agriculture; forestry; and materials management. For example, the OGWC supports shifting transportation infrastructure funding to a "utility" model that charges users commensurate with their use of the system including both physical infrastructure and environmental effects (e.g., airshed pollutants and greenhouse gas emissions). Another low-cost recommendation is for Oregon to recognize, co-brand and co-market products of Oregon companies that deliver their goods with fewer carbon emissions and less energy consumed than their competitors elsewhere.

The 2050 Challenge

Each OGWC workgroup was asked to begin its process by envisioning its subject area in a Year 2050 in which Oregon's emissions goal, set back in 2007, had been achieved. Each group's report begins by reaching for this 2050 outcome with only existing technologies – no magic bullets or potions. In all cases workgroups found this task doable, although confidence in achieving the outcomes was paired with a realistic assessment of the challenges in doing so.

We asked for this step for two reasons. First, we wished to avoid recommendations that might get Oregon more easily to its 2020 goal but make getting to 2050 harder. An example: the one-for-one displacement of conventional coal plants with conventional gas to generate electricity might get us to 2020, but in doing so, could lock us into forty more years of fossil fuel dependence.

The more important reason was to recognize that getting to 75 percent below 1990 levels (or nearly 90 percent below 2010 levels) will *not* be achieved by incremental thinking and actions. We can't count on having 200 mpg gasoline-powered cars in forty years, so what are our alternatives with today's technologies? We can put just so many inches of insulation in existing walls and attics – and we have to do that, every useful inch. Then what?

Some of our answers will have to be transformational ones; comparable to how, in the 1970s, we re-conceived "energy efficiency" as comparable to a new electricity generating plant because it directly displaced the need for that plant's output. The consequence of that idea has been regional efficiency investments displacing almost 4000 aMW of electric energy annually by 2010, saving regional ratepayers $2.3 billion annually in avoided energy costs.

Transformational Themes: The Next Big Ideas

What are these transformational ideas? Here is the Commission Chairman's short list of candidate recommendations, all drawn from the Roadmap:

Embed Carbon in the Planning Process: We're now beginning to look at wringing carbon out of transportation in our land use and infrastructure planning, and in developing "least cost planning" tools for transportation operations and facilities. DEQ is looking at "consumption-based" measurements of greenhouse gases in the things we buy, use and dispose of. Utilities now look at the "risk" of carbon regulation, but their plans don't include how they would meet their share of Oregon's reduction goals; those plans need to do so. We're starting to measure the carbon contained in our forests, and what happens to it under different management practices. In all of these areas, carbon accounting must become standard practice.

Embed Carbon in the Price of Energy: Oregon could shift its State revenue-raising model from heavy reliance on income and gas taxes to partial reliance on carbon taxes. Surcharges for carbon inefficiencies in buildings, and vehicle travel and parking, will raise revenue while sending signals that energy and carbon efficiency choices return economic benefits.

Leverage the Inherent Carbon Efficiencies of Cities: Density and good urban design lend themselves to carbon efficient travel (transit; bicycles; walking) and places to live, shop, work and play. Designing "complete communities" that integrate these uses into landscapes and amenities will add to public health and quality of life values as it adds carbon efficiency.

Leverage the Inherent Carbon Efficiencies of Buildings: A third of US energy is consumed in buildings. More efficient building shells and operating systems, tuned and retuned for maximum efficiency, will capture commensurate carbon savings. Zero net carbon building designs are already being demonstrated. The lessons learned must inform continuous strengthening of building codes. Since half the buildings that will exist in 2050 have yet to be built, there are huge opportunities to capture energy and carbon efficiencies; and huge opportunity costs with every one built to yesterday's standards.

Ramp Down Oil; Shift Transportation Loads to Electricity and Gas: Gasoline and diesel are the transportation fuels of the last century. New cars and light duty trucks will rely on high-carbon-efficient electric and hybrid engines to move us when transit, bikes and walking won't serve, and at efficiencies equivalent to more than 100 miles per gallon. Commercial vehicles may find natural gas engines more practical. Transforming both private and commercial fleets should be accelerated by public policy and private market infrastructure.

Ramp Down Coal Emissions: Shift Electric Loads to Efficiency and Renewables: Shifting to electric vehicles will gain us little if 40 percent of Oregon's power continues to come from burning coal. Ramping conventional coal down means rethinking how we use, generate, transmit and manage electricity so less is needed for any given task, and more electricity can come from low-carbon solar and wind without impairing system reliability. Technologies may enable a new generation of efficiency investments to be augmented with small, clean generating and storage systems in homes, offices and factories, linked by flexible transmission to great sweeps of wind turbines in Montana, Wyoming and the Dakotas.

Capture Carbon Across the Board: Savings have to be found in small and medium packages as well as transformational ones: replacing oil boilers and furnaces with cleaner natural gas; capturing greenhouse gases in healthy forests and the unbroken soils of no-till farms; converting captured methane emissions from dairy herds into clean power; developing industrial parks where they can be served by lower-carbon rail transport for longer hauls, and alternative-fueled delivery vehicles for shorter ones; and re-engineering industrial systems and processes for greater efficiencies.

Altogether there are 169 recommendations in the full *Interim Roadmap to 2020* report (including those described above) that the Commission is submitting to Oregon's Governor, Legislature, and citizens. Most are incremental; an important few are transformational. As our 2050 Vision statements make clear, Oregonians will need to act on most of them, and others unidentified, if we are to make our 2020 and 2050 goals. Even then, we understand Oregon can lead but can't succeed without concurrent efforts from other States, from their private citizens and businesses, from our national government, and from people and businesses and governments around the world.

There are no "magic bullet" technologies in these recommendations; no "X-Factor" solutions. We don't discount the emergence of such technologies. Indeed we believe they will be critically needed; we call for increased funding of focused research regionally and nationally, as well as a national carbon "cost" signal to stimulate innovation. But none of the ideas in this list is waiting around for any new technology. Instead they are creating the framework within which such technologies can emerge, take root, and grow into industries and jobs as well as carbon savings.

Climate Change Impacts and Preparation

Strategies to reduce Oregon's emissions are the primary focus of the Oregon Global Warming Commission, but we work in partnership with many other entities. Two of these – the Oregon Climate Change Research Institute (OCCRI) at Oregon State University, and the State Agency Directors' Adaptation Work Group – each delivered critical reports in December of 2010.

The OCCRI *Oregon Climate Assessment Report* is the work of over 100 researchers across the Oregon University System. Its key findings should surprise no one: likely impacts to Oregon's weather patterns, water supplies, agricultural production, forest health, fish and wildlife species and ecosystems, public health, transportation infrastructure and coastal communities.

The State's *Oregon Climate Change Adaptation Framework* takes that list of impacts and identifies near-term, low cost and high benefit actions Oregon can undertake to cope with the effects and cushion their costs to Oregonians, to their communities and livelihoods, and to the environmental values we hold dear in this state.

The OGWC has been involved in both efforts, and commends the researchers and authors for their contributions. Taken together with the *Interim Roadmap to 2020* report, these comprise a carefully considered and systematic response by Oregon to the pending threat of climate disruption, while taking responsibility for our share of the State's GHG emissions that contribute to climate change.

Principles

This introduction to the "Roadmap to 2020" project began with one quote from the 2004 Advisory Group report and recommendations. It ends by paying its respects to another: the principles adopted by that Group for proceeding into our uncertain climate future. The Commission reconsidered those principles, retained most of their wisdom, added some thoughts of its own, and offers this revised set of principles to the Governor, the Legislature, and the citizens of Oregon.

1. Oregon's greenhouse gas (GHG) reduction goals and solutions must be meaningful, firmly grounded in best available science and technology – and modified as the science evolves – and lead to effective reductions in Oregon's greenhouse gas emissions.
2. Oregon's GHG emissions reduction goals should be commensurate with the State's emissions relative to global emissions.
3. Oregon should first begin with the most cost-effective solutions, construing "cost" broadly to include near-term and long-term environmental, social and economic considerations, fairly weighing demand and supply options, and not neglecting actions that may have small near-term benefits but significant long-term potential.
4. Oregon should seek solutions that afford environmental and other co-benefits such as reducing other pollutants, or assisting businesses and households to cope with rising energy prices.
5. To the fullest extent possible, Oregon's actions should be designed to serve both the long-term economic well-being of the State and the goal of stabilizing GHG atmospheric concentrations at manageable levels.
6. Recognizing that there are always tradeoffs between a long-term investment strategy and near-term costs and cash flow, the Commission believes Oregon can and should be a leader - but not so far ahead of other jurisdictions that Oregon's businesses are disadvantaged. The State will need to build flexibility into its market and regulatory tools to relieve short-term competitive pressures if others aren't living up to their responsibilities.
7. Oregon should be creating long-term economic well-being with an "investment strategy" that buys efficiency savings, new technologies, energy price stability and a long-term competitive edge in selling – and profiting from – the tools developed and the lessons learned.
8. Oregon's actions will be guided by the need to protect access to reliable and affordable energy, and to needed goods, services and markets.

9. Oregon will act to broaden Oregonians' employment, housing, transportation, and energy choices so lower greenhouse gas alternatives are available and affordable. Oregonians preferring choices that result in higher greenhouse gas emissions must be prepared to pay the costs of those choices.
10. Oregon will look for ways to support innovation, especially if it leads to marketable products and services.
11. Oregon will partner with other states, Canadian provinces, tribal nations and other nations, where doing so will enhance the effectiveness of state actions and their co-benefits for Oregonians, recognizing that our actions will be most effective when they align corresponding actions by others.
12. Oregonians will strive to take responsibility for emissions from their purchasing decisions and waste disposal choices.
13. Reducing the State's greenhouse gas emissions won't eliminate the need to adapt to the warming climate that will result from changes to both human and natural ecosystems already fixed in the atmosphere. Oregon's adaptation strategies must continually evolve, be integrated into long-term planning, and address whole systems rather than individual effects.
14. Oregon is committed to equity in allocating both costs and benefits of this enterprise, paying special attention to those businesses and households least able to respond with their own resources. We recognize that emissions reductions will not be captured proportionately across all sectors, or across urban, suburban and rural communities. Cost effectiveness will condition allocation of responsibilities.

Next Steps

The Commission, OCCRI and the State Agency Directors are submitting their findings and recommendations to the Governor and Legislature, but also generally to the citizens of Oregon. Our conclusions are only meaningful if they are communicated effectively to, and resonate with, a majority of Oregonians.

In 2011 the Commission will be undertaking that communications effort – a "Roadshow for the Roadmap" – across the State. We will employ different channels and media to reach individuals, opinion leaders and stakeholder groups. We hope Oregonians will make it a true two-way conversation, letting us hear from you a full range of ideas and opinions. And while we encourage all to communicate their ideas directly to the Governor and their legislators, we'll ensure as well that they find their way into State policymaking circles.

Later in 2011 the Commission will reconsider the Roadmap in light of what we hear, as well as what we may have learned to date from advances in science and technology. We'll consider actions undertaken by communities, agencies and in the legislative session. The "Roadmap to 2020" process is in a sense always "interim" as we learn by doing and listening both. We urge all Oregonians to engage with us, to speak up and speak out.

The "Roadmap to 2020" Process

Context

In 2004 the Governor convened the Governor's Advisory Group on Global Warming to make recommendations on reducing greenhouse gas emissions in Oregon. Their final report, the *Oregon Strategy for Greenhouse Gas Reductions*, has served as the cornerstone for the State's greenhouse gas policy since its adoption. One of the key recommendations from that report, which the Governor endorsed, was a set of greenhouse gas reduction goals for Oregon. Those goals are to arrest the growth of Oregon's greenhouse gas emissions and begin to reduce greenhouse gas emissions by 2010, to achieve greenhouse gas levels that are 10 percent below 1990 levels by 2020, and by 2050, to achieve greenhouse gas levels that are at least 75 percent below 1990 levels. These targets were later put into statute by the 2007 Legislature at the same time the Global Warming Commission was established.

Much has changed since 2004. Although the *Oregon Strategy* report continues to prove its usefulness in guiding climate change policy (along with successor efforts), there is a need to both update and reexamine Oregon's path forward to meeting its greenhouse gas reduction goals. To address at least part of this need the Commission undertook a "Roadmap to 2020" Project in 2010 that offers recommendations for how Oregon can meet its 2020 greenhouse gas reduction goal (10% below 1990 levels), get a head start toward its 2050 goal (at least 75% below 1990 levels), and build a prosperous, clean-energy-based 21st century state economy. The "Roadmap to 2020" project was authorized by the Commission in April of 2010 through the passage of Resolution #2010-1-013, as follows:

Regarding a "Roadmap to 2020" Project for the Commission Resolution #: 2010-1-013

Commission Vote: 8 yes, 1 no (2 not present) *Origin: Angus Duncan, Commission Chair*

Whereas, the State of Oregon has adopted greenhouse gas emissions reduction goals for 2010, 2020 and 2050, and,

Whereas, since these goals were first proposed in 2004, the Oregon Legislature and Executive have acted in partnership with Oregon's communities, institutions, businesses and citizens, to slow and begin to reverse the growth of such emissions, and,

Whereas preliminary analysis indicates that these initiatives will succeed in meeting Oregon's 2010 goal, to "arrest" such growth "and begin to reduce greenhouse gas emissions," and,

Whereas meeting Oregon's next goal – "By 2020, achieve greenhouse gas levels that are 10% below 1990 levels" – will require redoubled efforts by all Oregonians, support from national emissions reduction policies, and significant technology gains as well, and,

Whereas substantial challenges remain for Oregonians to prepare for the likely effects of climate change on our communities, economy and natural resources, and, Whereas the Oregon Global Warming Commission (the "Commission") also has been charged, along with the Oregon Climate Change Research Institute, with informing Oregonians on "the scientific aspects and economic impacts of global warming (and on) ways to reduce greenhouse gas emissions and ways to prepare for the effects of global warming",

Now therefore be it resolved:

The Commission seeks to develop a "Roadmap to 2020" to recommend actions and strategies that may be used by the legislative and executive branches of succeeding State governments, in partnership with Oregon communities, institutions, businesses and citizens, to achieve the State's 2020 emissions reduction goal.

The Roadmap will make use of and rely upon the emissions reporting, collection, and analysis capabilities of state and federal agencies, and information provided by the Climate Change Research Institute and other institutions as appropriate.

The Roadmap will recommend actions that should be taken by Oregonians and the state legislature to prepare for the effects of climate change and the cost implications of those actions (as well as inaction), and the role that the OGWC and state agencies should play moving forward.

In these endeavors, the Commission intends to rely upon its committee structure to involve a broad and representative group of stakeholders, and to make use of and rely upon ongoing State and local agency activities and stakeholders' processes where they are available.

The Commission will invite Oregonians to review and comment on the proposed recommendations prior to submitting the Roadmap to the Governor and Legislature.

The Commission authorizes the establishment of a budget, to be assembled from foundation and private sector contributions, administered by the College of Oceanic and Atmospheric Sciences, Oregon State University, and employed to contract for professional services in support of Roadmap development.

The Commission will also solicit staff support as needed from State agencies, consistent with the direction provided to the Commission and the agencies in HB 3543, to ensure that its recommendations have full benefit of the expertise and authorities of these agencies.

The Chair of the Commission, the Vice-Chair, together with one of the co-Chairs each (appointed by the Commission Chair) from the Utilities and Stationary Sources Committee, the Transportation and Land Use Committee, and the Natural Resources Committee, will constitute a Project Oversight Special Committee to oversee management of the project, the budget and contract staff.

Elements of the Roadmap

With funding from private and foundation sources the "Roadmap to 2020" project commenced in the Spring of 2010 and continued through the Summer and Fall of 2010. The initial work of describing scenarios, sifting through possible recommendations, and evaluating them has been done by six committees of technical experts and stakeholders drawn from business, academia, non-governmental organizations, local government and State agency staff. The six technical committees were:

- Energy
- Transportation and Land Use
- Industrial Use
- Forestry
- Agriculture
- Materials Management

Although the process varied somewhat for each technical committee, in general, committees went through the following steps to develop elements for a "Roadmap to 2020" project report:

1) Assume that the State's 2050 greenhouse gas reduction goal is met, and envision what the sector under discussion might look like under a scenario that meets that assumption.
2) Conceive a list of the programs, policies, and practices that constitute actions consistent with achieving both the 2020 and 2050 greenhouse gas reduction goals for that sector.
3) Prioritize a list of the "Key Actions" that should be put in place in order to meet the State's 2020 emissions reduction goal, recognizing both the long-term potential of these actions to help meet the State's 2050 reduction goal and the short-term practicality of getting the action in place in time to help meet the 2020 emissions reduction goal.

Each of the six technical committees completed a "chapter" report for the "Roadmap to 2020" project, with each chapter including the key priority actions that should be undertaken for each sector, as well as the visioning exercise that outlined what each sector might look like in 2050. In addition to these core sections, additional narrative and supporting information were included in the reports, although the nature of that additional information varied from committee to committee. Actions that were not chosen as "key actions" can be found in the appendices of the full *Interim Roadmap to 2020* report.

Technical committee draft recommendations were presented to the Commission on October 8, 2010. The Commission adopted the *Roadmap* (as amended during Commission consideration) as an interim document on October 28, 2010 through the passage of Resolution #2010-3-014, which follows:

Adoption of an Interim "Roadmap to 2020" Report Resolution Number: 2010-3-014

Commission Vote: Unanimous *Origin: Angus Duncan, Commission Chair*

Whereas, the Oregon Global Warming Commission adopted Resolution # 2010-1-013 earlier this year which called for the development of a "Roadmap to 2020" to recommend actions and strategies that may be used by the legislative and executive branches of succeeding State governments, in partnership with Oregon communities, institutions, businesses and citizens, to achieve the State's 2020 emissions reduction goal, and,

Whereas six technical committees, composed of technical experts and stakeholders, were convened in the summer of 2010 to develop draft Roadmap recommendations for Commission consideration, and,

Whereas each of the technical committees (energy/utilities, industrial, forestry, agricultural, materials/waste management, transportation/land use) submitted a report with a list of potential actions to meet the 2020 reduction goals and a long-term vision of how the sector might operate if it were to be in a position to meet the 2050 reduction goal, and,

Whereas each technical committee specifically identified a small number of key recommended actions to be implemented to help meet the state's 2020 reduction goal, and,

Whereas additional "integrating actions" which are not sector-specific but have implications for most recommendations, emerged in the committee process and have been brought forward at this meeting of the Oregon Global Warming Commission for inclusion into the "Roadmap to 2020", and,

Whereas the Oregon Global Warming Commission has discussed and, where appropriate, modified the "Roadmap to 2020" report elements at this meeting of the Commission.

Now therefore be it resolved:

The Oregon Global Warming Commission adopts the "Roadmap to 2020" report elements as modified at this meeting of the Commission to form an Interim Roadmap to 2020 report. The report is labeled "interim" to acknowledge the desire of the Commission to further refine the "Roadmap to 2020" over time by, (1) conducting a public comment process in early 2011 on the Roadmap elements, (2) improving the quantitative basis for the Roadmap with more in-depth analysis, and (3) revisiting the balance of actions among sectors as additional quantitative analysis is done and with the benefit of viewing the Roadmap holistically, in contrast to the sector-specific manner in which it was created. It is the desire of the Commission to revise the Roadmap and create a new version, with the interim label removed, by the end of 2011.

Public Review Process and Revising the Roadmap over Time

The Commission will invite broad public review of all recommendations in early 2011 through a public process, and take comments into consideration in a 2011 revision of the Roadmap. This public process is still being developed and discussed, but it is anticipated that it will entail a series of public forums across the State to allow public feedback, as well as an electronic component to solicit feedback through the internet with outreach through social networking and media platforms. Concurrent with this public process will be deeper evaluation of the actions that have come out of the "Roadmap to 2020" process thus far, with a particular focus on: (1) evaluating actions on a quantitative basis; and, (2) incorporating choices and strategies developed in ongoing State and local government processes including those mandated by HB 2000 (2009) and SB 1059 (2010). By the end of 2011 the Commission is planning to finalize all aspects of the Roadmap.

For reasons of space only two sections of the *Interim Roadmap to 2020* report are captured in this document: the 2050 visioning exercise and the key actions for 2020. The many other sections and appendices of the *Interim Roadmap* can be accessed online on the Commission website.[2] Readers of this report are encouraged to explore the full *Roadmap* document to fully understand the context of the recommendations through the additional detail in the full version. The key actions identified in the *Roadmap* are also summarized below in Table 1 with detailed explanations for each of these key actions included later in this report (note the hyperlinked page number next to each action in Table 1).

[2] http://www.keeporegoncool.org/content/roadmap-2020

Table 1: Summary of Key Sector Actions by 2020 from “Roadmap to 2020” Process

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A VISION OF 2050: FUTURE STATEMENTS FROM THE ROADMAP TO 2020 PROCESS

A key part of the "Roadmap to 2020" process was a "back casting" exercise during which technical committees were asked to envision what their sector might look like in 2050 and put that vision on paper – assuming a world where Oregon's greenhouse gas reduction goals (with at least a 75 percent reduction) are met using only technologies that are now available or identifiably in the pipeline. The means by which this scenario could be achieved were then discussed by the committees, which ultimately provided a basis for decisions on what key actions were necessary by 2020 to begin the process of meeting the 2050 reduction goal.

Each technical committee produced a short narrative addressing this future vision of 2050 as part of their roadmap reports. These vision statements are compiled in this section of the report.

I. Energy

We cannot predict in detail how energy and capacity will be produced, delivered and consumed in 2050; we can propose scenarios that, relying on existing and emerging technologies only, could plausibly meet our aggregated goals of reliability, affordability, and low greenhouse gas and other emissions. It is likely that the architecture and operations of such an evolved system will be as different from today's as today's is from that of the mid-20th century. We can expect it to be reshaped by emerging technologies and evolving values, both reflected in the public policies and market forces of 2050; rearranging the basics – production, storage, transmission, distribution, and use of energy – and perhaps introducing new factors we can't anticipate. In one possible future, carbon capture and sequestration breakthroughs give new life to coal; in another, a policy preference for nuclear technologies prevails. What follows is one future scenario among the many possible; perhaps not even the most likely scenario, but one that can help illuminate the choices we face in reaching our greenhouse gas reduction goals while maintaining system reliability, quality and cost management.

Energy System Architecture and Operations

This 2050 system is more decentralized, contains more – and more diverse – resources, and relies heavily on Intelligence Technology (IT) for dynamic management and integration. It places a higher value on system flexibility, and the resources that supply flexibility. "Integration" is not primarily across generating plants but also between demand and supply sides, and even from customer to customer – the energy flowing not just downhill from plant to user but uphill as well, from user back into the utility system; and sideways, from user to user. The battery in my plug-in electric vehicle (PEV) powers your toaster in the morning, and may even supply backup capacity when the central grid goes down.

Communities are fully integrated as well. The farm on the corner supplies renewable gas to homes while waste heat from the industrial plant is fed into an efficient district system.

The priority energy resource of this 2050 system is energy efficiency (as it was in 2010, when it was the third largest source of electricity in the Pacific Northwest after hydro and coal) integrated into a modernized electricity grid. New homes and commercial buildings are energy and carbon high performance buildings, with consumption and related emissions >80% less than in 2010. This is achieved by virtue of their passive energy efficient designs, tight building envelopes, high-efficiency LED lighting (that produces lower heat loads for the air conditioning required by 2050's more frequent heat waves), heat pump or direct gas space and water heating (water preheated with rooftop solar thermal systems), and solar photovoltaic building skin elements (siding, windows, roofs).

The priority capacity resource in this scenario is also found on the customer side of the meter. Those buildings with excess power or thermal energy (or other "distributed" resources) may store it onsite (in a PEV battery or a fuel cell), or return it to the electric grid or gas supply system for storage or redistribution. "Smart" appliances talk to the utility "smart grid," buying and selling stored energy or capacity (from appliances that can be cycled on and off remotely) according to schedules mutually agreed to by the customer and utility.

Gas appliances in both residential and commercial uses can also be programmed to respond remotely to shortages of supply or weather-related spikes in demand (they might also support distributed electrical generation that could be called upon during peak power demand).

In 2050, electric and gas systems are also information systems. Achieving the benefits that Smart Grid technologies offer will require that we think and plan simultaneously for the electric and gas service system and the integrated role the data system will play in supporting these benefits.

This active role for customer-side electricity resources has enabled faster progress toward a power grid that is more flexible than today's system; that can respond more quickly and efficiently to changes elsewhere across the system, whether it is following loads or reacting to variable renewable resources ramping up and down. Most of the conventional coal and gas facilities that served as baseload resources in 2010 have been replaced by newer technologies that operate efficiently over a range of load factors, (pulverized coal plants were nearly all retired by 2030, freeing up east-west transmission that now brings High Plains wind to both West Coast and Mid-west markets). New gas turbine technology that can ramp up and down rapidly serves primarily as integrating resource for a grid that contains wind (in diverse wind regimes), solar, ocean, hydro , biomass and some geothermal renewable resources.

Wind and solar operate as "predictable" rather than "dispatchable" resources; the difference is that while system operators can't call on a wind-farm to increase generation when loads increase, they will know with higher probability than was the case in 2010 the level of output at which that wind-farm can continue to generate for the next hour, or day, or week ahead. IT systems will monitor and predict (1) changing loads, (2) dispatchable demand-side resources, and (3) available "predictable" resources. It will automatically dispatch (4) integrating resources – hydro plus new storage plus gas turbines – to backfill holes. Wind generators also can contract to reduce output to prevent over-generation and thereby preserve system balance.

Transmission, Storage and Controls

Such a system design relies on its transmission grid nearly as heavily as did the old architecture. But today's transmission grid is an intensively monitored and far more resilient, responsive, reliable and efficient system that can remotely diagnose and often repair its rare malfunctions. Transmission facilities are more strategically located and interconnected to be internally reinforcing, linking together and permitting efficient integration among loads, generation and storage while respecting environmentally sensitive landscapes and ecosystems. Siting new transmission facilities has become easier as communities realize its importance in a strategy of lower carbon emissions and greater energy independence.

Storage facilities are located both at the supply end (pumped storage, compressed air, advanced batteries, etc.), at load centers (batteries, fuel cells) and within loads (PHEV batteries, remotely-dispatched appliance cycling). Sophisticated control systems optimize flows and reduce congestion. The wide distribution of storage capability across the grid also strengthens system regulation and stability.

Electricity Generating Resources

In 2050, hydro still supplies + 50% of the region's electrical energy supply (and a significant share of the integrating services for wind and solar). That hydro is complemented by a mix of new wind, solar and other renewables, which together comprise >80% of electrical generation. Energy efficiency standards and investments have held overall load growth to + 0, excluding shifted transportation load (electric vehicles are estimated to have added 10% to 12% to overall energy load – assuming 60% of the light duty vehicle fleet is electrically-powered in 2050 – but has actually moderated the need for new electrical generating capacity by providing flexible load-center storage to the system). The entire system – supply, delivery and demand components – is planned and operated for optimum cost-effectiveness within hard reliability and carbon emissions constraints.

Gas

Natural gas supplies for both direct space and water heat, and for electricity generation as described above, are supplied domestically from both conventional and unconventional (e.g., shale gas) resources, and from renewable gas. This renewable gas may come from anaerobic digestion (animal waste, waste water treatments plants, landfills) or gasification of biomass. Between this supply, and robust US research, development, demonstration and commercialization of other renewable and energy efficiency products – and the shifting of most vehicles to electricity, gas and biofuels – the long-sought achievement of energy independence has been largely attained. To the extent energy products are still imported, whether equipment or fuels, our capability to replace imports with domestically-sourced products assures the US of price and supply leverage in global energy markets.

Oregon policies support, and utilities invest in, combined-heat-and-power (CHP) facilities to retrofit or displace boilers at industrial plants requiring substantial quantities of process heat. Oregon land use policies encourage co-location of such plants (which also enable industrial district heating systems) to reduce stranded investment risks.

Financing and Affordability

Early on, Oregon developed a State-sponsored energy financing platform that made use of State and local bonding authority, State revenues (including user assessments tied to carbon emissions), a strengthened and extended public purpose charge, and regulatory support for efficient utility access to capital markets to provide consistent financing support for realizing this energy future. The State's efforts were supported by BPA and utility investments in transmission capacity and control infrastructure. This financing was particularly important in effectively extending energy efficiency assistance to low-income households (including rental housing efficiencies captured through combined code requirements and loans secured by the properties). The model was not dissimilar to the public financing that created so much essential 20th century infrastructure, from dams and transmission lines to interstate highways.

Research

National and Oregon energy research agendas and budgets have received vigorous support over the last forty years, achieving gains in low- or zero-carbon fuels, energy efficiency (including building and appliance design, and behavioral response tools), supply and demand side controls, and low-carbon generating technologies. A reinvigorated research program will be pursued by the State in partnership with the federal government. Cost-effective carbon capture and storage (CSS) for fossil fuel plants remains elusive; while new energy storage technologies have combined with sophisticated control systems and wind/solar resource prediction capabilities to integrate a greater diversity of resources across larger geographic control areas. Conventional nuclear power plants have been deployed elsewhere in the US, while development interest in the Pacific Northwest focuses on the "pocket" nuclear designs with passive safety systems, standardized design elements and shorter development lead times, that were refined at Oregon State University.

Regulatory Predictability

Looking back from 2050, it's clear that the adoption of a mandatory national carbon emissions reduction policy (cap, cap and trade, tax or other device) proved essential to achieving Oregon – and national – GHG reduction goals. This single action provided homeowners, businesses and utilities with the predictability that both incented and enabled them to make carbon reduction investments at the scale required for deep emissions cuts. The required reductions were ramped in over time, while price ceilings and floors flattened out the spikes and dips that unnerve investors and lenders. The reduction curve encouraged innovation in carbon-reducing technologies and strategies (and created marketing opportunities for Oregon entrepreneurs).

II. Transportation and Land Use

How We Move Goods in Oregon in 2050

Oregon's economy remains trade-dependent and export-led, and the transportation system serves the engines driving the economy, supporting the growth of family-wage jobs. The system is viewed as moving people and goods rather than vehicles; and the design, planning, development, and usage of transportation reflects that shift. Market forces in the form of customer demand, cost reductions, and improved efficiencies and technology drive reduction in GHG emissions from freight movement. Awareness of emissions and opportunities to reduce costs are second nature to front-line staff operating machinery and vehicles in the movement of freight. Policy decisions take a systems approach and consider safety, economics, and GHGs.

Policy

Land has been preserved and (re-)zoned for industrial use on, adjacent to, and near highway interchanges and freight transportation corridors, where this would improve efficiency of freight movement, multiply intermodal opportunities and efficiencies, and reduce total vehicle miles traveled by trucks in Oregon. This also has enabled distribution and logistics complexes to be established at or near the ports of Morrow and Umatilla with product being shuttled between Portland and the mid-Columbia by barge.

Federal regulations implemented in 2007 and beyond regarding heavy-duty diesel engines have had a substantial impact as the trucks and engines built immediately prior to new regulations have been completely retired or replaced. Public policy requires manufacturers to improve the efficiency and reduce the emissions of truck engines through the use of market-based approaches.

As rail is usually more fuel-and-carbon-efficient for overland freight, and where rail is an option, land use planning has anticipated a need to better integrate freight rail. Long-range land use plans facilitate freight rail movement by supporting the development of industrial parks and "freight villages" adjacent to rail ramps where loads can be consolidated for shipment by rail or broken up for distribution. Markets for increased use of short line services have been identified and developed, and investments in infrastructure improvements have been funded.

Operations

All cities, counties, and MPOs working with the trucking industry have identified viable, important freight connectors, arterials, and routes. All signals are timed on these routes to allow large trucks to pass through without stopping while driving the speed limit. This reduces idling and consequently fuel consumption and GHG emissions. Freight vehicles of all kinds operate with limited or no idling.

Both US and international air space is opened up to allow flights (both cargo and passenger) to fly the most direct route possible between airports. Operations will be highly organized so that take-offs and landings can be managed in a way that allows planes to use very little fuel on descent and final approach. The airplanes themselves are fueled by lower-carbon fuels.

Design

All undivided roads have adequate passing and climbing lanes to reduce queuing of trucks and cars, thereby reducing emissions. Where possible on divided highways and where efficiency gains are possible, existing capacity exists and does not constrain other vehicle movement, truck-only lanes allow trucks consistent, efficient movement reducing starting, stopping, and slowing.

Process Improvement

Improvements in packaging have continued, enabling more freight to be shipped in fewer trips reducing both fuel consumption and GHG emissions.

Better technology and information about the transportation system has improved the modeling and operation of pick-up/delivery activities. This includes the ability to incorporate the operations of other fleets and private vehicles and their response to unpredicted problems on the network.

Capacity

Oregon ports and airports, where scale allows, have the facilities and service they need to capture 95% inbound and outbound freight within their market service areas. Oregon shippers no longer need to rely on transporting goods to/from ports and airports in California, Washington, British Columbia, and elsewhere.

Class I freight railroads (e.g., Burlington Northern Santa Fe and Union Pacific) have invested in new track capacity in Oregon and beyond enabling them to capture more long-haul freight volume moving into and out of Oregon. They are also cooperating to make more efficient two-way use of parallel tracking where it exists. Short-line railroads have also expanded to handle shorter distance freight movement.

Vehicle Manufacturing

Transportation vehicle manufacturers have modified designs (trucks, trains, airplanes, ships, etc.) to become more fuel-efficient and to reduce GHG emissions. Innovations in engine design, propulsion technology, aerodynamics, and fuel type and consumption allow for more freight to be hauled longer distances with fewer emissions.

How We Move People in Oregon in 2050

We've come a long way. In the forty years since 2010, Oregonians have thoughtfully, deliberately and persistently shifted the way we access work, school, play and shopping, especially in Oregon's urban areas where population densities support greater efficiencies.

Much like 1973's Senate Bill 100 laid the foundation for decades of wise land use in Oregon, the legislature adopted the "Options Now" bill, launching a mix of immediate and long-term actions setting Oregon on the path to a fossil-fuel free transportation system. Legislators recognized that wise transportation is the other side of the coin of wise land use. The cornerstone of the Options Now bill was the requirement that all Oregon cities larger than 10,000 people develop "Complete Community" Plans. These plans were a first step toward meeting local aspirations to create and maintain livable, vibrant communities that can accommodate a majority of non-work trips via walking, biking, shared rides, and, where available, public transportation.

Oregon legislators recognized that every dollar invested in providing transportation options keeps more dollars in the Oregon economy by reducing money exported to pay for petroleum. Oregon wisely shifted investments from those that worsened our petroleum addiction to those that boosted state and local economies.

Over the past four decades Oregon has retained most of the billions of dollars that would have otherwise been exported to pay for petroleum. The "Options Now" program became one of the most powerful economic development strategies in state history.

For four decades, vehicle miles traveled (VMT) within Oregon's metropolitan areas and major cities have been steadily dropping as people lived, worked, studied and played in greater proximity. This was accomplished by the State steadily increasing the share of transportation capacity funds and incentives going to rail, transit, bicycling and walking.

For most Oregonians, it's easy to walk, bike or take transit to work, school, parks, shop, worship and to visit with friends. For longer trips, Oregon's major cities are connected by quick, clean, frequent and convenient rail service. Rural areas have travel and vehicle choices that are both lower-carbon and lower-cost.

As the State, regional and local governments invested in building more and better transportation options, use of those options increased. Now, options for walking, bicycling, transit and driving make up a truly balanced system capable of meeting State GHG emission reduction targets set nearly 40 years earlier.

The legislature created an innovative system to reward ODOT, cities and counties for policies and projects that reduced petroleum use and GHG emissions. From Astoria to Ashland and Burns to Brookings, policies were adopted to determine and pay the true cost (including environmental consequences) of parking and driving, along with comparable costs of other modes of travel.

In 2050, nearly 90% of the miles traveled by vehicles in Oregon are from electric and other low-or non-carbon vehicles. And most of the electricity consumed by those vehicles is Oregon-based renewable resources. Many of the parts of those electric vehicles are made by Oregon workers, as is the technology that contributes to a more efficient operation of or transportation system.

There was concern early on that electric vehicles, with their lower operating costs, could create new pressures for urban sprawl. But Oregon's commitment to preserving the values embedded in its land use laws, together with a public transportation system that continuously improved its offerings created offsetting incentives to live and work within urban growth boundaries.

Oregonians now live longer than any other Americans. We get more exercise because we walk and bike more, and therefore have lower rates of many chronic diseases. After decades of reducing vehicle emissions; we have lower rates of asthma and other respiratory diseases.

The critical path to 2050 was established by two key policies offered in the "Options Now" legislation:

1. Establish pioneering least cost transportation planning that focused investment of our limited transportation budget in providing Oregonians with options that are both lower-cost and lower-carbon.
2. Reward ODOT, cities and counties for adopting policies that reduce fossil fuel consumption, vehicle miles traveled, and GHG emissions.

How We Use Land in Oregon in 2050

Oregon's shift to a low-carbon economy has given us, in 2050, the opportunity to live more prosperous, healthier lives by making the right long-term choices. Starting in 2010, anticipation of our impact 40 years hence became a foundational principle in the region for planning and developing our urban areas, using our natural resources and rural lands, and transporting our people, goods, and services. The highly energy-efficient homes and offices that have dominated the market over these four decades are not only much less expensive to operate and maintain, but with ever more sophisticated design have proven to be more comfortable and healthier to live in as well.

Oregon's land use patterns and practices have evolved with each decade of progress, and essentially will look to continue developing new urban constraints. By 2050, new development and redevelopment reflect compact, efficient mixed-use settlement patterns created largely through redevelopment and infill; our communities in 2050 have approximately the same footprint they did in 2012. Statewide intercity and interregional networks of transit service, broadband, and coordinated freight movement have enhanced personal and business mobility and accessibility at no net increase in industrial land consumption.

Highly energy-efficient building stock, assembled in more compact mixed-use neighborhoods result in increased convenience of urban living. More Oregonians have more choices of lifestyles with a smaller footprint but greater livability. As the lower-density neighborhoods from the last half of the 20th century were redeveloped, neighborhood centers for shopping and services were coupled with on-demand local transit to gain new efficiencies and convenience.

Greatly increased and convenient access to shared cars, walking, cycling, transit, and other services have allowed people to reduce their average driving per household, and downsize their household transportation costs. Urban households now own only one car on average. Commercial shared vehicles and expanded access to the full range of convenient transit options have allowed families and individuals to avoid many of the high costs associated with buying, operating, and maintaining cars for longer trips.

Local governments hardly need to build new roads, and are directing scarce dollars to maintaining and improving existing infrastructure.

Rural Oregon still relies greatly on personal autos and trucks, but these are efficient low-carbon and electric vehicles with an extended range. More efficient freight vehicles and IT-managed collection/delivery systems support more robust rural economies and better linkages between urban and rural places, communities, and economies statewide. Oregon's farms have efficient access to both local and global markets, and this diversification helps stabilize farm incomes.

Rural Oregon is also the source of much of the energy we use to power our vehicles, homes and businesses. Energy comes from wind, solar, biofuels, and combined-heat-and-power or cogeneration facilities at lumber-mills, dairies, wastewater treatment plants and landfills.

To prevent further urban spread, communities in the lands along and within 10 miles either side of the I-5 corridor – the part of Oregon that will be home to most of our population in 2050, as in 2010 – have adopted land-use strategies where living, working, learning, and experiencing nature are substantially co-located and easily accessible.

Roles for State agencies, local governments and businesses have been realigned to focus on sustainable development principles. Agencies and businesses have shifted from the traditional linear "take-make-waste" production model to a circular "borrow-use-return" production system. Shifting to this closed-loop approach has lead to cost savings, increased productivity, and ultimately to a competitive advantage for business while improving our quality of life and conserving nature.

To create a low-carbon, prosperous Oregon of 2050, we built on our historic land use and transportation policies, adopting a more rigorous integrated approach to land use and transportation planning that incorporates the following elements:

1. Building and redeveloping our communities to make them more convenient places to live, with or without a car. We added more destinations within walking distance of our homes and jobs; made the public realm more people-friendly and safer for pedestrians, cyclists and transit riders; and reduced the number of trips that required an automobile.
2. Developing a statewide system for intercity public transportation, in close partnership with private sector providers, local communities, public agencies, and others. Making it possible to inhabit not just a neighborhood but an entire state as a pedestrian. This extended the reach of citizens and created new luster for Oregon's international reputation as an environmental leader. Using the revenues from new funding sources like congestion pricing allows us to fund efficient options such as urban and intercity transit. This brings transportation choices to both urban and rural Oregonians.

3. Creating stronger, safer and more convenient links between the amenities in the public realm (parks, squares, public facilities, access to nature, beauty, etc.) and smaller, more efficient building and site designs.
4. Using transportation system pricing—tolls, transit fares, parking charges—to ensure that the people who choose to make heavy use of scarce transportation system capacity thereby creating congestion, pollution and GHGs pay the real cost of that use. Getting the prices right ensured market signals that allowed us to make smarter choices about where we live, how and when we moved around, which reduced the carbon emissions caused by driving.
5. Changing the way we raised and decided how to spend our scarce transportation dollars so we were getting the least-cost, biggest-bang for our buck system. This is defined as maximum mobility and accessibility for people, goods and services at the least cost in dollars, air quality, land consumption and GHG emissions.
6. Prioritizing the use of now-scarce gasoline and diesel fuels and associated infrastructure to support rural economies and goods movement, and backing it up with both public policy and public investment.

Technological development played a central role in Oregon's transition to a low-carbon future. However, Oregon's strategy of developing a diverse set of living, working and transportation choices for families and businesses avoided the overreliance on technological "silver bullets". This strategy allowed Oregon to continue protecting its farm, forest and wild lands as they coped with the stresses of adapting to the unavoidable climate change effects of water scarcity, variable land productivity and pressures on existing ecosystems accustomed to climate stability.

How We Make Transportation Choices, and Fund Them in Oregon in 2050

Reducing greenhouse gas (GHG) emissions from Oregon's transportation sector involves different institutional arrangements, policies, as well as direct actions (e.g., fleet conversion to low-carbon vehicles and fuels). These institutional changes were essential in enabling Oregon's transportation and land use institutions to become catalysts of change, enabling us to connect different uses and users, to think in terms of systems, of systemic change, and of collaborative efforts across boundaries instead of isolated actions that failed to connect and reinforce each other strategically.

Allocating GHG Emissions Among Emitters

Oregon early on reached agreement on the amount and timing of needed emissions reductions from transportation and other sectors that are sources of GHGs, giving Oregon citizens and businesses carbon predictability. GHG allocations were based on technical feasibility, amount of the reduction, cost, timing, and equity impacts. Different sub-sectors within transportation (e.g., air/sea/land freight, business, transit, and private vehicles) have allocations that declined over time at different rates, and to different levels (that still, in aggregate, meet an overall transportation sector allocation). Allocations within Oregon also conform to a national GHG budget, captured in a national "cap" mechanism, so Oregon's allocation reflects its fair share.

Planning

Transportation and land use planning in Oregon shifted to a "least cost planning" basis that internalizes the economic, environmental, social and other identifiable costs of fuel choices, land use actions, and GHG emissions. Planning and infrastructure investing for reduced GHG emissions consistent with State goals were embedded into planning protocols as a fixed limiting condition. Modeling tools for such a least cost path have been developed and applied, allowing for plans that can meet GHG reduction goals while optimizing for multiple attributes (e.g., safety; congestion-avoidance; travel time reliability; accessibility; modal share; etc.). Infrastructure investments and operations are consistent with the least cost plans.

"Locational" Costs Assessment

Urban areas, where most of the population lives in 2050, apply the lessons of least cost planning to integrating transportation with locational land use decisions. Internet-accessed models now display transportation "locational" costs (travel time/accessibility; travel costs; emissions effects; health effects) of choices of where to live and work. Businesses seeking new locations clearly can access what their shipping/distribution costs will be and their access to skilled work force. These costs can be integrated with other locational costs (e.g., energy, water, and services) to give those locating a residence, business, institutional or government office a more complete picture of the consequences of different location choices.

Transportation Funding and Cost Allocation

It was clear before 2010 that funding models for transportation were not working. The purchasing power of gas tax revenues were declining as the need to maintain existing and build new infrastructure was growing. More efficient mobility and accessibility were required for both freight and people. Existing funding models were also failing to capture the full range of costs created by transportation, in particular the costs of building capacity to accommodate peak transportation demand, and the costs of pollution and the increases in GHG emissions. Oregon pioneered a "utility" pricing model that levied a base ("capacity") charge for access to the transportation infrastructure (roads, transit, etc.); a usage-based ("energy") charge for each user's annual share of roadway, airshed, and GHG budget consumed; and a congestion ("peaking") charge to reflect peak period use. "Congestion pricing," together with real time information on traffic flows and slowdowns, now helps us avoid traffic jams and rush hours which contributes to more efficient use of our transportation infrastructure. As well, because demand is managed we now can avoid building a great deal of new infrastructure. Traffic – vehicle, pedestrian, transit, and bicycle – moves efficiently and predictably, reduces stress for all, and reduces costs and delays for commercial traffic. Computers designed for privacy and electronic applications accessible to drivers facilitate movement and access.

Research and Commercialization

Oregon has become a technical and business leader in developing advanced transportation solutions; building off its base and exploiting its comparative advantage already apparent in 2010. Modeling, planning, applied technology and user behavioral studies are combined into a cycle of constant investment and improvement in moving people and goods efficiently and equitably. The vehicles may be made elsewhere, but the systems that make them work are made in Oregon.

III. Industrial Use

Oregon industry is a zero waste, zero defect and 100% on-time producer of the most globally advanced products and industry services which have the lowest energy and raw materials intensity on the planet. For those reasons, Oregon industry products are sought after worldwide. Comprehensive industry enterprise management systems enable production whereby each product is labeled with its carbon and all materials content from raw material extraction through delivery to the end-user. GhG emissions from natural gas and petroleum combustion, semiconductor manufacturing gasses, cement manufacturing, iron and steel processes, ammonia and urea production, and other industrial emissions, in intensity per unit of production, is 75% of 1990 levels. Continuous improvement management is measured in real-time, on a commodity-by-commodity basis, in all industry with quality and safety control fully integrated.[3]

IV. Agriculture

Oregon has a thriving, resilient agricultural industry that is part of a diverse rural economy that produces food and agricultural crops more efficiently with fewer greenhouse gas (GHG) emissions. Agriculture has prepared for and adapted to climate changes in the most cost-effective and sustainable ways. The multifaceted economic, ecological and social benefits of farming and food systems to Oregon are recognized, quantified and rewarded, including the provision of a diverse and sustainable array of food, feed, and horticultural products. Ecosystem services such as carbon sequestration, clean air and water, healthy soil and wildlife habitat, visual amenities, and the essential role of agriculture in creating the fabric of strong communities, cultures, and economies, are recognized and rewarded.

Agricultural GHG reduction and carbon sequestration is an integral part of agricultural conservation research, planning, outreach and incentive programs

Greenhouse gas reduction and carbon sequestration is one of multiple conservation goals for agricultural lands, alongside water, air and soil quality and wildlife habitat, reflected in agricultural technical assistance programs, agricultural research and outreach programs, and conservation funding programs.

[3] The Industrial Use technical committee also prepared a vision statement for 2020 which is available in the full *Interim Roadmap to 2020* document online.

Benefits of reducing atmospheric GHG emissions and sequestering carbon have been quantified and fully realized on agricultural lands, where appropriate. Research has quantified the GHG reduction and carbon sequestration possibilities on agricultural lands, including soil carbon sequestration rates, soil nitrous oxide emissions, livestock diet strategies, and methane reduction through improved manure management. Research has developed the best agricultural practices to realize GHG reductions and these have been demonstrated and adopted by farmers and agricultural technical assistance and resource providers. Environmental policy and programs provide market-based and other economic incentives to farmers that foster the adoption of GHG reducing and sequestering practices based on sound agri-business considerations.

Agricultural management practices which effectively reduce and sequester GHG have been developed and applied consistent with regional conditions. Practices include those that enhance soil carbon sequestration, improve nitrogen use efficiency, increase ruminant digestion efficiency, capture gaseous emissions from manure and other wastes, generate renewable energy from agricultural lands and agricultural waste products, and reduce energy and fuel consumption.

Agriculture has prepared for and adapted to climate changes using the most cost-effective, technically feasible and sustainable paths

Agricultural research, outreach, conservation technical and financial assistance, and risk management funding programs have prepared agriculture for the effects of climate change, including reduced snowpack and seasonal water supply, increased atmospheric carbon, drought, warmer average temperatures, extreme weather events, and changes in pests and invasive plants. Through a combination of planning, research, education, efficiencies, and infrastructure improvement, agriculture is a strong, thriving industry despite these challenges because its practices and methods have evolved and adapted to a changing climate.

Ongoing efforts continue to help agriculture adapt and mitigate climate change. Research programs have increased crop yields and quality, improved input efficiency, and reduced our dependence on external energy sources. Examples of such programs include: crop breeding, crop management, abiotic stress management, soil management, and crop management.

Investment has increased local and regional food production, processing and distribution capacity and infrastructure to create a more resilient food system that better adapts to the uncertainties of climate change.

Agricultural GHG accounting is well established

Oregon has invested in the critical foundation for agriculture's full participation in State, national and international mitigation and adaptation programs by developing a consistent means for establishing baseline GHG levels and for addressing in a scientifically-defensible manner additions and changes to these levels in GHG accounting.

Robust incentives and well functioning ecosystem markets exist

Robust incentives and ecosystem markets are available and accessible to landowners with operations of all sizes. Measurable indices have been devised for agricultural systems (e.g., carbon, water quality, air quality, energy, hydrology, wildlife, native vegetation, space).

- Activity in the marketplace is at a level that investment returns to land owners are equal to or exceed inventory, accounting, and other transaction costs.
- Greenhouse gas reductions are accounted for, and aggregated information about their impact is shared globally.
- Markets depend upon solid oversight and accountability from national and international governing body.

Market emergence and function has resulted in a sustainable supply of verifiable ecosystem services that continue to motivate and maintain long-term investment. State governments cooperate with implementing and administering national and international policy agreements and standards for market participation and verification.

V. Forestry

The forest sector's contribution to achieving Oregon's greenhouse gas reductions goals will come primarily from increased carbon storage in forest ecosystems and long-lived forest products.

Despite predictive modeling and speculation, the effects of climate change on forest ecosystems are still uncertain and may, therefore, complicate future policy goals. For example, there is scientific consensus that the increase in average temperature predicted to occur will result in widespread changes in the geographic distribution of many tree species. How these changes occur across Oregon's ecoregions and then translate into the changes in the potential for carbon storage is highly uncertain. The probable increase in severe wildfires will add additional uncertainty to planning efforts and confound long-term projects to store more carbon in forest ecosystems. Expectations for carbon storage must reflect both geography and traditional benefits expected by various forest ownerships. The moist forest ecosystems west of the Cascade crest are more productive and have a greater opportunity for carbon storage than the drier eastside forestlands where the potential and occurrence of fires is much greater. These differences require different carbon strategies for different forest circumstances. Private and public forests have owners with different management objectives and expectations for economic returns that will likely result in different carbon strategies and outcomes.

Oregon's forest carbon management strategies are integrated into overall sustainable forestry objectives and practices that address fire regimes, insects, disease, drought, invasion by exotic species, and ecosystem function. Ecosystem dysfunctions resulting from misguided past practices – fire suppression, juniper range expansion – are addressed with policies that simultaneously target both increased carbon storage and resilient, productive forests. And since forest ecosystems cross the jurisdictional lines of forest management agencies common strategies and collaborative implementation must become standard practice.

With these primary qualifiers, the following describes one plausible pathway to Oregon's forest sector reducing Oregon's share of the atmospheric concentration of carbon dioxide in 2050 and beyond.

Federal and State Land Use Policies

Land use policies between 2010 and 2050 have been successful in reversing the historical trend and preventing forest land from converting to other uses, resulting in no net loss of forest land, enabling a measurable gain in statewide carbon storage. Cooperative and effective implementation of land use policies combined with forest carbon offset markets or other programs that reward reforestation have resulted in a net increase in forest area. Significant investments have enhanced the extent of services and benefits provided by Oregon's forests, including carbon sequestration and a long-lived product pool.

Federal Forest Lands

Federal forest land managers have collaborated with State and private forestland counterparts to work for measureable contributions in reducing Oregon's share of global CO_2 emissions. Policies have acknowledged the different goals for forests east (generally drier) and west (generally wetter) of the Cascades with an overall increase in forest carbon stores. East-side forests have been managed primarily for ecosystem restoration, safety, and climate adaptation with a minimum of incurred carbon debts (e.g., loss). West-side forests have been managed under national polices that protect broad ecosystem values consistent with the Oregon Global Warming Commission's desire to increase carbon storage to what is practically achievable in 40 years (and those policies are ongoing beyond 2050, although annual carbon gains will level off). Achievable carbon storage levels were arrived at by evaluating the costs and benefits of management for optimal carbon storage, then adjusting for the long term sustainability of other valued benefits and services expected from forest ecosystems that might be compromised in a one-dimensional focus on higher carbon densities.

State-Owned Forest Lands

State-owned forest lands have been managed for multiple purposes including the long-term storage of carbon, with an overall goal of increasing carbon capture through management practices, afforestation and reforestation. Major forest policy and management decisions are informed by a clear accounting of the consequent change in carbon storage that will occur. There has been a net increase in the amount of forest land owned and managed by the State. Much of the additional forest land has a carbon storage obligation within the terms of the property transfer. Oregon's state-owned forest lands show a measurable contribution to reducing atmospheric CO_2.

Privately-Owned forests

The net area of private forestlands in Oregon has remained constant since 2010, and the lands have been managed primarily for production of timber and wood products. Carbon storage levels have remained constant across all such lands, and in some cases have increased due to voluntary owner actions, frequently in collaboration with ecosystem services market mechanisms.

Atmospheric GHG reduction benefits have been optimized on private lands based on life-cycle analysis primarily through the following:

- The GHG reduction benefits of wood-based building materials over higher energy alternatives have been calculated to general government and stakeholder satisfaction, and are reflected in mitigation policies.
- GHG reduction benefits have been realized from a fully developed bioenergy infrastructure for the sustainable use of forest biomass residue and the anthropic waste stream.
- Additional GHG reduction benefits have been enabled through public and private sector investments using generally accepted certification standards and guidelines to promote carbon densification on privately owned forest lands.

Ecosystem Services Markets

Carbon prices and markets have fully emerged and are available to landowners of all sizes. This has created the appropriate incentives for forest conservation, improved forest management, and the use of bioenergy and wood substitutes. Measurable indices have been devised for forest systems investments (e.g. carbon, fiber, air, energy, hydrology, wildlife, information, space). These are updated on a regular basis, garnering widespread interest and motivating investment. Market decisions and investor confidence are integrally linked with the forest monitoring and carbon accounting systems described above.

- Activity in the marketplace is at a level such that investment returns to forest owners are equal to or exceed their inventory, accounting and other transaction costs.
- Market investments and forest carbon accounting data are validated and shared globally.
- Markets depend upon solid oversight from national and international governing bodies.

Market in verifiable ecosystem services have emerged, resulting in a sustainable supply of services including but not limited to carbon storage that continue to motivate and maintain long-term investment. Market structures permit participation by both large and small forestland owners. State governments cooperate with implementing and administering national and international policy agreements and standards for market participation and verification.

Forest Inventory and Carbon Accounting

A practical and statistical level of sufficiency in a standardized system of forest monitoring and carbon accounting of the role of Oregon's forests, on a lifecycle basis, in storing and contributing to the reduction in GHG levels has been established. This standardized carbon accounting system for the forest sector is sufficient for the full emergence of a solid ecosystem services marketplace. The system comprises a robust set of integrated state-of-the-art technologies encompassing biomass and carbon inventories, analysis and modeling, and reporting. Inventories continue to be a combination of field-based data collection systems and analyses of space and air-based remote sensing imagery. These technologies have become affordable and more integrated as technologies advance and emerge in image sensors, computational software and hardware, and atmospheric gas exchange. Significant improvements have been made to estimating carbon quantities in the components and transactions comprising forest ecosystems. Routine advancements in technology in each of these areas are being integrated to where they are mutually reinforcing and interdependent. A workforce capable of implementing these new accounting technologies has been trained.

Bioenergy and biofuels

After evaluation and verification of net carbon benefit, advances in technologies for bioenergy systems have allowed for biomass energy in the forest management sector. Fuels management, recovery and conversion technologies, and the scheduling and sequencing of forest biomass removal have been optimized to minimize short-term carbon debt. Demand for low-carbon energy production from forests has led to the integration of biofuel production from forest biomass with the timber harvest and transport systems. That biomass-sourced energy powers the removal and transportation of excess forest fuels out of Oregon's forests while also providing a supply of materials to the product carbon storage pool to benefit humanity, consistent with other values including adequate preservation of genetic material, hydrologic function, O_2 production, and forest productivity (CO_2 conversion).

The need to minimize the cost of management and transport of forest material has led to efficiencies in the removal, processing and transportation of the lower size range of forest material to maximize volume per unit haul distance. Technological breakthroughs in advanced materials engineering enable more energy and carbon efficient on-site processing operations.

Education and Public Perception

The general public has an understanding for the role that forests and forest products play in carbon management.

There is widespread understanding and acceptance that forest ecosystems are a principle component in, and valued as, a set of life supporting systems on the planet. This perception is brought about through advanced scientific understanding of the Earth's interacting biophysical systems and wide distribution of this knowledge through advances in free, widespread and highly effective social education systems. Advanced systems in technology for monitoring and measuring (remote sensing, field-based) forest functions – from atmospheric gas exchange to continuous detection and counting of individual organisms – has reduced uncertainty in resource composition, abundance, and flux. This advanced understanding of human interdependence with other biological systems has nurtured investments in the long-term sustainability, and management of multiple benefits supplied by forest ecosystems.

Investments have been made in the development of new technology and the transfer of that technological knowledge to landowners of all types. The lessons learned are propagated broadly to the public, and in more targeted ways (e.g., best practices; technology transfers) to forest landowners, forest workers and regulators.

VI. Materials Management

In the early 1970s, Oregon championed protection of the environment and quality of life through the nation's first bottle bill, land use planning system, and beach protections. We can be proud of this legacy, but today's challenges again call for bold vision and leadership. Our vision is that by 2050, Oregon has achieved major reductions in the emissions associated with the full life cycle of materials. These emissions have fallen to 88% below 1990 levels on a per-capita basis. The State has achieved its goal of a 75% reduction in absolute GHG emissions, when viewed both from a traditional inventory perspective (which focuses on the in-state production of materials) and also through the lens of consumption-based accounting (which focuses on the in-state consumption of materials). Both carbon-intensive production and carbon-intensive consumption have shifted to significantly lower carbon pathways. By finding ways to meet our needs without massive (and growing) resource consumption, Oregon communities and families have become stronger. Greater emphasis is placed on family, community, economic sensibility, personal health and development, and preserving our great natural heritage for future generations.

This significant reduction in emissions is a result of major changes in state, national, and international policies to address global warming and GHG emissions. Both producers (supply) and consumers (demand) have become involved in reducing emissions across all of the stages of the life cycle of materials and products used in Oregon, including raw material extraction, production, purchase, use, and end-of-life management. Because of the significance of emissions associated with production, significant supply-side changes have been made both inside and outside of Oregon.

By 2050, producers and consumers have long been provided with clear information regarding the climate impacts of their choices, including choices involving materials; as a result, producers are making and consumers are choosing materials that have significantly (~90%) lower life cycle emissions. Particular attention has been given to growing both the supply and demand of materials that are "regenerative," that is, that have the impact of removing carbon from the atmosphere when viewed over their entire life cycle. In some cases, this means that producers continue to make the same materials and products that were made in 1990, but use very different (low- and no-carbon) energy sources or production techniques. In other cases, producers are making new materials and products in lieu of some of the high-impact materials and products used and produced in 1990.

By 2050, through a combination of regulations, financial incentives, and consumer demand, producers of both goods and services making these changes have seen their businesses grow sustainably, while companies continuing to produce and/or use high-carbon materials have seen significant declines in market share. The new investments and production processes required for Oregon to achieve this vision have provided for economic and community vitality, by absorbing job losses resulting from the transition away from carbon-intensive materials, products, and processes.

By 2050, the cost of carbon (and other externalities) has been reflected in the price of goods, providing an added incentive to favor low-carbon production and consumption, while leading to a more efficient allocation of resources. Consumers, producers, and policymakers are also using the concept of a "carbon budget," an allowable amount of carbon that individuals, organizations, and communities can emit while achieving broad carbon emissions goals.

By 2050, the vision of product stewardship has been fully realized, and all parties involved in the design, production, sale and use of a product are taking responsibility for minimizing the product's environmental impact throughout all stages of the product's life. Producers, who have the greatest opportunity to reduce carbon impacts via "upstream" processes, have been actively and positively engaged. Early product stewardship activities, such as Oregon E-Cycles, where producers took greater responsibility for reducing product impacts at end-of-life, have continued, but the focus of product stewardship has expanded so that producers are taking responsibility for reducing the full life cycle impacts of their products, including greenhouse gases. Product life cycle impacts are being optimized holistically as opposed to optimizing individual life cycle stages. Efforts to achieve carbon goals have not significantly increased other environmental impacts.

By 2050, "net zero" buildings – both residential and commercial – are the norm. Evaluation of the built environment's contribution to climate change includes the full life cycle impacts of materials, and this more comprehensive view leads to greater reductions in greenhouse gas emissions.

By 2050, consumers have shifted their consumption of materials in favor of categories of products with lower carbon impacts, individual products that are "best in class" at reducing carbon emissions, and low-impact services. Oregonians are being provided with clear information on the carbon impact of products and how to reduce those impacts.

Oregon households have also increased their emphasis on education, savings and investment, providing them with stronger financial security, while also providing society with the human capital (education) and physical capital (infrastructure) necessary to transition to a low-carbon economy. Less money and time spent acquiring, maintaining, and managing stuff is allowing for greater emphasis on family, community, and personal health and development. As consumption returns to a level that can be sustained, shifts in investment, economic conditions, and social values have also enabled an equitable reduction in the average number of hours worked, slowing the treadmill of "work and spend."

While every Oregonian may be taking different paths to reduce their carbon footprints (associated with materials), examples of some of the common changes include the following:

- The use of energy-consuming products (cars, TVs, refrigerators, furnaces, etc.) is reduced, and those products that do use energy are highly efficient.

- Caloric intake of food is reduced to levels that optimize health, reversing the current epidemic of obesity (and associated health costs). Diets shift in favor of foods that offer simultaneous carbon reduction and health benefits.
- More Oregonians enjoy the benefits of living in homes that are high-quality, smaller, and energy-efficient. Multi-family dwellings and co-housing arrangements also allow for reductions in the climate-related impacts of materials. Building materials are designed and selected to optimize life cycle carbon reductions.
- Consumers favor low-carbon services over goods, for example, giving more experiential gifts and less “stuff” as gifts during holidays and celebrations.
- Individuals at all economic levels increase personal savings.
- Products are chosen from companies that employ best-in-class methods of low-carbon production and transportation.
- Products are designed to be appropriately durable, repairable, efficient, and recoverable. Consumers maintain, repair and upgrade them so as to minimize replacement, as appropriate.
- Consumers increasingly favor the purchase of reused goods over new. As products are made to last, the quality of reused goods is significantly improved.
- Material waste is minimized. For example, grocery stores, restaurants, and individual consumers all take steps to reduce the purchase of food that goes uneaten. More efficient use of purchased goods frees up resources for more productive uses.
- Products are being designed to facilitate recovery at end-of-life.

By 2050, when products and other materials are no longer wanted and cannot be reused, Oregon residents and businesses recover them for their next highest and best use. Organic wastes, such as food, are being diverted to facilities such as anaerobic digesters, composting sites, or other appropriate technologies. Recyclables are recycled at high rates, with a focus on “upcycling” to best uses. New recycling processes (both for existing recyclables and materials that currently were not recycled in 1990) – as well as select energy recovery processes – allow for the production of new materials and energy with significantly lower carbon impacts. Landfill methane emissions have long been minimized, both as the inflow of putrescible wastes has been reduced, and as landfills have continued to implement design and operational controls that reduce methane emissions. Methane from the decomposition of legacy wastes is recovered for energy, but landfilling has become truly an option of last resort. Similarly, carbon dioxide and nitrous oxide emissions from waste incinerators have been reduced as waste flows have shrunk and shifted to uses elsewhere with lower carbon impacts. Waste management decisions regarding cost-effectiveness are made including full social costs (including the cost of greenhouse gases).

While Oregon has made significant changes since 1990, other states and nations have as well. As a result, Oregonians in 2050 – and residents everywhere on our planet – are living much closer to the vision of sustainability. Oregonians are enjoying vibrant communities, strong families, and the benefits of personal health, economic sensibility, and a healthy environment.

Key Actions from the Interim Roadmap to 2020

With a vision for 2050 in place for each sector that recognizes the greenhouse gas reductions necessary to achieve the State's reduction goals, the technical committees were then able to focus on generating a list of the policies, programs, and practices they judged could contribute to meeting these goals. The process used to brainstorm these inventories of actions varied from committee to committee, but the unifying strategy was to get many potential actions on the table so that a subset of reasonable recommendations could be considered by each technical committee for prioritization. The process for prioritizing the assembled actions and for generating a small number of key actions also varied from committee to committee, but each committee was able to either pick a few single actions or consolidate multiple actions into a smaller number of key actions (or a combination thereof) so that each technical committee could generate between four and twelve high-priority "Key Actions." These key actions are detailed in each sector chapter of the full *Interim Roadmap to 2020* report, and are also included here. For the full context of these key actions please refer to the full *Roadmap* report[4] since, in some cases, you will find additional context and narrative not included here.

In addition to the key actions from each sector, the Commission chose to provide a set of recommendations that were not specific to any one sector. These "Integrating Recommendations" broadly address climate change policy at the state and national level, as well as the analytical needs necessary to support well substantiated climate change policy development. Note that the integrating recommendations are fundamentally different than the key actions identified in each sector in that the integrating recommendations don't directly lead to specific greenhouse gas reductions, but rather lay a foundation for implementation of the key actions identified in the "Roadmap to 2020" process.

Other Actions Considered in the "Roadmap to 2020" Process Are Available Online

Beyond the key actions (and the integrating recommendations) that follow in this report, a large number of other actions were considered by the technical committees. These actions can be found in the appendices of each sector report in the full version of the *Interim Roadmap to 2020* available online. The number of actions listed in these appendices is detailed below. Note that in some cases the "Key Actions" represent a mix of the actions considered, either in whole or in part. Therefore, not all are necessarily additional to the "Key Actions" included in both the full *Interim Roadmap to 2020* report and in this legislative report.

Technical Committee	**Number of Actions found in Full *Interim Roadmap to 2020***
Energy	32
Transportation & Land Use	51
Industrial Use	22
Agriculture	8
Forestry	22
Materials Management	38

4 http://www.keeporegoncool.org/content/roadmap-2020

I. Integrating Recommendations

1. Greenhouse Gas Reduction Goal for 2030 (IR-1)

The Oregon Global Warming Commission shall recommend to the Legislature a 2030 Oregon GHG reduction goal; thereafter and from time to time, but not less often than every ten years, the Commission shall revisit and recommend as needed ten- and twenty-year emissions reduction goals, and monitor progress toward their achievement.

The Oregon Legislature adopted greenhouse gas reduction goals for 2010, 2020 and 2050, following the recommendation of the Governor's Advisory Group on Global Warming in 2004. This gave the State near-term, intermediate and ending targets. With 2010 behind us, the 2020 goal becomes the near-term goal and the need for a new intermediate goal arises. This need is reinforced by the need to coordinate with other planning entities and initiatives which are already looking past 2020 (e.g., ODOT setting a State transportation GHG goal for 2035; Northwest Power and Conservation Council 20 year power plans; utility Integrated Resource Plans, etc.).

2. Greenhouse Gas Inventories (IR-2)

The Oregon Global Warming Commission, in collaboration with State agencies, local governments and others, should develop greenhouse gas accounting methodologies and results (a) by source, (b) by use/user, (c) by cost and timing of reduction choices, and (d) by county or other state geopolitical division. The Commission should use this accounting framework to allocate and sequence carbon reduction targets by cost, sector and geography, to enable Oregonians to better understand how emissions reduction goals can best be achieved, and what may be their share of the overall responsibility.

Oregon's current greenhouse gas inventory approach is largely "top-down," calculating emissions by sector, often from fuel use data or estimations. Electric utility emissions are an exception, relying on reporting from facilities generating electricity allocated to Oregon loads ("consumption-based"). A greenhouse gas emissions reporting system is being established by DEQ at legislative direction; and DEQ staff is working with stakeholders on modeling for a consistently consumption-based model. Finally, there is a need for data that can be disaggregated (a) geographically, to allow local governments to understand their emissions profiles by sector so they can design responses, and (b) by cost-effectiveness and timing, so Oregon can describe and pursue a least cost path to its emissions goals. The Commission should be interacting with all parties to ensure that data are consistent and usable by policymakers and managers.

3. Advocating for a national carbon cap or other equally effective national carbon reduction measure (IR-3)

The Oregon Global Warming Commission reaffirms its support and advocacy for a national carbon cap or other means to regulate and reduce greenhouse gas emissions economy-wide, as previously asserted in Resolution 2009-1-009, and will communicate with the President and with Oregon's Congressional

Delegation to this effect.

The Commission is already on the record in support of this kind of national action (". . . the Commission reaffirms its support for a fair and effective national solution to achieving greenhouse gas reduction goals comparable to Oregon's, one that employs marketplace tools such as a cap and trade mechanism, as ultimately preferable to regional or state-based initiatives."). The issue arose in several of the Roadmap Technical Subcommittees, but as it transcended the writ of any one subcommittee, members asked that it be considered by the Commission as a whole. As intra-state initiatives move ahead, they are handicapped by the absence of national policy that sets clear direction on greenhouse gas reduction goals and timing, that encourages private sector initiatives and innovations, and that protects the economic competitiveness of states, communities and businesses that are already reducing emissions.

4. Energy and Infrastructure Research Funding Priority (IR-4)

The Oregon Global Warming Commission and the State of Oregon should advocate with Oregon's Congressional Delegation and the President to assign the highest priority for federal research funding to energy and infrastructure opportunities that hold greatest promise for delivering near-term greenhouse gas reductions.

While much can be done to reduce emissions with existing technologies and applications, it is clear that achieving reductions comparable to Oregon's "greater than 75% below 1990 levels" will require significant technological advances in fuels, power plants, vehicles, appliances, lighting and other efficiency and fuel-switching options. Challenges such as carbon sequestration and assessing climate modification options remain beyond our reach as potentially needed tools. Yet federal funding for energy research is barely $5 billion annually (up from $3B in the last Administration, down from an inflation-adjusted $7.7B in 1979; and far below the budgets for health research [$30B] and defense [$80B]). Half or less of that budget goes to renewables and efficiency. Meanwhile, major reinvestment in transportation, power transmission, water and other infrastructure is needed to leverage technologies into widespread use. The Commission would be asserting that there should be no higher priority assigned to government research dollars than in finding ways to reduce emissions and preparing for the effects of climate change that cannot be avoided, and leveraging private sector investments toward the same outcomes.

II. Key Energy Actions for 2020

In all our State's greenhouse gas reduction strategies, Oregon acknowledges that while it can be a leader, it cannot by itself materially affect the growth of greenhouse gas emissions without reciprocal initiatives by other states, by our federal government, and by other countries across the globe. While there are actions that reduce greenhouse gas emissions that are worth taking in themselves – many energy efficiency investments, for example – ultimately attempts to go our own way in isolation would be not only ineffective, but would have adverse economic effects on Oregon households and businesses. Especially this is true in our electricity and gas utility sectors, where we are interconnected, by physical ties, access to fuels, and economics, to the rest of the country and the world. The recommendations that follow should be read with this qualifier in mind.

At the same time, we also assert the importance of providing leadership in this sector as Oregon has done so often in the past, from our transmission arrangement with our neighboring states and with Canada, to our pioneering work in energy efficiency and least cost planning. Leadership provided by Oregon and other states is not only essential to achieving essential greenhouse gas outcomes; it also positions our state to capitalize on emerging national and global clean energy markets. The recommendations must be read in this context as well.

We explicitly acknowledge the essential role that Least Cost/Integrated Resource Utility Planning (IRP) has assumed in the planning and decision-making processes of our state and region over the last three decades. The setting and achieving of energy and climate policy goals for utilities is best accomplished within this framework.

1. Develop State Energy and Climate Policy (EN-1)

Oregon should adopt clear, durable, integrated policy preferences on how best to meet reliability, affordability and environmental goals over a planning horizon of > 20 years, to allow households and businesses to plan and budget with confidence. The resulting energy policy should address: (1) utility energy supply, delivery, use and conservation (IOU and COU; electricity and natural gas); and (2) transportation energy supply, use and conservation; and (3) environmental, social, and health outcomes, including impacts on communities and workers. These goals should inform, but not supersede, prevailing utility IRP requirements and obligations. Oregon should adopt a set of benchmarks to serve as interim guides towards meeting the goals established in its energy policy. The benchmarks may speak to statewide and sector specific goals, but must contain language specifically stating that they do not apply to individual entities. Meeting the State's climate policy goals must be recognized as an effort that will require contributions by all citizens and corporations of the State. Joint planning by the State across fuels (electric and gas) and across sectors (energy, transport) can then inform both transportation and utility planning efforts. Utility integrated resource plans, should consider "net GHG reductions" that reflect load shifting between fuels and meeting new loads that may be emerging from the transportation sector.

2. Energy Efficiency (EN-2)

Develop and implement new standards, codes and incentives to address highly effective yet hard to deliver energy efficiency measures including but not limited to: appliance and lighting codes and standards; a retrofit building energy efficiency code; commercial building commissioning; rental housing codes; utility investment in energy efficiency; and incentives for high performance buildings.

3. Support and Plan for New Transmission (EN-3)

New transmission capacity for both gas and electricity will be required. Oregon siting standards should be periodically reviewed to assure that they satisfactorily reflect State and Federal reliability and safety requirements, the State's environmental values and regional and State energy policies that prioritize (a) the transition to enhanced system flexibility, and (b) access to low-carbon generating resources such as central station wind and solar. Full development and interconnection of distributed/load-center resources (efficiency; demand management; distributed renewables and storage) should be facilitated. New transmission capacity should give due consideration to using existing corridors; and new corridors should be created only if they are shown to be essential to meeting resource and environmental goals, while assuring power quality and system reliability consistent with applicable reliability standards and performance criteria (including line separation requirements).

4. Ramp Down Emissions Associated with Coal Generation (EN-4)

Coal-fired electricity generation to serve Oregon load emits a significant share of total CO_2 emissions attributable to the State. While technological and economic breakthroughs in Carbon Capture and Sequestration (CCS) or other carbon abatement technologies may provide cost-effective solutions in the future, these are not viable options today. Therefore, policy makers must understand the existing options available to Oregon utilities to begin making substantial reductions in emissions attributable to conventional coal-fired generation serving Oregon loads by 2020, and achieving the additional reductions thereafter necessary to support Oregon's deliberate, continuous progress toward achieving its 2050 greenhouse gas emissions reduction goal. The Legislature should direct and authorize the Oregon Public Utility Commission to direct Oregon utilities to investigate alternatives to continued use of coal-fired generation technologies, including the policies, programs, technologies and measures that might provide a reduction in the emissions from those sources, consistent with Oregon's greenhouse gas reduction goals as adopted by the Legislature. This evaluation should proceed within existing Integrated Resource Planning processes, including thorough IRP evaluations of the benefits, costs and effects on the quality and reliability of service of alternative pathways toward meeting the emission reduction goals. Other considerations may include: (1) reciprocal initiatives by other states or, preferably, by federal action; (2) sufficient time for an orderly replacement resource planning and acquisition process to assure system reliability and manage transition costs (and especially impacts to utility employees, local communities, and businesses and low-income household customers); (3) sustained progress on transmission infrastructure development, integration technologies (e.g., electricity storage) and practices required to bring low carbon variable renewable generating resources into the electricity grid; (4) success of efforts to reduce emissions in other sectors; and, (5) consideration of effects on Oregon's economy and employment.

5. OUS Energy Research Priorities (EN-5)

Oregon should support substantial increases in the federal investment in energy research so that it is commensurate with its importance to the nation. Oregon, through the Oregon University System, should invest in research priorities that include: building energy efficiency systems; design-integrated solar distributed generation applications; energy efficiency behavioral initiatives; distributed load center generation, storage (e.g., fuel cells) and control systems; V2G electric vehicle integration controls and configurations; biomass and ocean energy conversion technologies and support (e.g., biomass fuel) systems; small-scale nuclear generating technologies. Research also should be supported on the social, economic, health, and health equity aspects of changes in energy generation, storage, and transmission being considered in Oregon.

6. Modern Gas Infrastructure (EN-6)

In the next decade, natural gas infrastructure and operations will need to drive net reductions in greenhouse gases through: a) harvesting waste heat from generation near thermal loads; b) combining natural gas with renewable generation, such as solar thermal; c) serving a growing fleet of natural gas powered vehicles (e.g., centrally fueled fleets, heavy duty vehicles); and d) gathering and cleaning to pipeline quality renewable natural gas from a wide variety of biogas sources. State energy policies should be designed to ensure adequate natural gas infrastructure and "the best fuel for the best use;" these policies should in turn inform utility Integrated Resource Plans. Where a showing is made of net greenhouse gas reduction potential from the direct use of natural gas, integration of renewable resources or use of high-efficiency electrical appliances for critical space and water heating, State policy should prioritize such use.

7. Smart Grid and Integration of Resources (EN-7)

To fully realize the potential of renewable and demand side resources, advances are needed in technology, information systems, the grid, and system operations. These include Smart Grid initiatives described in Recommendation 16[5], and the improvements in the integration of renewable resources including tapping demand-side flexibilities as described in Recommendation 23.[6]

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[5] Smart Grid: Oregon State agencies, utilities and University disciplines should prioritize, deploy and demonstrate Smart Grid technologies and associated information and applications that result in a future utility system that meets end-user needs more effectively. Three broad areas for emphasis are:
(a) distribution/transmission system improvements and reconfigurations, including distribution-transmission interface;
(b) underlying data/information systems; and
(c) introduction of "Smart Grid-capable" metering, appliances, V2G vehicle and infrastructure designs and other interactive elements of a fully-realized system.
Smart Grid improvements that facilitate integration of variable renewable resources, energy efficiency, and taking advantage of opportunities to tap the demand side to meet needs for capacity and flexibility will be emphasized. This future system should encourage and support greater end-user energy use control while also addressing privacy, security, access, equity, and technical considerations. State incentive and regulatory policies for Smart Grid development, planning, deployment, and reporting reflects this prioritization and these considerations.

[6] Integration of Demand- and Supply-side Generation and Loads: Utilities, regulators and legislators, regionally and in Oregon, should address the planning, regulatory, design and operating issues that currently frustrate the efficient integration of new, low-carbon demand- and supply-side energy resources into the grid. This may involve modifying both (1) utility grid operating protocols and (2) regulatory/incentive signals that frustrate efficient integration of variable, non-dispatchable renewable resources such as wind and solar. Examples of the former include balancing authorities too constricted to capture geographic diversity, and static (vs. dynamic in-hour) scheduling. Examples of the latter include tax incentives and environmental attribute markets that may penalize rather than reward flexible operations of these resources in ways that may adversely affect efficient system operations. These actions are additional to, and interdependent with, new energy management and storage capabilities mediated by Smart Grid tools.

III. Key Transportation and Land Use Actions for 2020

The following Key Actions were developed by reviewing numerous local and regional climate change action plans, and where appropriate, new and enhanced action items were developed. The top 12 Key Actions, our "Clean Dozen," are listed below. While this list represents the T&LU Technical Committee's top 12 actions, many more actions were considered (see Appendix B in the full *Interim Roadmap to 2020* report). The process concluded that most of these actions, including but not limited to the top 12, will be needed to reach our 2020 and 2050 State goals.

1. Change the Way We Fund Transportation (TLU-1)

Develop and deploy a "utility" funding model for State and local transportation infrastructure, transit fleets and operations, and other transportation costs. Such a model should include:

- A base ("capacity") "access" based charge to all who use any part of the system, whether driving, biking, busing, or using goods and services delivered from the system;
- An ("energy") "usage" based charge (i.e., VMT charge) to reflect the amount one uses the system, that includes both the cost of infrastructure and externalities (e.g., airshed pollutant contribution; carbon emissions);
- A ("peak") "congestion" based charge to reflect peak period use of the system.

Oregon has relied for decades on a gas tax applied to light-duty vehicles to fund the State's portion of transportation capital and operating costs (heavy duty freight vehicles pay a weight-mile tax rather than a fuel tax) as directed by the State Constitution. This reliance on the gas tax should come to an end for three reasons. First, the amount of the gas tax is fixed and has declined in purchasing power due to the combined influence of inflation, dramatic increases in transportation infrastructure costs, and the effect of more efficient vehicles. Second, proceeds from the tax are directed constitutionally solely to expensive highway-related costs, leaving other least-cost mobility and accessibility solutions unfunded. Third, transportation charges should be levied commensurate with use of the system (as highway freight charges now are) rather than more narrowly on the amount of fuel used. *A change in Oregon's Constitution will be required to transition to a 'utility' funding model.*

"Utility" rate design evolved from electric and gas utilities as a way to allocate costs fairly and according to use of the system. In the case of transportation, a "utility" design would charge all parties a base or "access" rate because all parties benefit from the system, either by using the highways, buses and trains directly, or relying on them to bring them goods and services.

A "usage" charge would reflect miles traveled in the system and how efficiently those miles are traveled. The usage charge would reflect miles traveled by different modes (e.g., auto, bus, train, bicycle) and the efficiency of the mode (e.g., an average emissions per VMT/passenger for a bus rider; an efficiency rating that might be captured instead as a graduated registration fee within the "access" charge).

A “peak” or “congestion” charge would be triggered when vehicles create congestion, and would reward those who use available real-time traffic information to avoid congested sections of the system at times of congestion (thus avoiding the need to incur additional capital costs of new facilities to accommodate the increased congestion).

This strategy for pricing publicly-supplied transportation services (roads, buses, trains) should: (a) more fairly allocate all costs to users (including land consumption, air pollution and climate impact costs); (b) provide price signals which create incentives for the public to use existing infrastructure more efficiently in meeting their transportation needs; and, (c) lower pollution and emissions per person-mile traveled because of gains in efficiency.

The above action will only work if we can truly define the total cast of the transportation system.

2. Develop New Funding Sources (TLU-2)

Develop new, stable sources of funding for climate-friendly transportation.

It is imperative that every transportation dollar spent move us closer to meeting the State’s greenhouse gas reduction goals. However, Oregon’s current method of funding transportation is inflexible and unstable, and thinly spread funds are insufficient to meet our needs. Oregon has a constitutional requirement to use gas tax dollars on road improvements instead of on a broader suite of transportation alternatives that could achieve “least cost” mobility and access. Oregon is also one of only four states with no sales tax. To make critical investments in transportation infrastructure, operations and programs that will enable us to meet our GHG reduction goals, we need new sources of funding that are diverse, stable, predictable and flexible, as well as moving towards a ‘utility’ based methodology described above. Included in the development of the utility method would be defined approaches for governance, administration, and allocation of revenues generated from the utility rate base. Existing authorities and commissions may not be correctly structured to administer a new rate.

The T&LU Technical Committee did not fully explore the viability or revenue-raising potential of all possible new sources of funding; however, the following have been identified as options in need of future exploration by the T&LU Technical Committee, the Global Warming Commission, the Governor and Legislature, and others:

- Maximizing the use of all discretionary funds (e.g., federal funds for multimodal transportation).
- Offering drivers the opportunity to make a voluntary contribution to an alternative transportation fund to offset the impact of their driving behavior when they renew their vehicle registration or driver’s license.
- Reducing the senior medical deduction for high-income seniors and dedicating savings to Oregon’s Special Transportation Fund to support special needs transit.
- Implementing taxes on the act of parking or imposing a business license tax based on the number of parking spaces a business makes available for employees and the public.
- Dedicating State lottery revenue to multimodal transportation.
- Expanding payroll tax authority and implementing and raising payroll taxes to fund transit.

3. Expand Urban Transit (TLU-3)

Expand Urban Transit to Provide Travel Choices, Reduce Carbon Intensity of Travel, and Curb Vehicle Miles Traveled.

- Expand and improve public transportation infrastructure and operations in the State's urban areas to provide lower carbon intensity travel options that reduce the number of vehicle miles traveled, while meeting the access and mobility needs of commuters, low-income citizens, seniors, disabled persons, school kids, recreationalists, and others who because of circumstance or choice seek public transportation options.
- Extend coverage and/or increase frequency and capacity of urban transit service to urbanized areas with transit-supportive land use policies; shaping the level of service to density factors and density development goals consistent with transit agency policies.
- Provide separated lanes where possible and/or traffic signal priority for public transportation vehicles to reduce travel time, reduce idling, and improve the reliability and operating efficiency of transit service.

The benefits of public transportation are many. At the national level**:**

- Public transportation's overall effects save the United States 4.2 billion gallons of gasoline annually: more than 3 times the amount of gasoline imported from Kuwait.
- Households near public transit drive an average of 4,400 fewer miles than households with no access to public transit.
- Communities that have invested in public transit reduce the nation's carbon emissions by 37 million metric tons annually. This is equivalent to the GHG emissions from all the electricity used by New York City; Washington, DC; Atlanta; Denver; and Los Angeles – *combined!*
- One person switching to public transit can reduce daily carbon emissions by 20 pounds, or more than 4,800 pounds in a year. A single commuter switching his or her commute to public transportation can reduce a household's carbon emissions by 10%, or up to 30% if he or she eliminates a second car.[7]

The Federal Transit Administration has also assessed the carbon footprint of transit agencies and compared their performance to that of other modes.[8] FTA's analysis found that "national averages demonstrate that public transportation produces significantly lower GHG emissions per passenger mile than private vehicles."[9] Analysis specific to TriMet found riders emitting 53% less GHG per passenger mile than the national average for single-occupancy private vehicles.[10]

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[7] Source: http://www.apta.com/mediacenter/ptbenefits/Pages/default.aspx
[8] Source: http://www.fta.dot.gov/documents/PublicTransportationsRoleInRespondingToClimateChange2010.pdf
[9] Ibid., p. 2
[10] Ibid,, pp11-12, with modal emission factors weighted by the modal split of ridership

GHG emission reductions at the community level are attributable to the provision of transit service through three pathways:

- Mode Shift: Benefits from directly shifting trips from more carbon-intensive modes (low-occupancy private vehicles) to less carbon-intensive modes (bus and rail transit).
- Congestion Relief: Benefits through improved operating efficiency of private automobiles, and commercial vehicles, including reduced idling and stop-and-go traffic.
- Land-Use Factor: Benefits produced through transit enabling more compact land-use patterns that promote walking and cycling, shorter and less frequent trips in private automobiles, and reduced private vehicle ownership.

Modeling commissioned by the New York Metropolitan Transportation Authority (MTA), indicates that the MTA helps avoid the emission of 8.24 metric tons of GHG emissions for every 1 metric ton that its own operations emit. This number can and does vary from region to region. Even within the MTA service region (the largest transit-served area in the country), the "avoidance factor" at the sub-regional level varied from about 2 to 20, with 8.24 being a weighted average for the entire region.[11]

While the same modeling has not yet been fully run for TriMet or other Oregon transit districts, initial TriMet analyses using a similar approach suggest an avoidance factor of approximately 1.84 due to mode shift and congestion relief alone. However, this likely substantially underestimates the overall avoidance factor since it excludes the emissions avoided due to more compact development patterns enabled by transit (the most significant factor in the MTA analysis). The "land use factor" is likely to be a significant factor in the Portland region, where much of the documented GHG savings from the transportation and land use sector comes from lowering over time VMT in the Portland region as a result of more compact development within the urban growth boundary. Even without this land use factor being considered, TriMet services reduces nearly two tons of GHGs for every single ton it emits, making the expansion of high-quality, productive transit service a key reduction strategy for GHGs from transportation and land use for urban areas in Oregon.

4. Create Complete Communities (TLU-4)

Require the development and implementation of "Complete Community Plans" for all urban areas that are subject to Comprehensive Planning in the State of Oregon (cities over 10,000).

"Complete Community Plans" (e.g., 20 minute neighborhoods) are intended to meet local aspirations for creating and maintaining livable, vibrant communities that can accommodate a majority of non-work

[11] Sources:
http://apta.com/resources/hottopics/Documents/Executive_Summary_Recommended_Practice_for_Quantifying_Greenhouse_Gas_Emissions_from_Transit.pdf
and
http://www.mta.info/sustainability/pdf/MTA%20Carbon%20Model%20Report%20&%20Presentation.pdf

trips via walking, biking, shared rides, and, where available, public transportation. Complete community plans should include, but not be limited to:

- Higher density, mixed-use zoning and development incentives aligned with public transit and a connected system of "complete" streets that include pedestrian amenities and bicycle facilities (bike boulevards, lanes, parking).
- Parking management plans that limit parking in order to allow more efficient use of land and to balance parking supply with actual demand.
- Land use plans that identify a development and implementation strategy of key community amenities to fit local aspirations for shopping, parks, schools, libraries, public plazas, farmers markets, and other places for people to congregate and meet everyday needs.
- Housing plans that balance housing needs for all income levels and housing types and leverage access to public transit, walking, and bicycles.

Oregon Department of Land Conservation and Development (DLCD) would be responsible for statewide rule-making and review of local comp plans to ensure compliance for complete community plans.

Collective research conducted by Metro during the 2010 Update to the Regional Transportation Plan on trip generation rates shows complete neighborhoods and communities with compact urban form, access to transit and a greater mix of uses generates shorter vehicle trips with a 20-50% reduction in vehicular trips when compared to rates in lower-density, suburban style development. The finding confirms that ITE trip generation rates tend to overestimate automobile trips for compact, mixed-use development patterns. Recent data collection in areas with these development characteristics within the Portland region showed an average reduction of 40 percent between the ITE vehicle trip rates and observed trips.

5. Keep Urban Footprints Compact (TLU-5)

Keep employment and population growth within existing UGBs.

Land within Oregon is considered a finite resource and must serve future generations. In addition to urban needs, the State's lands must serve agricultural, forest, and natural habitat purposes. Therefore, with limited exceptions (i.e., allowing flexibility within UGBs without modifying total urban land supply), we must accommodate residential and employment growth within existing urban growth boundaries by focusing new development on vacant developable land or through infill and redevelopment. This requirement would take effect after December 2012 and exceptions should only be approved for specific uses that cannot be accommodated within an existing UGB or for growth that accommodates integrated transportation and land use planning for complete communities.

Objectives would focus on land conservation and include:

- Strategies to better balance housing and employment within UGBs in order to minimize expansion of urban "travel sheds."

- Brownfield redevelopment. While difficult, efforts to minimize urban footprints by cleaning up and reusing large parcels of mostly vacant land should be accelerated, partnerships fostered, and incentives developed.

- Transit Oriented Developments to better leverage mixed-use high-density development with transit investments.

Comparisons between urban areas that expand land areas and those that restrict urban growth to inside existing growth boundaries show that vehicle miles of travel and GHG emissions can be reduced up to 20 percent over 20 years at growth rates between one to two percent per year.

6. Move Freight the Low-Carbon Way (TLU-6)

Reduce carbon emissions from freight movement in Oregon and help improve the efficiency and cost-effectiveness of freight movement.

The freight community has a number of opportunities to contribute to reductions in greenhouse gas emissions. Because freight movement competes on a regional, national and global scale, policies and programs must be harmonized with other states and countries to avoid unintended consequences. Those low-carbon strategies that offer the greatest potential are those that will both reduce carbon emissions from freight movement in Oregon while helping improve the efficiency and cost-effectiveness of freight movement.

- Improve tools and transparency to accurately show how freight moves through the system in order to improve efficiency of freight movement and infrastructure investment. This includes the development and deployment of Intelligent Transportation System (ITS) elements to inform drivers of existing conditions and route alternatives as well as the collection and sharing of truck trip routing data to identify where operational or infrastructural inefficiencies exist.

- Make strategic investments in multi-modal freight transportation, including intermodal freight transshipment facilities as well as infrastructure capacity to enable cost-effective mode shifting over time from less carbon-efficient modes (e.g., truck, air) to more carbon-efficient modes (e.g., rail) for medium and long-haul freight movement. Ensure such investments are commensurate with and result in an identifiable public benefit (consistent with Least Cost Planning principles) and leverage private investments where possible.

- Site industrial land/facilities along key freight corridors and interchanges, and support and conserve regional significant industrial areas that may provide for future intermodal facilities and efficient local deliveries.

- Implement market-based incentive programs to incent truck and rail fleets to switch to more efficient engines and fuel types and to adopt alternative sources of power (rather than their own engines) to power while idled. Regulation may also be necessary.

- Implement incentive programs needed to increase capture of inbound and outbound freight within Oregon ports' and airports market service areas, thereby maximizing the use of the most efficient modes of freight movement.

- Engage the private sector to determine what shippers are already doing or are looking into resulting in positive emission results and identify those innovations that Oregon could help with implementation support (e.g., shipping practices, vehicle design/aerodynamics, etc.).

Reducing emissions from freight transportation is one area which can benefit from both public and private sector innovation. This combination can also result in benefits in other areas such as safety, reduced infrastructure and operational costs, and reduced conflict between land uses. In Columbus, OH, for example industry, government, and higher education as part of a larger strategy to attract the logistics industry are working to develop green logistics solutions and practices. The primary attraction for these private-sector developments is cost savings, yet they reduce the impact of freight movement. The following examples illustrate the potential:

- In 2009 Wal-Mart implemented a low-packaging strategy to reduce the packaging around many of the products they sell. By doing so they were able to ship more freight on the same truck or rail car than they did before. By the end of 2009, they had increased the number of cases of products shipped by 161 million, yet reduced VMT 87 million miles and gas consumption 15 million gallons.
- Boeing's most recent improvement to its 747 freighter has resulted in a reduction in fuel consumption of 17% per metric ton of cargo and about a 20% reduction in carbon emissions all while carrying 16% more cargo. Alaska Airline is testing bio-jet fuel that significantly reduces emissions.

Knowing and understanding where research and development in logistics practices, equipment manufacturing, and other areas is making advances can shape future policy and programs. Oregon, through policy, its research universities, and partnerships with the freight community can advance the state of the practice and encourage competition and innovation.

7. Embed Climate Change in Transportation Planning (TLU-7)

Embed greenhouse gas mitigation and climate change adaptation goals into least cost transportation and land use planning conducted by state, regional and local governments.

From the overarching Oregon Transportation Plan developed by ODOT to the local comprehensive plans and transportation system plans developed by cities and counties, all levels of government must plan to reduce greenhouse gas emissions, adapt to climate change, and prepare for the inevitable escalation in the cost of petroleum fuels.

State, regional and local governments must align spending programs to support transportation investments that result in reduced GHGs and/or help communities adapt to climate change with the least cost plans. We recommend that:

- ODOT develop and deploy a Least Cost Planning (LCP) model for state and local government transportation decision-making pursuant to House Bill 2001. A robust LCP model, adapted from electric utility LCP, would take a comprehensive approach to solving transportation problems along the sustainability triple-bottom-line of the economy, the environment, and social equity. It should consider how to affect transportation demand as well as transportation supply. It considers all direct and indirect costs on a lifecycle basis. "Cost" should include not only the up-front price of an option, but also costs that can be quantified (like congestion and GHG emissions) and costs that are qualitative in nature (like equity). It should compare the benefits and costs of a variety of solutions and ranks them according to cost-effectiveness or benefit/cost ratios. It ensures that solving one transportation problem doesn't exacerbate another transportation problem. Oregon's LCP model should incorporate GHGs as a hard constraint; in other words, when applying LCP, GHGs must not exceed a specific emissions level related to metropolitan area or statewide GHG reduction targets.
- LCDC incorporate GHG reduction goals into the Statewide Land Use Planning Goals and align existing VMT reduction requirements with GHG reduction goals.
- LCDC and DLCD develop and incorporate climate change adaptation risk assessment and planning and Statewide Land Use Planning Goals.
- ODOT incorporate GHG reduction goals and strategies to meet those goals into all modal plans (Oregon Highway Plan, Oregon Rail Plan, etc.) as they are updated, utilizing the statewide strategy for reducing GHG emissions from transportation sector being developed pursuant to Senate Bill 1059.
- Local governments, MPOs, and the State work cooperatively, as financing is available, to develop, adopt and implement scenarios to achieve their transportation-related GHG targets, using strategies that best fit their communities. This would occur once ODOT and DLCD have completed their Senate Bill 1059[12] requirements to develop a statewide strategy to reduce GHG emissions from the transportation sector, set targets for reduction of GHG emissions from light vehicle travel for the State's six major metropolitan areas, develop guidelines for scenario planning, develop a toolkit to assist local governments in reducing GHGs from transportation, develop rules for Complete Community Planning, and educate the public about the costs and benefits of reducing transportation-related GHG emissions.
- Utilize newly developed GHG accounting and reporting methods, which include lifecycle carbon emissions (i.e. construction energy), operations (vehicle miles traveled and flow) and maintenance, in all planning efforts.

8. Expand Intercity Transportation Options/Choice (TLU-8)

Provide efficient and reliable intercity transit, with higher-speed rail as a central component.

[12] ODOT and DLCD are currently working with local governments, agencies and stakeholders to develop a Statewide Strategy for Transportation for Oregon, as required by SB 1059. The strategy will serve as a foundation for LCDC's rulemaking on GHG targets for light duty vehicles within MPO areas. Technical and policy committees were formed or are being formed to advise OTC and LCDC on the strategy and rulemaking. The recommendations in this report are not intended to conflict with the outcome of that effort; rather the intent is to enrich it.

Passenger rail and other fast, reliable intercity options are essential components of a low-carbon transportation future. We recommend that the State:

- Pursue its near-term plan (by 2017) to increase train speeds between Eugene and Vancouver, BC to 110 mph, improve on-time performance to 95 percent, pave the way for additional daily roundtrips to be added in the future, and consider switching to electric power for the route, potentially using solar panels on the state-owned right-of-way to help provide the electricity. These improvements could triple ridership on the Eugene to Portland segment reducing the State's CO_2 emissions by nearly 70,000 pounds a year[13] and laying the groundwork for eventual high-speed service.
- Explore other opportunities for commuter rail and long-distance passenger rail.
- Link Oregon communities not served by passenger rail via intercity bus service.
- Build stations in the right places, where passengers have access to a variety of transportation options for completing their trip and where passenger rail can provide a catalyst for transit-oriented development.

Passenger rail travel currently emits 60 percent less CO_2 per passenger mile then cars and 66 percent less than planes.[14] Newer locomotives are becoming even more efficient, and switching rail lines from diesel to electric power could reduce GHG emissions even further. We need to think big—imagine all major U.S. cities within 100 to 500 miles of each other linked by true high-speed rail by mid-century. Here in the Pacific Northwest, the Amtrak Cascades line between Eugene, Portland, Seattle and Vancouver, B.C.—which is less than 500 miles from end to end and where ridership has increased eight-fold over the past 15 years—is particularly ripe for substantial investment. While this corridor should be the initial focus of our high-speed rail efforts, other corridors can be served by lower-speed passenger and commuter rail; and all communities not served by rail must be linked with frequent and reliable intercity bus service.

9. Reduce Demand by Increasing Options (TLU-9)

Implement cost-effective Transportation Demand Management (TDM) programs that increase use of travel options. TDM is a quick, inexpensive approach to reducing the number and length of drive-alone trips.

Nationwide, agencies have been successful at reducing drive-alone trips by adopting demand reduction targets, then implementing community-appropriate strategies to achieve the target. But Oregon currently lacks statewide and regional TDM strategies with clear goals, roles and funding. An effective TDM program would:

- Reward ODOT, MPOs, cities, counties and transit agencies that establish 2020 Demand Reduction targets and implement strategies to achieve the targets.

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13 Oregon Department of Transportation, Rail Division, *High-Speed Rail/Intercity Passenger Rail Service Development Plan*, 2 October 2009.

14 Center for Clean Air Policy and Center for Neighborhood Technology, *High Speed Rail and Greenhouse Gas Emissions in the U.S.*, January 2006.

- Develop and market a new Statewide Rideshare Online program, a tri-state advanced ridesharing program for personal and commercial car sharing. Involve private sector and marketing experts in the development. Offer incentives for participation.
- Develop and implement "Corridor TDM" programs in large new transportation construction projects. ODOT, local agencies and employers collaboratively provide corridor users information and incentives to carpool, vanpool, use transit, walk, bicycle and telecommute. Similar programs have proven effective, reducing drive alone trips 8 – 13%.
- Provide baseline funding for TDM programs in jurisdictions with major employers and ongoing congestion programs, similar to WSDOT's successful Commute Trip Reduction (CTR) program.
- Provide incentive funds for a competitive, performance-based TDM program, open to local agencies and private sector employers and entrepreneurs who prove measurable trip reduction, similar to WSDOT's successful Trip Reduction Performance Program.
- Reduce or eliminate government-supported parking subsidies.
- Reward local agencies that implement Transportation Management Plan (TMP) standards for large and mid-sized new development projects. Developers and/or project owners provide employees and residents information and incentives to use travel options.
- Expand the use of local transportation management associations and parking management districts to coordinate TDM and parking programs.
- Support companies in setting up and marketing Peer-to-Peer (P2P) car sharing. P2P car sharing enables owners of underutilized vehicles to add their cars into a P2P network during certain hours for other members to use for an hourly rate. Example companies include relayrides.com and spride.com.

10. Manage and Price Parking (TLU-10)

Encourage less single-occupancy vehicle travel and less travel during peak periods by implementing one or more parking management strategies.

We recommend the following:

- Charging for parking.
- Modifying existing parking charges by eliminating discounts for daily or monthly parking, structuring parking fees to reflect peak period use, and/or setting hourly rates higher once a certain number of hours have passed.
- Requiring employers to offer employees a "parking cash-out" option where the employee can choose the parking benefit or the cash equivalent of the benefit.
- Impose a business license tax based on the number of parking spaces a business makes available for employees and the public to encourage more efficient use of land.
- Develop shared parking policies and practices.

99% of automobile trips end in a free parking spot. But neither land nor pavement are free, and the availability of free or heavily subsidized parking encourages driving. When designed in conjunction with other land use and pricing measures, parking pricing policies and parking management policies can ensure the appropriate supply of parking for a given area while encouraging carpooling and trips by other modes. Studies conducted by the US EPA of various employee parking programs found a 12-39% reduction in vehicle miles traveled and a 66-81% reduction in single occupancy vehicle trips to worksites. Similarly, the studies found community-wide pricing programs resulted in a 19-31% reduction in vehicle trips.[15]

11. Support Electric Vehicles (TLU-11)

Deploy an Oregon Electric Vehicle (EV) Strategy designed to double the 2020 National level (estimated at 5% of total fleet) of light duty vehicles registered in Oregon qualifying as electric or plug-in electric vehicles. [16]

Accomplish this through:

- Creation of a new Transportation Electrification Tax Credit (TETC) for electric vehicles and infrastructure, as recommended by the 2010 Working Group (Governor's Alternative Fuels Advisory Committee).
- Incentives such as tax credits and feebates for EV purchases including freight vehicles.
- Tax credits and other incentives to fund EV charging stations and infrastructure in residences, work places, and public places.
- Incentives for and investments in electric vehicle fleet purchases and set EV purchase standards for government fleets.
- Redesign urban streets to accommodate and encourage deployment of low-speed electric vehicles (including two and three-wheeled EVs).
- Deployment of smart grid technology for EV charging by 2020 to significantly reduce the need for utility infrastructure upgrades.

Use of electricity for powering vehicles will reduce harmful emissions and promote sustainable mobility. In Oregon, our electricity partly comes from renewable sources but also coal and natural gas. Nonetheless, powering vehicles with electricity produced from any of our energy sources is more efficient than using gasoline powered engines. According to the US Department of Energy, electric motors convert 75 percent of the chemical energy from the batteries to power the wheels, while internal combustion engines (ICEs) only convert 15 to 20 percent. Even with energy losses at the power plants and through transmission, electric vehicles are producing considerably less GHG emissions than internal combustion engines. As the percentage of renewable energy sources increases, the benefits of electric vehicles will also increase.

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[15] US EPA (1997) "Opportunities to Improve Air Quality through Transportation Pricing Programs

[16] The EC-Vehicle Electrification Roadmap, published in 2010, projected a 5% by 2020 national target.

While EVs are a substantial improvement over internal combustion engines, driving EVs in the next decade is not a "cure-all" and will still contribute to GHG emissions; therefore, promotion of EVs needs to be integrated with other strategies to most efficiently meet GHG targets.

12. Adopt Low-Carbon Fuel Standard (TLU-12)

Ensure an Oregon low-carbon fuels market through adoption of a low-carbon fuel standard and local production of sustainable biofuels.

The Oregon Department of Environmental Quality is currently undertaking rulemaking to adopt a low carbon fuel standard. The low-carbon fuel standard will require providers of transportation fuels to reduce the carbon intensity of the fuel mix they deliver to Oregon by at least 10% over a 10 year period. This will grow Oregon's clean energy industry, from electric vehicle manufacturing to cellulosic biofuels; discourage unclean energy investments, such as fuel from coal-to-liquids and oil produced from tar sands and oil shale; reduce Oregon's dependence on imported oil, keeping more money in the State; and reduce the sensitivity of Oregon's economy to oil price uncertainty and shocks resulting from refinery outages, cartel actions or disruptions in world oil supplies. The rules will apply only to major transportation fuels, allow for a phased-in schedule, provide quality assurance, and allow deferrals and exemptions as necessary to ensure adequate fuel supplies.

- The DEQ rulemaking needs to be completed with accurate GHG intensity methodologies that reduce life-cycle carbon impacts of Oregon's fuels.
- Current statutory authority expires in 2015; this "sunset" needs to be removed so that long-term market stability encourages investments in fueling, vehicles, and local fuel production.
- Companion actions are needed to increase state and local support for building in-state fuel production and processing infrastructure, which studies indicate will have major benefits for rural Oregon economies.

Oregon's overwhelming dependence on petroleum as a single feedstock for its transportation fuels leads to volatility in prices and high GHG intensities throughout the transportation sector. One essential component for Oregon to reduce its GHG emissions in the transportation sector is to reduce the GHG intensity of transportation fuels. Providing diversity in sources of transportation fuels will reduce the volatility in prices, increase new economic opportunities for the development of in-state production of liquid fuels, and do this while reducing GHG emissions statewide.

A low-carbon fuel standard requires all providers of transportation fuels to meet a declining standard for GHG-intensity of its fuels. HB 2186, passed by the 2009 Legislature, established these requirements in Oregon through 2015. The Department of Environmental Quality is developing the rules to implement the market mechanisms that will allow complying entities to most cost-effectively meet the GHG intensity reductions of the fuels they sell. Innovations in biofuels, and emerging replacement fuels, such as electricity to power electric vehicles, will likely play a major role in the State's effort to meet these important standards.

IV. Key Industrial Use Actions for 2020

To accomplish GhG reductions of 10% below 1990 levels by 2020 requires a 29% reduction from 2005 emissions levels across all sectors statewide. To accomplish this the following actions must be taken to accelerate industry use of efficient technology and practices: align and motivate industry leadership around greenhouse gas emissions reduction goals, as well as improve streamlining and provide additional access to financing and incentives. Water use is an important component of the energy use of many industrial processes, and increases in water efficiency should also be part of the greenhouse gas emissions reduction strategy. Attention must be paid to development of the industrial workforce required to assure the capacity to lead substantive industry process change.

1. Accelerate use of energy efficient technology and practice (IU-1)

Energy efficiency in boilers, thermal systems, motors and drives, refrigeration, air compression, lighting, materials handling and best design, operations and maintenance practices are not in widespread use in industry. The Northwest Power and Conservation Council identified in their Sixth Power Plan some 700 average megawatts of cost-effective known electric energy savings potential in Oregon. An estimated 200 average megawatts of that potential is in industry. The Energy Trust of Oregon is on track to accomplish nearly half or 300 average megawatts of that potential over the next decade, but from all market sectors including residential, commercial, industrial and new construction. Additional services and resources and approaches are called for to directly target Oregon's large industrial facilities and Oregon's other large greenhouse gas emitters such as universities and hospitals. Natural gas energy savings technologies in boiler systems and many direct use thermal improvements are known and proven. The Energy Trust of Oregon has accomplished 21 million therms per year of natural gas savings through their efficiency programs to date. However, most of those savings can be attributed to commercial uses. Oregon's industrial energy efficiency service programs for natural gas focus on utility purchasers of natural gas while a larger proportion of industrial natural gas is purchased through pipeline contracts and not subject to public purpose charge incentives or organized services. This larger source of GhG emissions needs to be addressed through development of GhG metrics by industry, services and expertise from higher education, and focusing incentives, resources and financing options on these large GhG emissions. A comprehensive combined heat and power initiative has not been delivered in Oregon and evaluation, planning and implementation of one will result in significant reductions of GhG in Oregon's largest industries.

- Implement an aggressive boiler and direct natural gas efficiency initiative targeting industry.
- Provide additional cross-cutting industry efficiency training, analysis and implementation technical assistance.
- Provide support for distributed generation; assess and initiate industry wide combined heat and power evaluations and support investment; assess and initiate industry wide distributed renewable generation scoping studies and investment.

2. Establish GhG leadership recognition program (IU-2)

Focused and deliberate planning and implementation of GhG reduction strategies needs to be understood as value-added by industry leadership. Recognition and "branding' of early commitment to effective GhG reduction needs to support that understanding, commitment and progress. Oregon has not historically engaged, nor fully supported, industry sectors to share best practices, identify benchmarks or determine the needed services to accomplish meaningful and valuable GhG reductions though energy efficiency and other measures. The Northwest Food Processors Association has begun to provide the planning, services and recognition to their members who have formally adopted energy intensity reduction goals. That effort is proving results and the lessons learned will benefit other industry sectors. Implementation of an industry "Leaders" program (detailed in box below) will be essential to the success of these actions. The committee believes an industry "leaders" approach will be critical to the success of any regulatory accomplishment of Oregon industry GhG reductions as well, should they be considered. Recognition for industries that are successful and on track with GhG intensity or overall reductions will be essential as well. National and international expert assistance with the planning, initiation and implementation of industry sector (pulp and paper, wood products, steel, microelectronics, chemicals, metals casting) goals, plans, benchmarks (metrics) and practices needs to be coordinated and facilitated with industry leader participation.

- Create a recognition, branding and marketing "Oregon Top Twentieth" or "Leaders" program that includes primary industry and the services. Integrate into Oregon marketing programs (see box below).
- Assign State government to focus goals and action implementation on the top nine emissions and top ten industry sectors.

Details of "Leaders Program" of Industry Support and Recognition "Leaders" program

This program would seek a long term commitment and goal from industry CEO's and would coordinate the long term strategy and support that will help each company reach its goal. This program would be high profile and would include elements of public relations, marketing and executive-to-executive forums to create a network of business leaders.

Resources from organizations like Oregon Department of Energy, Energy Trust of Oregon, Northwest Energy Efficiency Alliance, the Climate Trust, Climate Solutions, Northwest Food Processors Association, Oregon Business Council, Associated Oregon Industries, Northwest Natural Gas, US Department of Energy and others would be coordinated to develop, fund and manage the program. A minimum of 5 years of intense assistance would be committed to participating facilities, tied to a multi-year plan created for each facility upon joining. Long-term commitment by federal, state, local and utilities to providing industry assistance is critical to assuring industry's active participation and progress towards GhG emissions reductions.

Projected launch date would be June 2011 and would target high gas consumption facilities but would be open to any industrial company. Characteristics of the GHG Leadership program include:

1. Would be completely voluntary but would require CEO (or equivalent) signature to participate

2. High profile and include PR, news releases, Oregon Governor, etc.
3. Targeted at large carbon emitters (directly or indirectly)
4. Requires participating companies to sign an agreement to target either reduction of carbon emissions by 10-25% over 10 years or to reach the top x percentile in their industry within x years – go beyond what is required
5. Initial 10 companies would sign an MOU with the Governor and CEO's from US DOE, ETO, NEEA, BPA, etc
6. Support would be coordinated beforehand by all signing organizations so that a clear and concise package was offered to those signing
7. A resource would be assigned to each company to develop the strategy for the company as well as coordinate resources and paperwork from all supporting organizations
8. Progress would be tracked by individual companies and would be shared through secure data collection.
9. There would be a six month check-in with the Governor and signing CEO's
10. There would be a one year dinner and award with all participants
11. Goals would be to get 10 companies within 3 months, 35% of targeted companies within 2 years and 80% within 10 years
12. Support would include management, technical, business, renewable energy, waste recover and emission reduction
13. Initial efforts would include CEO to CEO roundtables and discussions, development of the MOUs and development of the "support" package

3. Improve access to financing and incentives (IU-3)

Oregon financing and incentives have not directly targeted GhG emissions reductions. Energy efficiency and renewable resource incentives and finance have resulted in GhG reductions. Oregon's largest industrial natural gas uses are not eligible for public purpose charge incentives or services. Access to GhG specific incentives and financing will help industry to set goals for reductions while providing ready, assured, fixed rate and terms finance. Coupled with focused cross-cutting technology knowledge, service and implementation assistance, bond backed financing of industrial GhG reduction efforts will improve industry profitability, provide employment and sustain accomplishment of industry GhG emissions reductions.

- Maintain and expand state incentives and financing that target industry GHG.
- Review, evaluate and adopt the most effective emerging or innovative funding mechanisms, particularly those that leverage private dollars
- Increase Energy Trust of Oregon (ETO) initiatives for industry.
- Encourage congressional delegation to expedite energy legislation with expansion of investment tax credit to GHG.

4. Build human capacity to innovate and execute industry process improvements (IU-4)

Perhaps the most significant opportunity to reduce Oregon industry GhG emissions and improve their global competitiveness is through significant changes in industry processes. Facilitated by USDOE, the pulp and paper, steel, wood products, biotechnology and microelectronics industries have partnered to identify fundamental changes in materials transformation (see Appendix B in the full *Interim Roadmap* report for examples) and production resulting in substantial energy savings and GhG reduction. These changes are essential for industry to begin to address the challenges of meeting the 2050 goal of 75% GhG reduction from 1990 levels. Engaging higher education in providing technical assistance to Oregon's industries will both provide needed services now and prepare the future workforce for the daunting task(s) of implementing these fundamental changes. Drawing upon national "Roadmaps" for specific industries, engaging the national laboratories and using all possible federal resources (Commerce, Energy and Environmental Protection) will require planning, concerted human resources, curriculum emphasis and further technology research and application. Developing the science to where industry is confident of outcomes and supported technically in applications will be critical.

To accomplish these actions, a planned partnership of industry, state government, industry associations and utility efficiency advocacy groups must be developed and effectively managed. Energy efficiency technologies and practices are believed to be capable of providing cost effective approaches to accomplishing the 2020 reduction goals. Substantive industrial process changes or new CO_2 free energy sources will be required for savings past that threshold to meet the 2050 objective of having all industrial GhG emissions at 4 MMTCO2e.

- Develop Oregon industry specific plans and roadmaps for 2020 and 2050.
- Partner with industry to direct multi-discipline teams from agencies and higher education to develop a center of excellence to help industry sectors.
- Build lean manufacturing practices into standard engineering programs at state universities and community colleges.

V. Key Agricultural Actions for 2020

Each of the priority actions described below requires capacity, commitment, and funding for ongoing research, outreach and easily accessible incentives and financing. Without capacity, commitment and funding, the change that is possible in Oregon agriculture to reduce GHG emissions and adapt to climate change will not be realized. In a time of shrinking budgets, this means that budgets for university and local resource provider staff to do research and outreach, and for incentives and financing for GHG reduction, carbon sequestration and climate change adaptation must be increased.

1. Increase Nutrient Use Efficiency (AG-1)

- Create targeted research, outreach programs, technical assistance and tools that increase nutrient use efficiency in Oregon agriculture.
- Research soil emission coefficients to establish baseline and future emissions data.
- Create an initiative to identify strategies and actions to close the nutrient loop (better utilize all organic materials, urban and rural, for plant nutrition and building soil quality). Bring together waste management industry and agricultural industry to determine how to more efficiently use organic materials in an economically viable way.

2. Increase Carbon Sequestration in Crop Management (AG-2)

- Determine irrigated soil carbon sequestration rates.
- Encourage practices that sequester carbon in the soil and build soil quality.
- Increase outreach and incentives to protect and restore native vegetation, habitats and riparian areas along agricultural lands.

3. Develop Manure to Energy Methods (AG-3)

- Develop low-cost technology, incentives, offsets and technical assistance to significantly increase adoption of methane capture and digester technology for all size animal operations.

4. Proactively Prepare for and Adapt to Climate Change Impacts on Water Supply (AG-4)

- Promote irrigation efficiency.
- Help facilitate water storage projects at all scales that are protective of Oregon's watersheds and natural resources.

VI. Key Forestry Actions for 2020

The following Key Actions were developed in part by reviewing various local and regional Global Warming plans and developing enhanced recommendations where possible. The remaining actions are included in the full *Interim Roadmap to 2020* report (in Appendix A of the Forestry chapter).

- Establish a Carbon Inventory for Oregon Forests
- Pursue Reforestation/Afforestation
- Invest in Key Research Actions - impacts of climate change, adaptation tools, and benefits of durable products
- Advance Energy and Forest policies supporting biomass facilities

Overall goal: Between 2010 and 2150[17]*, no net loss of Oregon forested lands and a net gain in carbon storage in an amount to be determined.*

Oregon's forests are a carbon sink, capturing more carbon than they release. As such, Oregon's forests and its forest sector have and will continue to contribute to the goal of achieving reductions in greenhouse gas emissions by remaining a robust and sustainable sector in Oregon.

1. Carbon Inventory (FY-1)

- Establish a carbon inventory for all Oregon forests. This will require a collaborative effort to define and develop an agreed upon approach for developing and maintaining a carbon

[17] The effects of actions in the forestry sector are realized over many decades. We recommend 2150 as the end-date for the Commission's Forestry vision rather than 2050 to communicate the time-scale differences between this sector and the others that make up Oregon's carbon reduction management strategies.

inventory system. Based on these data, establish baselines and both long-term and intermediate goals for carbon storage, for different forest types and ownerships, including overall storage gains in public forests.

2. Reforestation/Afforestation/Acquisition (FY-2)

- The Federal government, the State and Oregon communities should seek reforestation opportunities on lands previously forested, irrespective of ownership.

- The Federal government should assure sufficient resources for reforestation on Federal forestlands.

- The Federal, State, Local, and non-profit sectors should seek to acquire forestlands that can be conserved, restored and managed.

- Afforestation opportunities should also be sought and welcomed, but should be carefully evaluated for unintended consequences to ecosystem values before proceeding (e.g. "planting of non-native trees rather than natives").

3. Research (FY-3)

- Oregon Climate Change Research Institute and the Oregon University System should collaborate with the Federal and State Government and private land owners to project and map actual changes in the productivity, function, and fire susceptibility of Oregon's forested ecosystem as well as changes in the geography of forest biodiversity that are anticipated from changes in climate.

- A significant effort within the broader scientific community should be given to identifying a comprehensive set of features, across sectors, predicted to be affected by changes in climate and their impact on carbon storage. These features or indicators should become the focus of status and trend monitoring to inform adaptation planning at local and regional levels.

- Oregon Department of Forestry, Department of Environmental Quality, and stakeholders, in collaboration with the Oregon University System and identified experts, should develop a strategy for use and reuse of durable forest products, along with carbon sequestration/gain values that may accrue.

- Oregon University System, in collaboration with other relevant research entities, will support the research and design of information and tools necessary to support the carbon inventory system outlined above in Key Action FY-1.

4. Biomass (FY-4)

- State of Oregon energy and forest policies and tax incentives should encourage landowners to develop fores**t** and range biomass production capabilities supporting biomass energy facilities where this can be done consistent with or enhancing ecosystem values.

VII. Key Materials Management Actions for 2020

The following Key Actions were developed in part by reviewing various local and regional Global Warming plans and developing enhanced recommendations where possible. The remaining actions are included in Appendices A and C in the full *Interim Roadmap to 2020* report.

1. Advocate for carbon price signal across life cycle of products and materials (either by an emissions cap and/or a carbon tax), including imports (border adjustment mechanism/carbon tariff if necessary) (MM-1)

The Commission should advocate for policies that incorporate a carbon price signal across the life cycle of products and other materials. A price on carbon across the full life cycle (resource extraction, manufacturing, transport, use, and end-of-life) offers the potential for significant reductions in greenhouse gas emissions associated with the life cycle of products and materials.

The Materials Management Committee did not evaluate the relative advantages and disadvantages of capping emissions (either via "cap-and-trade", "cap-and-dividend" or some variation) vs. taxing emissions. However, given the global nature of many supply chains, and keeping with the Committee's vision of not penalizing Oregon or other domestic producers (relative to foreign competition), it will likely be important to apply a "border adjustment mechanism" to help ensure a level playing field. This mechanism, often discussed in the form of a carbon tariff, adds to the price of products that are made in locations whereby some or all of their upstream emissions are not covered by a carbon cap and/or tax.

2. Conduct research to develop a consumption-based GHG inventory and inventory methodology; consider integration with State's conventional inventory, identify high-carbon product categories (MM-2)

One of the fundamental challenges facing materials management programs and policies is the manner in which greenhouse gas emissions are typically inventoried, and how these inventories are subsequently communicated and used. Inventories typically focus on emissions inside the geographic area, although they often adjust for electricity used (even if the production of the electricity occurs elsewhere). Materials management contributes significantly to emissions – 42% of domestic emissions by EPA's estimate – but many of the emissions go uncounted in state and especially in local inventories. As a result, the nexus of materials management and greenhouse gas emissions reduction has generally suffered from benign neglect. The Commission's 2020 Vision project and the establishment of the Materials Management Committee is a notable exception, but the field still suffers from challenges associated with emissions accounting.

One potential solution that has attracted interest in the last few years is consumption-based accounting. DEQ already has a project underway to develop a consumption-based GHG inventory for Oregon. This project has several limitations, including that it is a first-generation model (Oregon is the first community in the U.S. to undertake such an inventory), is limited to the year 2005, and may not be readily usable by local governments in their climate action planning efforts. Further, it isn't yet clear if consumption-based accounting can be integrated with the State's conventional inventory, what the limitations of consumption-based accounting are, and what would be required to conduct a consumption-based inventory in future years.

DEQ should complete this project, and then the Global Warming Commission should convene a workgroup to review the State's GHG inventory and consider if and how consumption-based accounting could be integrated into it. (A separate workgroup convened by DEQ, including a representative from the Commission, met in September and October of 2010 and reviewed DEQ's draft consumption-based inventory and this will inform DEQ's next steps.)

Also, one of the benefits of consumption-based accounting is that it provides information on the GHG intensity and emissions associated with different categories of consumption, including different categories of products and materials. This could be very useful for the purposes of policy and program development and implementation. DEQ's current effort will provide a screening-level evaluation of different products and materials; to be widely accepted, these results will likely need verification via process life cycle assessments/carbon footprints or some other method, thus requiring additional effort.

3. Develop and disseminate information: easy-to-use life cycle metrics for different food types (MM-3)

The State should develop and disseminate information that will aid consumers and retailers in food purchasing decisions. Foundational data would help to disseminate estimates of the industry-average "carbon footprint" for different types of foods, as well as for key variables in the life cycle of those foods. For example, tomatoes may have different greenhouse gas impacts depending on whether they are grown in soils or hydroponically, what soil conditions they are grown in, how they are fertilized, whether they are grown in greenhouses, how the greenhouses are heated, how the tomatoes are packaged, and how and how far they are transported to market. Knowing the relative contribution of each life cycle stage and also the relative impact (or lack thereof) of these variables would spur better decision-making and reduce the current state of confusion. Fortunately, extensive research has already been undertaken (and more is underway) on estimating the carbon footprint of many different common foods. This foundational life cycle-based GHG data could be summarized and made available in several different formats, such as a website, a cell phone application, or even displayed in retail stores using simple color-coded carbon footprint indicators or wallet cards listing the "top 10" carbon-intensive food products. This information can aid retail buyers trying to make better purchasing decisions.

4. Standards, incentives, and/or mandates for carbon footprinting, labeling of products (MM-4)

Carbon footprinting refers to the act of evaluating the greenhouse gas emissions associated with the life cycle of a product. Products can be both consumer goods and also products or materials sold business-to-business. Carbon footprints can be shared with customers either indirectly (on request, akin to a material safety data sheet) or via a carbon label (akin to a nutrition label) printed on the product or its packaging.

Carbon footprinting and/or labeling is believed to reduce GHG emissions in several ways. First, as the producer examines the greenhouse gas emissions associated with a product, it gains better understanding of the causes of these emissions and opportunities to reduce them. Second, knowing that customers (consumers, other businesses) may use the carbon footprint (or label) in product selection, producers are incented to reduce their emissions. Finally, customers may use the footprint or label to reduce the GHG emissions associated with their own purchases.

The State should advocate for and/or adopt standards, incentives, and/or mandates for carbon footprinting and/or labeling.

- *Standards* refer to the accounting methods or rules that guide the actual analysis and reporting. Good standards provide for carbon footprints that are comprehensive, meaningful, clear, and transparent. Two existing standards include the PAS 2050 carbon footprint standard (developed by BSI British Standards on behalf of the UK Department of Environment, Food and Rural Affairs and the Carbon Trust) and the newly-developed Product Life Cycle Accounting and Reporting Standard (developed under the GHG Protocol Initiative, and currently being pilot-tested). ISO also has plans to develop a carbon footprint standard.
- *Incentives* at the state level may take the form of tax credits, preferential state purchasing, recognition/promotion, and/or regulatory relief.
- *Mandates* would require certain products sold into Oregon (regardless of location of production) to have an associated carbon footprint and/or label. This could be viewed as a form of product stewardship.

5. Focus product stewardship on upstream emissions, and design for appropriate durability, repairability, reusability, efficiency, and recovery (MM-5)

Product stewardship is an environmental management strategy in which all parties involved in the design, production, sale and use of a product take responsibility for minimizing the product's environmental impact throughout all stages of the product's life. The greatest responsibility lies with whoever has the most ability to affect the life cycle environmental impacts of the product.

Recent examples of product stewardship in Oregon are the Oregon E-Cycles program and the PaintCare program. While both of these examples focus on the stewardship of products at end-of-life, there is strong interest in applying product stewardship principles to the full life cycle of products, particularly where upstream impacts are large. Recommendation #4 (carbon footprinting, labeling), above, is an example of product stewardship incorporating an "upstream" focus.

Oregon should apply the principle of product stewardship to mandate reductions in full life cycle greenhouse gas emissions, upstream and downstream. In most cases, upstream emissions dominate, so the focus of this recommendation is primarily upstream (in contrast to recommendation #28 in the full

Roadmap document, which focuses downstream).[18] The policy might also mandate or incent "upstream" design changes by producers that reduce life cycle greenhouse gas emissions through changes such as making products more durable, repairable, reusable, or efficient. While these attributes generally reduce greenhouse gas emissions, care must be given to optimizing actual emissions reductions; for example, designing a product to last for 50 years when the average consumer replaces it every 5 years may actually increase emissions. So while these attributes should inform policy, the policy should be designed to achieve a holistic reduction in greenhouse gas emissions.

The details of this policy approach are undefined but should be developed as the next step in implementing this recommendation. At the highest and simplest level, one conceptual example involves requiring producers of stewarded products to evaluate the life cycle greenhouse gas emissions associated with their product (see recommendation MM-4), and then to achieve an emissions reduction goal by a certain date in the future.

6. Establish higher standards for new buildings: "net zero" plus offset of materials (MM-6)

"Net zero" energy buildings are those that produce all of the operational energy used by the building in any given year. The State should establish higher standards for new buildings, combining net zero operational energy with a carbon offset program to account for the life cycle GHG impacts of the materials used in the building.

7. Provide information and outreach to consumers on product impacts and opportunities to reduce those impacts (MM-7)

Some Oregonians seek information on how they can reduce their personal (or businesses') contribution to global warming. The choice of products, as well as how those products are used, contributes significantly to global warming, and so should be part of any outreach effort by the State.

Outreach can take several forms. The Global Warming Commission, along with State agencies, can provide information on how different products contribute to global warming, and what some of the opportunities are to reduce those impacts. Other organizations might take a more active role in promoting specific actions. Where appropriate, outreach should use principles of social marketing (e.g., the use of commitments and norms), and highlight co-benefits.

8. Reduce (prevent) waste of food at the retail and consumer level by 5-50% (MM-8)

By one estimate, food waste in the US has increased from 30% of the available food supply in 1974 to almost 40% in recent years; in 1974, approximately 900 kcal per person per day was wasted, whereas in

[18] For example, among domestic GHG emissions, roughly 42% of emissions are associated with the life cycle (excluding use) of products and other materials; less than 2% (of the total) are associated with end-of-life management; the remaining 40% are "upstream," associated with production and transport.

2003 Americans wasted ~1,400 kcal per person per day.[19] The majority of food waste occurs at the consumer level. Some food waste is composed of the non-edible portions of food, but there is also a significant amount of edible food wasted. Reducing (preventing) the waste of food reduces GHG emissions across the entire life cycle.

Meal planning, food storage, and proper food preparation practices are some ways to reduce food waste. At the retail level (including both markets and food service operations), better forecasting, inventory control, food storage, portion control, and reutilization offer opportunities to reduce food waste.

An effective strategy to reduce food waste first requires a better understanding of the causes of food waste. The literature suggests dozens of different reasons, from social norms and financial pressures faced by consumers to agricultural subsidies creating a "supply push" effect, whereby increased food availability and marketing results in Americans being unable to match their food intake with the increased supply of cheap, readily available food. As a first step, the State should undertake additional research to better understand the root causes of food waste and better evaluate actions the state and others could take to reduce it. The State should then implement new programs, as informed by this research, to reduce the waste of food.

9. Conduct research on highest/best use for organic wastes and waste to energy and the carbon impact of different conversion technologies (MM-9)

The State should conduct, or support, three related but separate research projects. First, there should be a review of methods (aerobic composting, anaerobic composting, anaerobic digestion, wastewater disposal, landfill disposal, incineration, etc.) for managing organic wastes. The evaluation would consider both greenhouse gas impacts as well as other environmental considerations. This evaluation would inform a variety of policy and program efforts, including future discussions on a potential ban on landfilling of putrescible wastes such as food.[20] Second, there should be a review and evaluation of the greenhouse gas impact of conversion technologies (pyrolysis, gasification, etc.), including a comparison of the impacts to other disposal and recovery options. Third the State should develop guidelines and recommendations for appropriate use of waste to energy technologies that protect the environment and health and avoid unintended consequences. This information would help guide policy and program development by State and local agencies, and would also inform investment decisions by industry.

[19] Hall KD, Guo J, Dore M, Chow CC (2009) The Progressive Increase of Food Waste in America and Its Environmental Impact. PLoS ONE 4(11): e7940. doi:10.1371/journal.pone.0007940.

[20] This was discussed as an alternative by the Materials Management Committee but not recommended. Rather, several Committee members suggested that it be further evaluated.

Update on Global Warming Commission Activity

I. Summary of Commission Activity

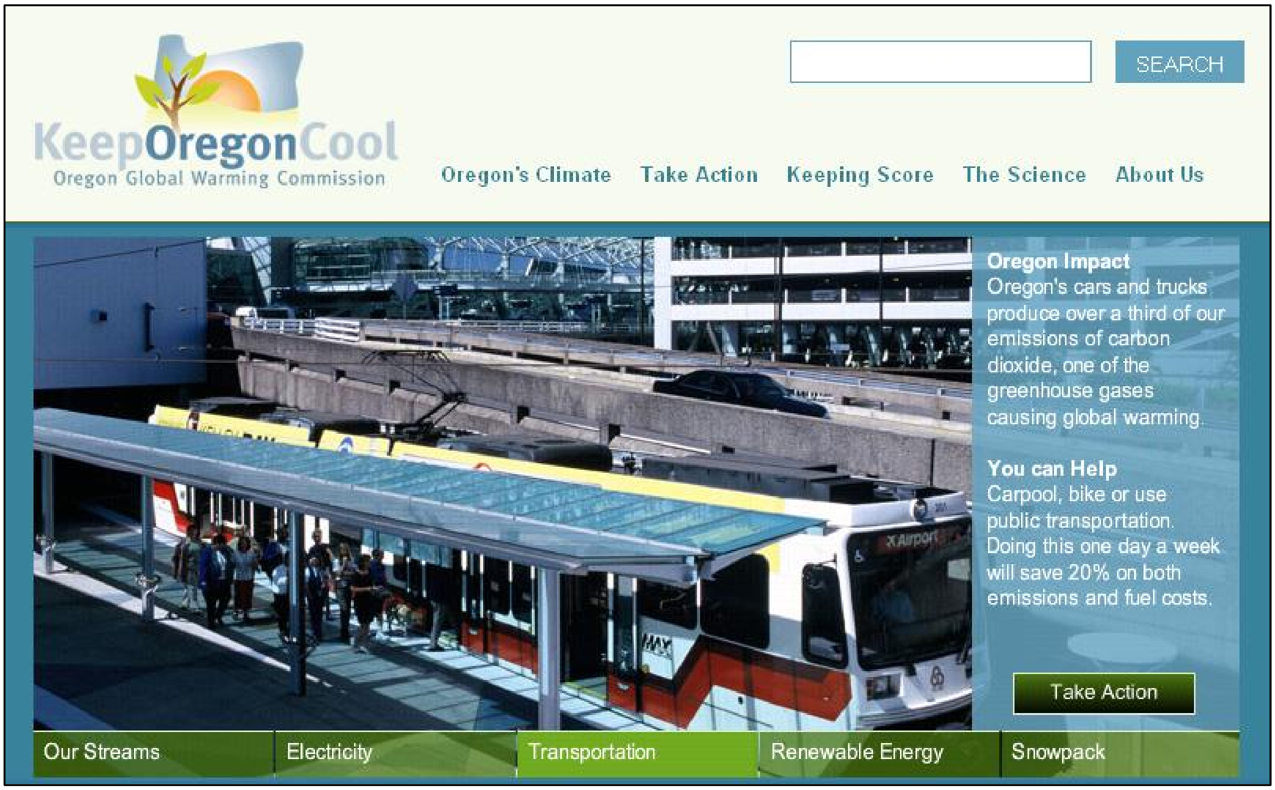
The Oregon Global Warming Commission met six times in the two-year period since the Commission's last report to the Legislature. In the months leading into the last biennium and in January of 2009 the Commission focused heavily on greenhouse gas mitigation policy, with a specific focus on proposals for a regional cap-and-trade system. The Commission then moved on to a range of other issues in 2009. Adaptation and preparation to climate change dominated much of the Commission's attention, with several presentations on the topic and strong interest in encouraging several nascent initiatives that were beginning with State agencies and the newly-formed Oregon Climate Change Research Institute. The Commission also kept up with the rapidly evolving issues around cap-and-trade policy, particularly as the debate intensified at the federal level (see resolution section below). The Commission's focus in 2010 was almost solely on initiating the "Roadmap to 2020" process and completing the *Interim Roadmap to 2020* report, which has been presented in detail earlier in this report.

II. The "Keep Oregon Cool" Commission Website

A major achievement of the Commission in 2009 was the creation of the Commission's official website, "Keep Oregon Cool." Design and implementation of the website was overseen by the Communications and Outreach Committee of the Commission. As noted in the previous report to the Legislature, seed money for the web site was provided by the Bullitt Foundation which allowed the Commission to retain (with substantial pro bono contributions) the Oregon-based firm Fish Marketing for the work. Integral to the website development process was the development of a Commission "brand" to use as the basis for the Commission's outreach work on climate change. Outreach is part of the Commission's legislatively-directed mission. No State funds were employed in developing and operating the site, although the Commission relied upon State and Oregon University System staff to ensure the accuracy of the substantive materials presented. Products included the Commission's logo (as seen on the front of this report), as well as an overall strategy for organizing and populating the website and rolling it out to the public. The site went live in October of 2009, with announcements sent to TV, radio and print media around the State and press coverage in the *Oregonian* and Oregon Public Broadcasting.

The Keep Oregon Cool website features a lively, engaging front page (see screen shot in Figure 1 below) with a slide show of climate change issues and solutions, links to the major sections of the website and key news items, and background narrative. The site includes a "take action" area with key steps that citizens can take to help mitigate climate change. It also includes a "keeping score" area with a variety of information on greenhouse gas emissions, a history and summary of State and local climate change policies, case studies of climate change mitigation, and information on preparing for and adapting to climate change. There are also several areas of the site with information on climate change science and, importantly, Oregon-specific impacts of climate change (in contrast to the more general national or regional information frequently used on other websites). Finally, the Keep Oregon Cool site is the administrative home of the Commission as well, complete with information on past and future Commission meetings, an archive of Commission decisions and reports, and the ongoing Roadmap process (including the full *Interim Roadmap to 2020* document referenced throughout this report).

Figure 1: Front Page of "Keep Oregon Cool", the Oregon Global Warming Commission's Website



III. Resolutions of the Commission

The Oregon Global Warming Commission voted on, and passed, six resolutions this past biennium. The first resolution passed by the Commission in the first month of the biennium (#2009-1-009 relating to a regional cap-and-trade approach and the Western Climate Initiative) was included in the Commission's prior Report to the Legislature. For that reason it is not included in this report. The two resolutions passed by the Commission in 2010 both related to the Roadmap to 2020 process and were discussed and included earlier in this report in the section on the Roadmap to 2020 process.

Two of the resolutions that the Commission focused on in 2009 were oriented toward discussions occurring in the 2009 Oregon Legislature. The Commission registered their strong support for the Oregon Climate Change Research Institute (OCCRI) in Resolution # 2009-2-010, as follows:

Regarding the Oregon Climate Change Research Institute (OCCRI) Resolution #: 2009-2-010

Commission Vote: Unanimous *Origin: Commissioner Bradbury*

Resolved, that the Oregon Global Warming Commission strongly supports the critical role that the Director of the Oregon Climate Change Research Institute, Phil Mote, and the OCCRI play in helping this state move forward effectively in dealing with climate change. The Oregon Global Warming Commission very strongly supports, and hopes the Oregon Legislature maintains the support for, this newly formed office.

Furthermore, while recognizing that OCCRI may not be immune from budget cuts, the Oregon Global Warming Commission hopes that the OCCRI is not subjected to disproportionate cuts within the higher education budget of the Oregon University System.

The Commission also chose to support a proposed climate outreach program (the "Oregon Climate Corps") being championed by the Climate Leadership Initiative at the University of Oregon. The bill in question did eventually pass the Oregon Legislature. The text of the resolution as adopted is below:

Regarding SB 942 in the 2009 Legislative Session Resolution #: 2009-2-011

Commission Vote: Unanimous *Origin: Commissioner Bradbury*

Resolved, that the Oregon Global Warming Commission supports the passage of Senate Bill 942 relating to the Oregon Climate Corps in the 2009 Session of the Legislature.

The Commission continued to focus on issues related to a cap-and-trade program as the debate around cap-and-trade increasingly shifted toward Washington D.C. In the Fall of 2009 the Commission chose to address the debate on cap and trade occurring at the federal level through the passage of resolution # 2009-3-012. The text of the resolution as adopted follows:

Regarding the American Clean Energy and Security Act of 2009 Resolution #: 2009-3-012

Commission Vote: Unanimous *Origin: Commissioners Bradbury and Brauer-Reike*

Global climate change is a growing threat to Oregonians, Americans and our neighbors in countries around the globe. Newly emerging science shows that some climate events, which were not expected to occur until years from now – for example, the disappearance of the Arctic ice cap – are already happening or will likely happen sooner than previously expected.

The many consequences of unchecked climate change in Oregon are likely to include: (a) declining snowpack leading to competition for dwindling summer flows by aquatic ecosystems, municipal water supplies, irrigated agriculture, power generation, river transportation and recreation; (b) increased frequency and intensity of forest fires; (c) erosion of coastline geology with consequences for coastal roads and other infrastructure; (d) increased adverse public health effects, and (e) changes in plant and animal species distribution.

These and other serious climate effects are probable even if greenhouse gas emissions are immediately and decisively brought under control. However, decisions made today will greatly affect the magnitude of effects to be experienced in Oregon and around the world later in the century.

Oregon has sought to aggressively address climate issues for two decades, acting as key organizer in Western states efforts to prompt national action and moving decisively to arrest and reduce our own emissions. We were among the earliest states to adopt emissions reduction goals, and we are on track to achieve our 2010 goal of arresting emissions growth and beginning to reduce absolute emissions. Among many local government initiatives, the City of Portland set a goal of not exceeding its 1990 emissions levels, and has met that goal.

But Oregonians – and this Commission – understand that State and local initiatives, however productive, are no substitute for coordinated global and national actions to cap and reduce greenhouse gas emissions if we are to avoid the worst case scenarios laid out by the Intergovernmental Panel on Climate Change (IPCC). The United States must provide global leadership in this undertaking, beginning with actionable commitments in Copenhagen backed up by Congressional action on climate.

This Commission therefore resolves to call upon Oregon's elected representatives in the United States Congress to debate, amend as necessary and enact without delay the American Clean Energy and Security Act of 2009.

The Commission understands that the issues are complex and require careful balancing of obligations and consequences. For example, the Congress needs to ensure that in setting greenhouse gas caps and reduction schedules it reinforces, and does not undermine, State, local government and private citizen incentives to reduce emissions.

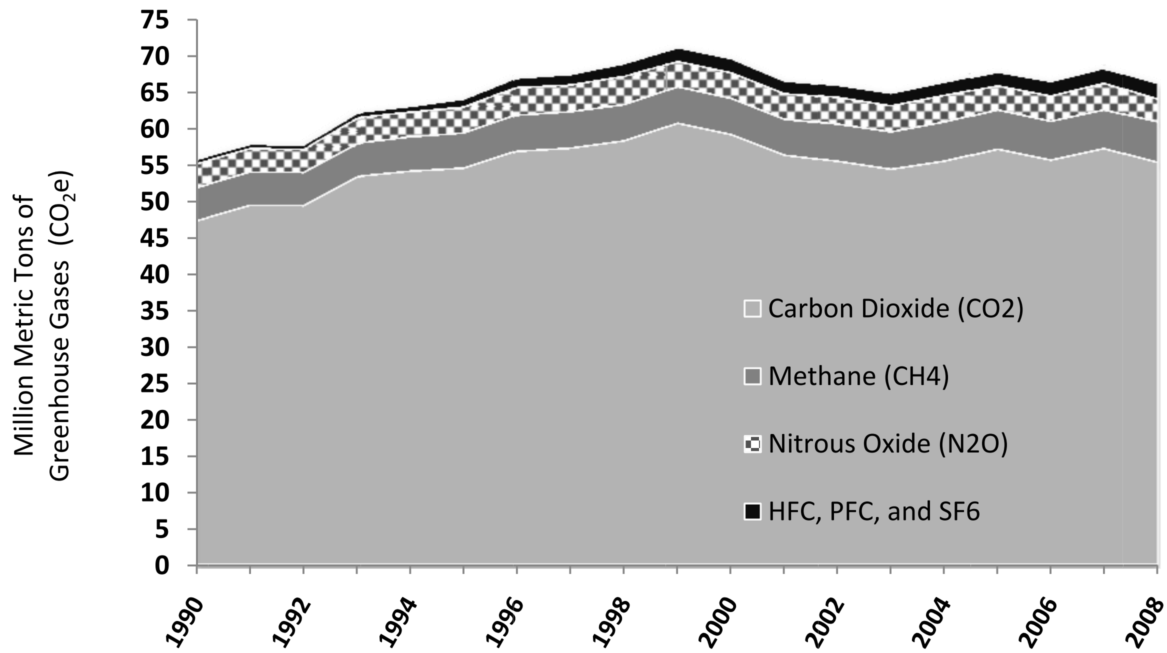
That said, we encourage the Congress to adopt a sound, equitable and timely bill that begins immediately to reduce this nation's greenhouse gas emissions in concert with emission reductions around the world.

PROGRESS TOWARD OREGON'S CLIMATE CHANGE GOALS

I. Summary of Current Oregon Greenhouse Gas Emissions

Carbon dioxide (CO_2) dominates the State's anthropogenic (human-caused) greenhouse gas emissions, typically responsible for about 85 percent of these emissions. Methane, nitrous oxide, and an array of fluorinated industrial gases – hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6) – comprise the remaining portion (in order of abundance, normalized to CO_2). Greenhouse gas emissions in Oregon rose steadily in the 1990s to about 25 percent above 1990 levels at the end of the decade, but fell steeply in the early 2000s. From 1999 to 2001 Oregon electricity use – and the greenhouse gas emissions associated with that electricity use – fell due to a number of factors,

Figure 2: Oregon Greenhouse Gas Emissions by Greenhouse Gas 1990 - 2008

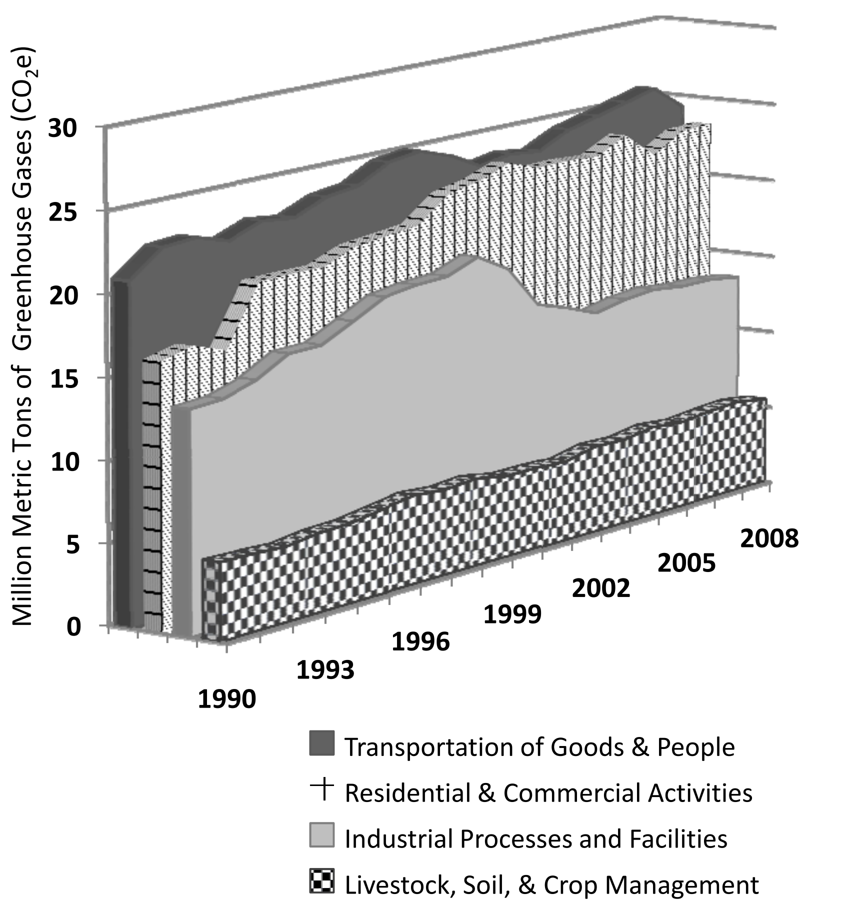


including public appeals for conservation during a drought, a general slowdown in the economy, and sharply higher electricity prices during the energy crisis of the early 2000s. In recent years, greenhouse gas emissions have leveled off. The historical quantity and composition of Oregon's greenhouse gas emissions from 1990 until the most recent year that data are available (2008) is shown in Figure 2.

Most of Oregon's greenhouse gas emissions are energy-related, mirroring the CO_2 proportion of emissions at roughly 85 percent. In terms of economic sectors of activity, the transportation of goods and people accounts for the largest share of emissions at about 37 to 38 percent in recent years. Residential and commercial activity in homes, offices, stores, and the like, using energy, generating municipal solid waste, and fertilizing lawns, etc. is a close second, at around 33 to 35 percent. The industrial sector has been stable in recent years at around 20 percent of emissions. Agricultural activities have hovered around 8 percent, representing the smallest share of emissions in Oregon.

As can be seen in Figure 3 on the next page, these proportions have changed over time. The transportation sector has remained the largest sector but the fastest growing sector has been the residential & commercial sector. In contrast, emissions from the industrial sector have decreased considerably, a reflection of both the changing portfolio of Oregon's economy and efficiency increases. The agricultural sector has remained relatively constant over time relative to the others. Understanding how these profiles are evolving will be critical to shaping future emissions reduction strategies, which clearly need to focus on the transportation, residential, and commercial sectors that continue to grow despite existing measures, and must be brought under control for the State goals to be met.

Figure 3: Greenhouse Gas Emissions by Sector over Time

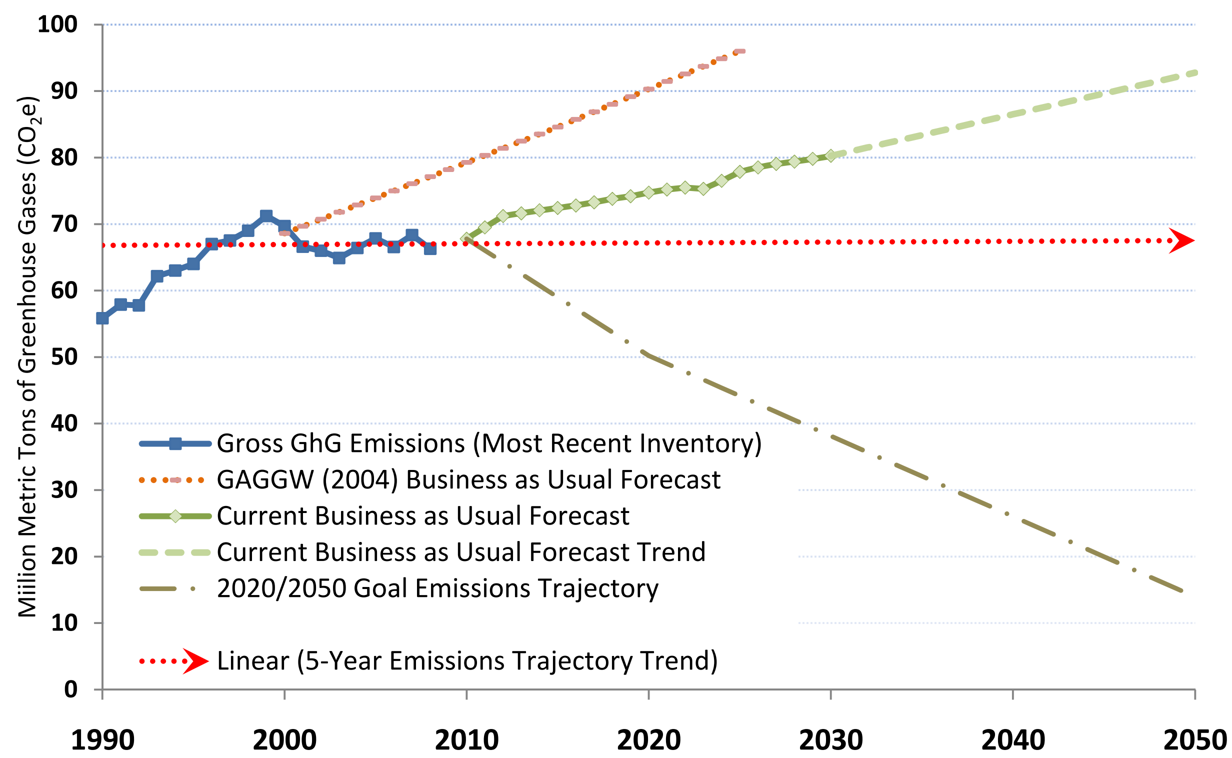


A detailed accounting of Oregon's greenhouse gas emissions is included in Appendix 2 at the end of the report. In the appendix are specifics on the assignment of greenhouse gas emissions to economic sectors that forms the basis for Figure 3. This appendix also contains data on emissions from electricity generation within the State's borders that can be used to generate an alternative perspective on the State's greenhouse gas emissions, as well as trends in carbon sequestration and releases. A "business as usual" greenhouse gas emissions forecast is also included, along with a summary of how the forecast is created.

II. Progress Toward Oregon's Greenhouse Gas Reduction Goals

In its 2009 Report to the Legislature the Commission reported that Oregon appeared to be on track to meet the first legislated greenhouse gas reduction goal – to arrest the growth of emissions and to begin reducing those emissions by 2010. This assessment was based on the best estimate of projected greenhouse gas emission trajectories available at the time of that report. However, that report also noted that Oregon was not in a position to claim that the direction that greenhouse gas emissions were heading would put the State in a position to meet its 2020 goal of lowering emissions to 10 percent below 1990 levels or the 2050 emission reduction goal of bringing emissions down to at least 75 percent below 1990 levels. Due to the normal lag in availability of the data necessary to complete the State's greenhouse gas inventory emission estimates for 2009 and 2010 are not yet available, and will not be until the next biennium. However, with greenhouse gas emissions data now available through 2008 a better sense of the State's progress toward its greenhouse gas reductions goals is possible.

Figure 4: Current Five-Year Emissions Trajectory Relative to BAU Forecasts and GhG Goals



Although the law that established Oregon's greenhouse gas reduction goals (*ORS 468A.205*) does not provide a specific standard by which to judge whether greenhouse gas 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 – with a similarly flat or decreasing trajectory after 2010 – should suffice as "arresting" those emissions. The best measure available to assess progress toward that standard at this point in time is unclear. Two options are available. One option is to look at the linear trend of emissions in recent years and assume that trend holds into the near future. Using that approach one can see that the greenhouse gas emissions trajectory based on the last five years of available data is essentially flat.[21] This is demonstrated in Figure 4, which lays out the historical greenhouse gas inventory data that are currently available and the linear trend line (the dotted line with an arrow) that results from using the last five years of these available greenhouse gas emissions inventory data as an appropriate time period to base the recent emissions trend. Another option is to create a more complicated forecast based on existing energy and emission trends, as well as the policies and programs expected in the future.

Figure 4 illustrates the results of two forecasting exercises that assume that the policies and programs in place at the time do not improve over time – "business as usual" (BAU) conditions – but expected increases in population and economic activity does occur in the future. In 2004 the Governor's Advisory Group on Global Warming (GAGGW) created a "business as usual" forecast to measure the impact of

[21] Remembering that the transportation and buildings sectors have shown continuing emissions increases during this period that may not continue to be offset by industrial sector declining emissions.

their recommended policies. That forecast, which began in the last year inventory data were available (2000), rose steeply although actual inventoried emissions turned out to be sharply lower than the GAGGW "business as usual" forecast. The most recent "business as usual" forecast is also shown in Figure 4, along with the emissions trend past the 2030 end point of this forecast. [22] Encouragingly, it can be seen that with the programs, policies, and practices in place as of today (in contrast to 2004) the expected rise in emissions (based on this recent forecast) is substantially lower than the baseline forecast used earlier by the GAGGW in their analysis. Actual emissions for the foreseeable future may be substantially less – as was the case with the earlier GAGGW forecast and actual emissions.

In terms of predicting whether Oregon will be in compliance with the 2010 greenhouse gas reduction goal, the analysis represented in Figure 4 is encouraging. The current five-year greenhouse gas emissions trend line clearly reveals a flat emissions trajectory. In addition, the best available estimate for 2010, based on the current "business as usual" forecast, falls within a range that reinforces this multi-year trend of a flat emissions trajectory. Taken together, the flat emissions trajectory evident in the most recent available inventory data and the point forecast for 2010 that falls within this same trajectory range create a compelling argument that the emissions trajectory will stay flat (on average) through 2010. Therefore, it appears highly likely that greenhouse gas emissions for Oregon will have been "arrested" for a reasonable period of time when the data are available for the year 2010.

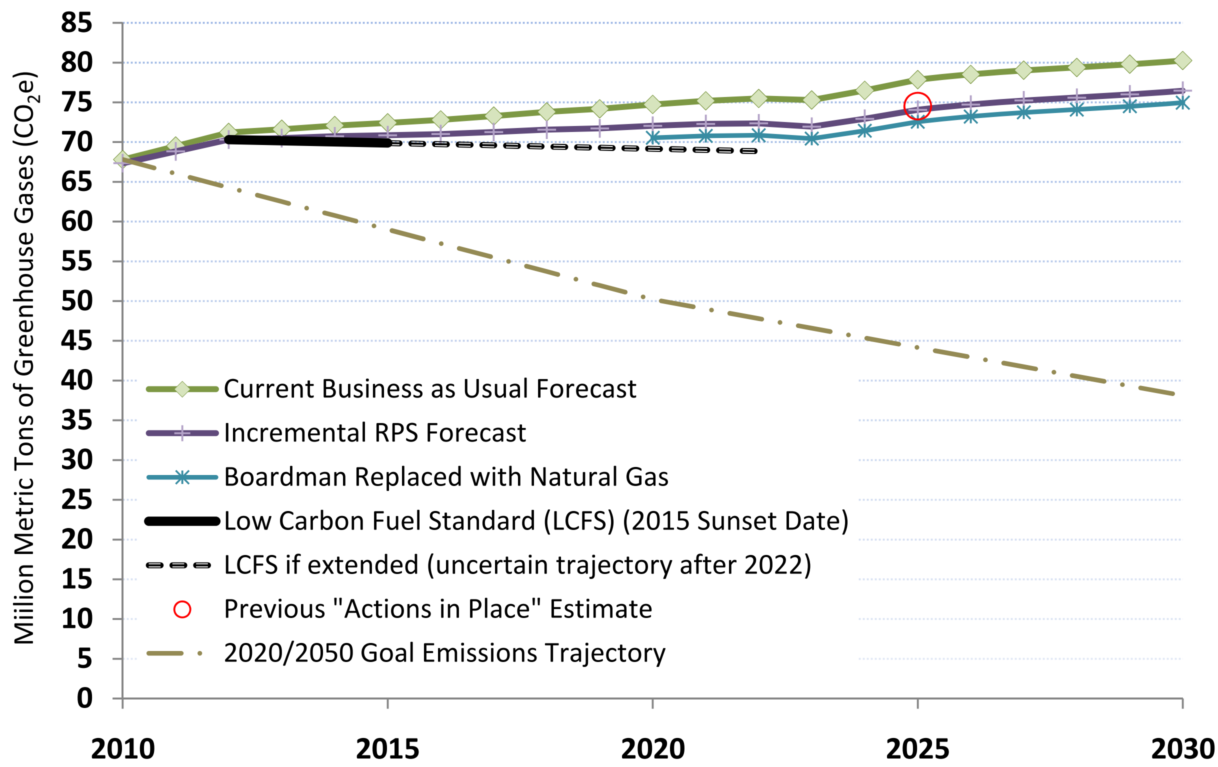
However, arresting emissions by 2010 is only the first part of the 2010 greenhouse gas reductions goal. The second part of the goal is to begin reducing emissions, making progress toward the emission trajectory mapped out in Figure 4 that achieves the 2020 and 2050 greenhouse gas reduction goals. Will the emissions trajectory moving forward from 2008 represent a clear "plateau" of emissions growth, with declining emissions thereafter? Perhaps if the current emission trajectory holds into the near future. Or perhaps not, if instead the current "business as usual" forecast holds into the future. But we can say with strong certainty that greenhouse gas emissions in the future will be lower than that predicted by the current "business as usual" forecast. This is because in addition to ongoing incremental progress in energy efficiency, land use measures, waste reduction, and other actions there are key large-scale greenhouse gas reduction policies that are moving forward at this time that are not captured, either in full or in part, by the current "business as usual" emissions forecast.

Figure 5 demonstrates the cumulative impacts of three of these key large-scale policies using the current "business as usual" forecast as a baseline. The reductions necessary to achieve the 2020 and 2050 goals are also plotted to provide perspective. The three key policies illustrated in Figure 5 are as follows:

Renewable Portfolio Standard (RPS): The current "business as usual" forecast captures the gains made thus far in increasing the share of renewable energy used in the State's power mix – some of which was undoubtedly steered by the Oregon RPS. However, those gains will clearly increase if Oregon remains on track to meet its 2025 RPS goals as they currently exist in law. Conversely, those gains may not materialize if the RPS is eliminated or modified so that existing generation capacity is substituted for new renewable energy growth in the future. Thus the incremental gain between where we are today, as

[22] For more details on the most recent "business as usual" emissions forecast prepared for this report please see Table 13 in Appendix 2.

Figure 5: Impact of Key Near-Term Policy Actions on Business as Usual Emissions Forecast



reflected in the current BAU forecast, and what we will attain if we remain on track with the RPS is a key emissions reduction policy represented by the first trajectory below the "business as usual" forecast in Figure 5. Note that this "Incremental RPS" emissions trajectory intersects the point at which the Commission assumed that Oregon would be at in 2025, based on the analysis in its last report to the Legislature, given the policies and programs that had been put in place at the time of that report (which included the full RPS).[23] The strong correlation between that point estimate (the open circle in Figure 5) and the "Incremental RPS" forecast provides assurance that the current "business as usual" forecast captures the impact of activities put in place since the creation of the GAGGW forecast.

Boardman Power Plant: The recent agreement to end coal combustion at PGE's Boardman power plant by the end of 2020 will clearly have an impact on the State's greenhouse gas footprint. That impact will not be felt until 2020, and will likely be mitigated by the fact that replacement power will need to be procured, either from the general power pool that supplies Oregon or from a new (or refurbished) power plant on the Boardman site. It is also important to note that about a third of Boardman's power is sent out of state at this time, so not all of the emissions saved should be credited within Oregon. For this analysis the replacement power is assumed to be natural gas, although it is important to note that PGE, State regulators and stakeholders have agreed to explore alternatives that could offer comparable

[23] Specifically the "Emissions Trajectory of Actions or Policies Now in Place" line on the progress figure described on page 18 of the last OGWC Report to the Legislature (January 2009).

power service with lower carbon emissions. The emissions trajectory associated with a natural gas replacement option is located below the "Incremental RPS Forecast" line in Figure 5 and begins in 2020.

Low Carbon Fuel Standard (LCFS): Legislation passed in 2009 authorizes Oregon's Environmental Quality Commission (EQC) to put in place a low carbon fuel standard that would reduce the carbon intensity of the transportation fuel mix used in this State by 10 percent (on a life-cycle emissions basis). Assuming that the EQC moves forward and puts in place that standard, a drop in emissions can be expected, at least for a few years since the LCFS currently is set to expire in 2015. However, if the Oregon Legislature chooses to continue this program, substantial reductions can be expected by 2022 and beyond. This emissions trajectory is mapped out in Figure 5 with both solid and dashed lines based on an approximate translation of the point estimates for the program available for 2022.[24] The emissions trajectory past 2022 is unclear at this time, and therefore no attempt has been made to represent that uncertain trajectory past 2022 in Figure 5. Future analysis may be able to better project these impacts.

Taken together, the analysis represented in Figure 4 and Figure 5 presents a somewhat complicated but still optimistic view on the State's progress toward its greenhouse gas reduction goals. It does seem clear at this point that by the year 2010 greenhouse gas emissions will have stabilized for a number of years and will represent, on average, a more or less flat emissions trajectory. It also appears that combined with the policies and programs put in place thus far by the State of Oregon a few key policies either coming into effect by 2020 or realizing their full potential by that time period will "turn the corner" on Oregon's emission growth and help to propel emissions downward, starting as early as 2012.

The period of time between 2010 and 2012 is less clear. If the current trend in greenhouse gas emissions holds through that time period, we can expect continued flat emissions through to 2012 and then a downward sloping trend. In contrast, the aggregate forecast represented in Figure 5 predicts a slight bump in emissions between 2010 and 2012, creating a more complicated picture of reaching the 2010 greenhouse gas reduction goal. Nonetheless, that bump is not expected to exceed peak historical emissions and, once the expected downward trend begins in 2012, the oscillating emission trend of recent years would likely continue and the linear trend line that has been flat thus far should continue. Thus, it is reasonable to expect that in the future, looking back at the data as they are expected to play out given this forecast, there will be a clear plateau evident in the emissions data in the 2010 time period, with a downward sloping emissions trajectory afterward. Given the margin of error inherent in any forecasting process the important point is that the necessary actions will be in place to ensure that there is a reversal in the "business as usual" emissions forecast such that the downward trend towards Oregon's greenhouse gas emissions reduction goals will begin soon, perhaps as early as next year.

Finally, it is important to note that the current emissions trajectory, and that predicted from implementation of the key greenhouse gas mitigation measures noted above, does not place the State on a path to meet its 2020 and 2050 emission reduction goals. Although the general outlook for greenhouse gas emissions going forward is more encouraging than was reported by the Commission in its last report to the Oregon Legislature, there is still not a clear path to meeting those two future

[24] Oregon Department of Environmental Quality, "Final Report: Oregon Low Carbon Fuel Standards Advisory Committee Process and Program Design", January 25, 2011, page 163.

greenhouse gas reduction goals. That is in large part the role of the Roadmap to 2020 project the Commission has undertaken. A next step for the Commission will be to take the actions identified in the Roadmap process and to quantify their potential impact, as well as make decisions on the degree to which action should be undertaken on those emission reduction measures. In practical terms, to take the type of analysis demonstrated in Figure 5 with the three "big" policies and to extend that analysis, so that the key actions identified in the "Roadmap to 2020" process are grouped together in a manner to demonstrate a clear and cumulative pathway to meeting the State's 2020 greenhouse gas reduction goal. This exercise will involve making some tough decisions about how much of a burden some sectors may have to bear in the short term if the 2020 goal is to be met, and how much of that burden may fall in later years as the State continues its path to meeting its long term emission reduction goal in 2050.

III. New Directions in Tracking Oregon's Greenhouse Gas Emissions

Historically, Oregon and other states have been limited in the types of greenhouse gas data that they have been able to collect, analyze, and use to prepare greenhouse gas inventories. "Bottom up" emissions data that is measured or computed directly from greenhouse gas emissions sources have not been available for the vast majority of emission sources. Therefore, a variety of estimation and modeling techniques have been used to generate emission estimates. Typically these methods involve using energy use, industrial activity, or socioeconomic indicators along with appropriate emission factors to generate greenhouse gas emission estimates for the combined impact of a set of emission sources. Oregon has relied on this type of "top down" inventory approach for the past twenty years. The protocols and methodologies used in this approach mirror the same approaches used by the US Environmental Protection Agency (EPA) in its preparation of the national inventory pursuant to international reporting agreements. As a result, Oregon's greenhouse gas inventory can be compared to similar inventory efforts in other states and the national inventory with few concerns since the same methodologies and protocols are used. The ability to compare these data, over time within Oregon and in relation to other states, is one of the primary reasons why maintenance of this consistent measure of Oregon's greenhouse gas emission is important.

In the last biennium there have been new developments in tracking greenhouse gases in Oregon that are providing important new perspectives and a fuller understanding of Oregon's total carbon footprint. These new analytical frameworks provide richer sets of data that are tailored to analyzing in greater depth some of the most difficult questions facing Oregon policy makers. Most significantly, since 2009, Oregon has required emitters of significant amounts of greenhouse gases to report their emissions to the Oregon Department of Environmental Quality (DEQ) and similar requirements have also been put in place by the US Environmental Protection Agency. These mandatory reporting processes will be a new and important source of "bottom up" emissions data that will enhance ongoing efforts to track Oregon's greenhouse gas emissions. The reporting rules currently in effect for Oregon target only about 30 to 40 percent of the State's total emissions, but new rules put in place in 2010 broaden the reporting umbrella to upwards of 80 to 90 percent of emissions. Over time these new "bottom up" data will be integrated with the "top down" data to enhance the overall Oregon greenhouse gas inventory process.

Another new development has been the use of life-cycle accounting techniques to more fully understand the total greenhouse gas footprint of policies and individual actions in Oregon. Traditional inventories normally concentrate on measuring or estimating emissions at a single moment in time, i.e., the moment when a greenhouse gas is emitted within the geographical boundaries that the inventory is concerned with.[25] However, the total "carbon footprint" of a product, or the cumulative impact of an action or policy, may be more accurately characterized if all the emissions associated with the product or action over the course of time are counted – regardless of where the emissions occur or how many times greenhouse gases are released into the atmosphere.

This type of approach is being applied in Oregon in two similar ways. In response to legislative direction in the 2010 session, several State agencies have been working to develop a comprehensive inventory and forecast of Oregon's transportation emissions that recognizes the differences in life cycle carbon intensity of transportation fuels. For example, differences in the total cumulative emissions associated with gasoline derived from Alaska in contrast to gasoline that is derived form the Middle East, or emission differences between gasoline vehicles and electric vehicles. Because the refining pathway of most transportation fuel is well understood, it is possible to develop fairly precise estimates for most petroleum-based fuels. Alternative fuels, such as biofuels or electricity, are more challenging. This inventory work is particularly important in providing a foundation for transportation scenario planning called for under SB 1059 (2010) and for use with the Low Carbon Fuel Standard (HB 2186, 2009).

Life-cycle methods are also being used in an effort to better understand how Oregon consumers are affecting global greenhouse gas emissions. As previously noted in the Materials Management "Key Actions" section, the Oregon Department of Environmental Quality is undergoing a research effort to develop a consumption-based inventory for a single year (2005) covering all Oregon-related emissions. This inventory attempts to capture all the emissions associated with the purchase or use of a single product or service, e.g., an item of clothing or paying for a service. The approach is similar to the life-cycle analysis work described for transportation fuels, however, because of the lack of data for many elements in the life span of a number of products and services current methods rely on a number of approximations and modeling techniques. In this way the consumption-based approach is similar to the current "top down" inventory approach used to generate an inventory for Oregon, but is completed within a much different geographic and temporal framework. The results offer a valuable new perspective on the "carbon footprint" of Oregonians, one that includes not only the emissions that occur in the State as a result of purchase and use decisions, but also those emissions occurring elsewhere – with a particular focus on emissions that are "imported" along with the products that we consume.

Finally, it is important that Oregon account not only for greenhouse gases emitted, either within the boundaries of the State or as a result of the actions of Oregonians, but also to understand the extent to which greenhouse gases are removed from the atmosphere in Oregon. Understanding these flows show how the carbon stocks in Oregon's forests and agricultural lands contribute to and helps mitigate climate change. Until recently few data have been available on the flow of carbon ("flux") involving

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[25] Historically emissions from plants, trees, etc. have typically been considered biogenic "carbon neutral" emissions and therefore zero-emission sources even though this carbon neutrality does occur over time.

Oregon's forests that are specific to Oregon (i.e., provide data not on a regional or ecosystem basis but rather within Oregon's boundaries). Even rarer have been data that provide year-by-year estimates of carbon flux in Oregon that can be used in the context of an annual greenhouse gas inventory. Recent work by Oregon State University has provided reasonable data on carbon flux that are both specific to Oregon and offered in a format that can be interpreted year-to-year. There are still substantial uncertainties with estimating carbon flux in Oregon's forests, but we are at a point where a reasonable "net" inventory that incorporates the carbon flows in Oregon can be part of the inventory process.

In the last two years Oregon has moved from being in a position to only understand its greenhouse gas footprint through one lens to a position where multiple perspectives are possible. These different efforts build on each other, offering not only improvements in the accuracy and completeness of the greenhouse gas data set in Oregon, but also valuable policy tools in better understanding the myriad ways that Oregonians can take action in mitigating global climate change. Table 2 below summarizes these various efforts, illustrating how these different approaches offer differing perspectives and provide some context for the relative state of maturity of these different inventory approaches.

Table 2: Comparison of Approaches and Methodologies of Oregon's Inventory Efforts

	Gross Emissions Inventory	**Net Greenhouse Gas Inventory**	**Oregon Mandatory Reporting**	**Life-Cycle Emissions Inventory**	**Consumption-Based Emissions Inventory**
General Description	Estimate of combustion and process emissions at point of use	Same as gross, but also with removals of GhGs from the atmosphere	Point-source & fuel combustion GhG emissions measurement	Estimate of total emissions from beginning of product life to its use/disposal	Manufacture, transport, use, and disposal emissions of products
Scope	All sectors with GhG emissions	All sectors plus forestry, ag, & waste removals	GhG emitters above 2,500 tonnes/year	Transportation sector only	Economy-wide
Status	Ongoing since 1990	Rough data since 2009	2009 data ready in 2011	Preliminary modeling	Draft study completed
Emissions Covered	100%	100%	30-40 % now, 80+% in future	unknown	100%
Data Currently Available for Years	1990 through 2008 (with about a two year data lag)	1990 through 2002 (updates planned)	2009 for large emitters, 2010 reporting in process	1990 through 2010 planned with 5-year increments	2005 only
Confidence in Data[26]	Medium to High	Low to Medium	High after verification	Medium	Medium
Emissions Forecast	Through 2030	None	None	Through 2050 (5-year gaps)	None
Inventory Approach	"Top Down"	"Top Down"	"Bottom Up"	"Top Down"	"Top Down"

[26] This is a subjective assessment based on whether conflicting data may exist for the same source or sources, known weaknesses in existing methodologies, and the degree to which the efforts are assumption-driven.

IV. Progress in Preparing For and Adapting to Climate Change in Oregon

The Commission is charged with not only tracking progress toward Oregon's greenhouse gas reduction targets, but also tracking the progress that Oregon has made in preparing for and adapting to the impacts of climate change. In its 2009 Report to the Legislature the Commission noted that, "work in this area has only just begun in many sectors, and also with the State agencies that work with those sectors of the economy." In the last biennium this situation has changed. Throughout 2010 a large number of State agencies met on a regular basis to begin plotting a strategy for dealing with the impacts of climate change. This work was led by the Department of Land Conservation and Development (and included Global Warming Commission participation), and resulted in the release of *The Oregon Climate Change Adaptation Framework* in December of 2010, which provides the first detailed outline of policy responses to the Oregon impacts of climate change.

Concurrently, and not coincidentally, the Oregon Climate Change Research Institute (OCCRI) completed the first Oregon Climate Assessment Report (OCAR) during this time, providing a scientific basis for understanding the impacts of climate change on Oregon. An Oregon-specific assessment of these impacts had been lacking as State agencies and other have generally had to rely on regional or national impact assessments and extrapolate to Oregon. Staff from OCCRI worked with State agencies as they worked on the *Adaptation Framework*, incorporating the results of the OCAR process into the adaptation planning process as both processes evolved. The OCAR went through extensive review and revision to ensure a high level of scientific integrity, including extensive comment periods and an external peer review process using reviewers outside of Oregon. The final report from the OCAR process was released at the end of 2010 and presented to the Oregon Legislature in December 2010.

As a result of the combined efforts of the OCAR and the State agency adaptation planning process, it was possible to match key recommendations from the adaption planning process with the key climate change risks to Oregon that stood out in the OCAR process. Priority actions were derived from the adaption planning process and matched to these key risks, along with the probably of these key risks occurring. The summary of *The Oregon Climate Change Adaptation Framework* is below for reference:

Climate Risks and Short-Term Priority Actions from "The Oregon Climate Change Adaptation Framework" (State of Oregon, December 2010)

Very likely to occur

1. **Increase in average annual air temperatures and likelihood of extreme heat events**
   - Enhance and sustain public health system capacity to prepare for and respond to heat waves and smoke emergencies, and improve delivery of information on heat events and cooling centers, especially for isolated and vulnerable populations.
2. **Changes in hydrology and water supply; reduced snowpack and water availability in some basins; changes in water quality and timing of water availability**

- Maintain the capacity to provide assistance to landowners to restore wetlands, uplands and riparian zones to increase the capacity for natural water storage.
- Improve real-time forecasting of water delivery and basin yields to improve management of stored water.
- Improve capacity to provide technical assistance and incentives to increase storage capacity and to improve conservation, reuse, and water use efficiency among all consumptive water uses.

Likely to occur

3. Increase in wildfire frequency and intensity

- Include wildfires in planning to reduce vulnerability to natural hazards.
- Restore fire-adapted ecosystems to withstand natural recurring wildfires.
- Develop short- and medium-term climate change adaptation strategies for forests and other fire-prone habitats, and improve development standards to reduce exposure to fire risk at the urban-wildland interface.
- Improve the capabilities of public health agencies to plan for and respond to the public health and safety risks of wildfire emergencies

4. Increase in ocean temperatures, with potential for changes in ocean chemistry and increased ocean acidification

- Increase research on the impacts of changes in ocean temperature and chemistry on estuarine and near-shore marine habitats and resources, including commercial and recreational fisheries.

5. Increased incidence of drought

- Improve capacity to provide technical assistance and incentives to increase storage capacity and to improve conservation, reuse, and water use efficiency among all consumptive water uses.

6. Increased coastal erosion and risk of inundation from increasing sea levels and increasing wave heights and storm surges

- Inventory and map coastal shorelands that are at risk of erosion or inundation, or are barriers to shoreline migration, and develop long-term state and local adaptation strategies for shorelands.

7. Changes in the abundance and geographical distributions of plant species and habitats for aquatic and terrestrial wildlife

- Identify ways to manage ecosystems that will improve their resilience to changes in climate conditions.

8. Increase in diseases, invasive species, and insect, animal and plant pests

- Increase monitoring, detection and control measures for pest insects and plant and wildlife diseases.
- Increase surveillance and monitoring for climate-sensitive infectious diseases to humans
- Increase outreach and community education about disease and invasive species prevention measures.
- Seek new means of securing resources to detect and combat diseases and invasive species.

9. Loss of wetland ecosystems and services

- Support implementation of priority actions for Risks 2, 5, 6, 7 and 10 related to hydrologic changes, drought, coastal erosion and inundation, habitats, and flooding.

More likely than not to occur

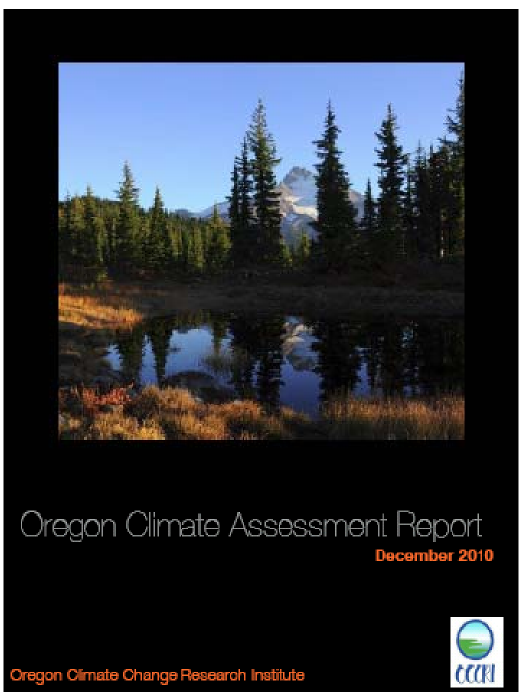
10. Increased frequency of extreme precipitation events and incidence and magnitude of damaging floods

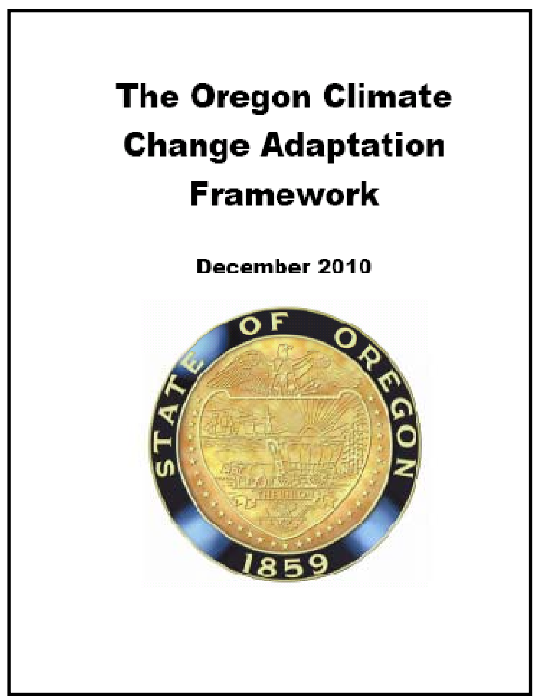
- Inventory past flood conditions and define and map future flood conditions.
- Improve capability to rapidly assess and repair damaged transportation infrastructure, in order to ensure rapid reopening of transportation corridors.

11. Increased incidence of landslides

- Develop public education and outreach on landslide risks and how to adapt to landslide risks.

Please refer to the full reports from the OCAR process and from the State agency adaptation planning process for full information on these priority action recommendations and the assessment of climate change risks to Oregon. The *Oregon Climate Assessment Report* can be found at http://occri.net/ocar and *The Oregon Climate Change Adaptation Framework* can be found at http://www.lcd.state.or.us/LCD/docs/ClimateChange/Framework_Final.pdf.





APPENDIX 1: ROADMAP TO 2020 PROCESS PARTICIPANTS

Appreciation from the Commission is extended to all the stakeholders and citizens who took the time to help out with the Interim Roadmap to 2020 process, including those listed below and many others who participated in one or more meetings or otherwise provided comments or suggestions along the way. Note that Angus Duncan, Chair of the OGWC, was a participant in all of the technical committees below.

Energy

Paul Norman	Chair, Retired from Bonneville Power Administration
Jason Eisdorfer	Bonneville Power Administration
Bob Jenks	Citizens' Utility Board
Michael Armstrong	City of Portland
Terry Morlan	Northwest Power and Conservation Council
John Mohlis	ColPac Building Trades Council
Reuben Plantico	Portland General Electric
Tom O'Connor	Oregon Municipal Utilities Association
Bill Drumheller	Oregon Department of Energy
Phil Carver	Oregon Public Utility Commission
Erik Colville	Oregon Public Utility Commission
Bill Edmonds	Northwest Natural Gas
Robert Procter	Oregon Public Utility Commission
Jason Heuser	Eugene Water and Electric Board
Dick Varner	Eugene Water and Electric Board
Hal Nelson	Claremont Graduate University (Staff)

Transportation and Land Use

Mike Hoglund	Metro (Co-Chair)
Alan Zelenka	City of Eugene /MPO (Co-Chair)
Jim Edelson	Ecumenical Ministries of Oregon
Ethan Seltzer	Portland State University
Eric Hesse	TriMet
Peter Hurley	City of Portland
Dave Mayfield	Electric Transportation Engineering Corporation
Chris Hagerbaumer	Oregon Environmental Council
Scott Drumm	Port of Portland
Bob Cortright	Department of Land Conservation and Development
Tom Schwetz	Lane Transit District
Eric Lemelson	Lemelson Vineyards
Margi Bradway	Oregon Department of Transportation

Forestry

Brian Kernohan	Forest Capital Partners
Andrew Yost	Oregon Department of Forestry
Linc Cannon	Oregon Forest Industries Council
Beverly Law	Oregon State University
Elaine O'Neill	CORRIM
Greg Miller	Weyerhaeuser
Mark Harmon	Oregon State University
Olga Krankina	Oregon State University
Rick Brown	Defenders of Wildlife
Steve Dettman	EcoTrust
Evan Smith	The Conservation Fund
Mike Cloughsey	Oregon Forest Resource Institute
Peter Weisberg	The Climate Trust
Jeannette Griese	Bureau of Land Management
Tom Demeo	US Forest Service

Agriculture

Stephanie Page	Oregon Department of Agriculture
Allison Hensey	Oregon Environmental Council
Tammee Dennee	Oregon Wheat Growers League
Steve Petrie	Oregon State University
Shanna Brownstein	Climate Trust
Sharon Peterson	Northwest Energy Efficiency Alliance
Lori Rhodig	Northwest Energy Efficiency Alliance
Bill White	US Department of Agriculture
Bill Drumheller	Oregon Department of Energy
Kumar Venkat	Clean Metrics Corp
Whitney Rideout	Oregon Association of Nurseries

Industrial Use

Lisa Adatto,	Climate Solutions, Co-Chair
Dale Gehring	ESCO, Co-Chair
Pam Barrow	Northwest Food Processors
Sergio Dias	Sergio Dias Consulting, LLC
Brendan McCarthy	Portland General Electric
Ruben Plantico	Portland General Electric
Elaine Prause	Energy Trust of Oregon

Marty Sedler	Intel
Victor Shestakov	Climate Solutions
Bill Drumheller	Oregon Department of Energy
John Wallner	Northwest Energy Efficiency Alliance
Mark Kendall	Kendall Energy Consulting, LLC (Staff)

Materials Management

David Allaway	Oregon Department of Environmental Quality
Pamela Brody-Heine	Zero Waste Alliance
Eden Brukman	International Living Building Institute
Cheyenne Chapman	Zero Waste Alliance
Steve Cohen	City of Portland
Katy Daily	Recycling Advocates
George Duvendack	Waste Management
Lee Fortier	Rogue Disposal/Dry Creek Landfill
Chris Harris	New Seasons Market
Jack Hoeck	Rexius
Meg Lynch	Metro
Jeff Murray	Far West Fibers/Association of Oregon Recyclers
Ethan Nelson	City of Eugene
Babe O'Sullivan	City of Portland
Jordan Palmeri	Oregon Department of Environmental Quality
Timm Schimke	Deschutes County
Tim Spencer	Oregon Department of Environmental Quality
Jody Snyder	Waste Connections
Douglas Tsoi	Partners for a Sustainable Washington County Community
Kumar Venkat	CleanMetrics Corp.
David Vonasek	Solid Waste Association of North America, Oregon Beaver Chapter
Dan Wilson	Waste Management

Roadmap to 2020 Project Management: Justin Klure and Therese Hampton, Pacific Energy Ventures, LLC

Funding for the Roadmap to 2020 Project provided by: The Bullitt Foundation, The Lazar Foundation, The Lemelson Foundation, Northwest Natural Gas, and Portland General Electric.

APPENDIX 2: UPDATE AND REVISION OF OREGON GREENHOUSE GAS INVENTORY & FORECAST

All emissions data are expressed in Million Metric Tons of Carbon Dioxide Equivalent ($MMTCO_2e$)

Table 3: Total Oregon Gross Greenhouse Gas Emissions, including Emissions Associated with the Use of Electricity[27]

1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
55.841	57.906	57.782	62.159	63.012	64.013	66.989	67.531	69.005	71.217	69.695	66.613	65.994	64.893	66.407	67.848	66.567	68.352	66.292

Table 4: Oregon Greenhouse Gas Emissions, Proportional by Key Economic Sector and by Type of Greenhouse Gas

	Proportion by Key Sectors				Proportion by Greenhouse Gas			
	Transportation	Residential & Commercial	Industrial	Agriculture	Carbon Dioxide (CO_2)	Methane (CH_4)	Nitrous Oxide (N_2O)	High Global Warming Potential (HGWP) Gases
1990	37.5%	29.3%	24.6%	8.6%	84.8%	8.2%	5.9%	1.1%
1991	38.9%	29.0%	23.9%	8.2%	85.4%	7.9%	5.6%	1.1%
1992	39.2%	27.8%	25.0%	8.0%	85.5%	7.9%	5.5%	1.1%
1993	35.4%	31.7%	25.0%	7.8%	85.9%	7.4%	5.6%	1.1%
1994	36.1%	31.3%	24.7%	7.8%	85.8%	7.5%	5.4%	1.3%
1995	35.2%	30.8%	25.9%	8.2%	85.1%	7.6%	5.6%	1.7%
1996	34.9%	30.6%	26.3%	8.2%	85.0%	7.4%	5.7%	1.9%
1997	35.0%	30.7%	26.4%	7.9%	84.9%	7.4%	5.5%	2.2%
1998	35.8%	30.3%	26.0%	8.0%	84.6%	7.2%	5.7%	2.5%
1999	35.0%	31.5%	26.3%	7.2%	85.3%	7.1%	4.9%	2.7%
2000	34.8%	32.8%	25.1%	7.3%	85.0%	7.2%	5.1%	2.8%
2001	34.8%	35.4%	22.2%	7.6%	84.6%	7.4%	5.3%	2.6%
2002	35.7%	34.6%	21.4%	8.3%	84.1%	7.8%	5.6%	2.5%
2003	35.9%	35.3%	20.5%	8.3%	83.9%	7.9%	5.5%	2.7%
2004	36.6%	34.2%	20.6%	8.6%	83.6%	8.1%	5.5%	2.7%
2005	36.5%	35.0%	20.5%	8.1%	84.3%	8.0%	4.9%	2.8%
2006	37.9%	33.1%	20.5%	8.5%	83.7%	8.1%	5.2%	3.0%
2007	37.7%	33.9%	19.9%	8.5%	83.8%	7.8%	5.4%	3.0%
2008	36.5%	35.1%	20.1%	8.2%	83.5%	8.5%	4.7%	3.3%

[27] Unless noted otherwise, emissions data for the State greenhouse gas inventory are generated from the US EPA State Inventory Tool (SIT) (January 2011 release) by the Oregon Department of Energy, with additional data and contributions from the Oregon Department of Environmental Quality and Oregon Department of Agriculture.

Table 5: Greenhouse Gas Emissions from the Transportation Sector[28]

	Carbon Dioxide			Methane			Nitrous Oxide				HGWP[29]	
	Combustion of Petroleum[30]	Combustion of Natural Gas	Light Rail Electricity Use	Passenger & Light Vehicles	Non-Road Vehicles & Equipment[31]	Heavy-Duty Vehicles	Natural Gas Distribution[32] (sector share)	Passenger & Light Vehicles	Non-Road Vehicles & Equipment	Heavy-Duty Vehicles	Refrigerants, A/C, Fire Protection[33]	Transportation Sector Emissions
1990	19.5042	0.4886	0.0035	0.0799	0.0091	0.0059	0.0001	0.7885	0.0477	0.0196	0.0019	**20.9489**
1991	21.0690	0.4818	0.0039	0.0740	0.0111	0.0058	0.0001	0.7907	0.0595	0.0208	0.0037	**22.5204**
1992	21.2171	0.3760	0.0040	0.0771	0.0110	0.0058	0.0001	0.8831	0.0605	0.0228	0.0101	**22.6676**
1993	20.5767	0.2704	0.0047	0.0790	0.0087	0.0058	0.0001	0.9608	0.0504	0.0245	0.0326	**22.0137**
1994	21.2381	0.3226	0.0049	0.0745	0.0093	0.0056	0.0001	0.9591	0.0536	0.0251	0.0744	**22.7674**
1995	20.7914	0.4039	0.0063	0.0713	0.0091	0.0055	0.0001	0.9735	0.0527	0.0256	0.1732	**22.5126**
1996	21.5467	0.4420	0.0050	0.0670	0.0090	0.0051	0.0001	0.9717	0.0533	0.0267	0.2426	**23.3693**
1997	21.4137	0.7066	0.0050	0.0661	0.0099	0.0049	0.0001	1.0162	0.0590	0.0301	0.3108	**23.6224**
1998	22.3785	0.7451	0.0064	0.0635	0.0101	0.0045	0.0002	1.0244	0.0608	0.0324	0.3563	**24.6823**
1999	22.7879	0.5785	0.0153	0.0594	0.0085	0.0043	0.0002	1.0103	0.0543	0.0332	0.4046	**24.9564**
2000	22.0174	0.6468	0.0163	0.0552	0.0076	0.0039	0.0003	0.9722	0.0487	0.0321	0.4517	**24.2520**
2001	21.0627	0.6032	0.0169	0.0523	0.0075	0.0032	0.0004	0.8966	0.0441	0.0275	0.4891	**23.2034**
2002	21.5765	0.4993	0.0168	0.0447	0.0076	0.0031	0.0004	0.8038	0.0458	0.0283	0.5280	**23.5543**
2003	21.4761	0.3835	0.0234	0.0410	0.0061	0.0029	0.0005	0.7401	0.0428	0.0286	0.5641	**23.3091**
2004	22.3319	0.5240	0.0256	0.0378	0.0076	0.0029	0.0005	0.6738	0.0471	0.0280	0.5995	**24.2787**
2005	22.9697	0.4098	0.0270	0.0343	0.0081	0.0028	0.0011	0.6000	0.0497	0.0252	0.6325	**24.7601**
2006	23.4615	0.4622	0.0260	0.0317	0.0083	0.0017	0.0010	0.5391	0.0499	0.0131	0.6646	**25.2591**
2007	23.9692	0.5242	0.0275	0.0284	0.0089	0.0018	0.0009	0.4601	0.0536	0.0129	0.6828	**25.7703**
2008	22.6213	0.4100	0.0277	0.0253	0.0055	0.0019	0.0010	0.3852	0.0269	0.0127	0.7021	**24.2197**

All emissions data are expressed in Million Metric Tons of Carbon Dioxide Equivalent ($MMTCO_2e$)

28 Assignment to economic sectors has been done following EPA protocol in the national inventory. Some variations exist from the EPA approach due to lack of Oregon-specific data or where EPA assumptions are blatantly incorrect for application to Oregon.

29 High Global Warming Potential Gases (HGWP) include hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6).

30 Note that these emissions are based on fuel consumption data only. Therefore it is not possible to parse these data by vehicle category, weight class, on- or off-road use, and so forth. The Oregon Department of Transportation and the Department of Environmental Quality are working to produce estimates at that level of detail.

31 This category includes boats, locomotives, farm equipment, construction equipment, aircraft, snowmobiles, small gasoline powered utility equipment, heavy-duty gasoline powered utility equipment, and heavy-duty diesel powered utility equipment.

32 Emissions from natural gas distribution are based on that sector's proportional share of natural gas consumption in Oregon (according to EIA) for that year.

33 This category represents the consumption of ozone depleting substances (ODS) in general. Specified uses in heading are examples relevant to this sector.

Table 6: Greenhouse Gas Emissions from the Residential and Commercial Sector, Part I: Carbon Dioxide Emissions[34]

	Carbon Dioxide								
	Residential Electricity Use[35]	Commercial Electricity Use	Residential Natural Gas Combustion	Commercial Natural Gas Combustion	Residential Petroleum Combustion	Commercial Petroleum Combustion	Waste Incineration[36]	Residential Coal Combustion	Commercial Coal Combustion
1990	5.9550	4.6816	1.2676	1.1085	0.7577	0.7851	0.1460	0.0009	0.0034
1991	6.1758	4.7995	1.4382	1.2198	0.7286	0.6550	0.1459	0.0004	0.0018
1992	5.8864	4.8690	1.2717	1.0769	0.6076	0.5907	0.1427	0.0004	0.0018
1993	7.7430	5.9635	1.6424	1.3263	0.7538	0.4892	0.1454	0.0008	0.0038
1994	7.6351	6.2269	1.6000	1.2734	0.7325	0.4553	0.1442	0.0003	0.0020
1995	7.5679	6.2891	1.5539	1.2412	0.6460	0.5581	0.1411	0.0003	0.0019
1996	7.8149	6.3683	1.8384	1.4159	0.6170	0.4988	0.1413	0.0000	0.0000
1997	7.8154	6.5840	1.8109	1.4180	0.5446	0.4866	0.1406	0.0002	0.0019
1998	7.8133	6.5630	1.9154	1.4462	0.5237	0.5405	0.1383	0.0000	0.0000
1999	8.3772	7.1196	2.1673	1.6023	0.5984	0.4522	0.1337	0.0001	0.0004
2000	8.4494	7.2981	2.1153	1.5627	0.6100	0.5333	0.1322	0.0000	0.0000
2001	8.6867	7.5752	2.0872	1.5207	0.6471	0.6437	0.1303	0.0000	0.0000
2002	8.2918	7.2601	2.1119	1.5063	0.6079	0.5740	0.1280	0.0000	0.0000
2003	8.5327	7.4492	1.9910	1.3937	0.5629	0.3560	0.1267	0.0000	0.0000
2004	8.4656	7.3679	2.0598	1.4013	0.4358	0.3441	0.1226	0.0000	0.0000
2005	9.0225	7.5666	2.1860	1.5174	0.4524	0.3399	0.1207	0.0000	0.0000
2006	8.0454	6.8181	2.2534	1.5286	0.4176	0.3202	0.1201	0.0000	0.0000
2007	8.6557	7.2315	2.3171	1.5674	0.3553	0.2893	0.1189	0.0000	0.0000
2008	8.5188	6.9800	2.4475	1.6539	0.3935	0.3695	0.1178	0.0000	0.0000

Data continued in Table 7 on next page

All emissions data are expressed in Million Metric Tons of Carbon Dioxide Equivalent ($MMTCO_2e$)

[34] Assignment to economic sectors has been done following EPA protocol in the national inventory. Some variations exist from the EPA approach due to lack of Oregon-specific data or where EPA assumptions are blatantly incorrect for application to Oregon.

[35] Electricity consumption data and emissions factors are generated by the Oregon Department of Energy and input into the SIT electricity consumption module.

[36] Waste and materials data are calculated by Oregon Department of Environmental Quality and are used in place of the default data in the EPA State Inventory Tool.

Table 7: Greenhouse Gas Emissions from the Residential and Commercial Sector, Part II: Methane, Nitrous Oxide and HGWP Gas Emissions

	Methane					Nitrous Oxide					HGWP[37]	
	Municipal Solid Waste Landfills	Natural Gas Distribution[38] (sector share)	Municipal Wastewater	Residential Combustion Byproducts	Commercial Combustion Byproducts	Municipal Wastewater	Fertilization of Landscaped Areas	Waste Incineration[39]	Residential Combustion Byproducts	Commercial Consumption Byproducts	Refrigerants, Aerosols, Fire Protection[40]	Residential & Commercial Sector Emissions
1990	0.9702	0.2373	0.1912	0.0514	0.0162	0.0778	0.0565	0.0197	0.0118	0.0049	0.0013	**16.3440**
1991	0.9739	0.2408	0.1963	0.0538	0.0162	0.0806	0.0546	0.0197	0.0123	0.0047	0.0026	**16.8205**
1992	0.9208	0.2442	0.2000	0.0556	0.0141	0.0836	0.0572	0.0193	0.0124	0.0041	0.0071	**16.0656**
1993	0.9088	0.2476	0.2041	0.0678	0.0176	0.0853	0.0565	0.0196	0.0151	0.0047	0.0228	**19.7179**
1994	0.8877	0.2510	0.2076	0.0644	0.0118	0.0875	0.0620	0.0194	0.0144	0.0034	0.0521	**19.7311**
1995	0.8526	0.2544	0.2113	0.0641	0.0121	0.0883	0.0613	0.0190	0.0142	0.0037	0.1212	**19.7016**
1996	0.9017	0.2579	0.2149	0.0668	0.0125	0.0906	0.0660	0.0190	0.0147	0.0037	0.1698	**20.5120**
1997	0.9536	0.2613	0.2181	0.0574	0.0128	0.0912	0.0719	0.0188	0.0127	0.0037	0.2176	**20.7213**
1998	0.9851	0.2507	0.2208	0.0517	0.0119	0.0931	0.0705	0.0185	0.0115	0.0036	0.2494	**20.9074**
1999	0.9922	0.2629	0.2230	0.0549	0.0124	0.0957	0.0534	0.0179	0.0124	0.0036	0.2832	**22.4626**
2000	1.0204	0.3256	0.2308	0.0585	0.0131	0.0999	0.0397	0.0176	0.0131	0.0039	0.3162	**22.8396**
2001	1.0664	0.3428	0.2334	0.0900	0.0195	0.1028	0.0578	0.0173	0.0194	0.0054	0.3424	**23.5882**
2002	1.0914	0.3473	0.2366	0.0912	0.0197	0.1016	0.0824	0.0170	0.0195	0.0053	0.3696	**22.8614**
2003	1.1485	0.3512	0.2389	0.0953	0.0195	0.1025	0.0937	0.0167	0.0202	0.0048	0.3949	**22.8986**
2004	1.1816	0.3495	0.2405	0.0973	0.0191	0.1042	0.0901	0.0162	0.0204	0.0047	0.4196	**22.7404**
2005	1.1768	0.3678	0.2436	0.0519	0.0113	0.1065	0.0800	0.0159	0.0115	0.0031	0.4427	**23.7166**
2006	1.1519	0.3763	0.2476	0.0477	0.0107	0.1088	0.0783	0.0158	0.0106	0.0030	0.4652	**22.0193**
2007	1.2343	0.3939	0.2513	0.0520	0.0111	0.1109	0.0842	0.0156	0.0113	0.0030	0.4780	**23.1807**
2008	1.3562	0.4094	0.2544	0.0545	0.0120	0.1126	0.0829	0.0154	0.0119	0.0034	0.4915	**23.2852**

All emissions data are expressed in Million Metric Tons of Carbon Dioxide Equivalent ($MMTCO_2e$)

[37] High Global Warming Potential Gases (HGWP) include hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6).
[38] Emissions from natural gas distribution are based on that sector's proportional share of natural gas consumption in Oregon (according to EIA) for that year.
[39] Waste and materials data are calculated by Oregon Department of Environmental Quality and are used in place of the default data in the EPA State Inventory Tool.
[40] This category represents the consumption of ozone depleting substances (ODS) in general. Specified uses in heading are examples relevant to this sector.

Table 8: Greenhouse Gas Emissions from the Industrial Sector, Part I: Carbon Dioxide Emissions[41]

	Carbon Dioxide										
	Industrial Electricity Use[42]	Natural Gas Combustion	Petroleum Combustion	Iron & Steel Production	Cement Manufacture	Coal Combustion	Ammonia Production & Urea Consumption	Lime Manufacture	Soda Ash Production & Consumption	Waste Incineration[43]	Limestone and Dolomite Use
1990	6.0009	2.6020	2.6415	0.7042	0.2161	0.1373	0.0770	0.0855	0.0311	0.0653	0.0087
1991	5.9232	2.9532	2.3925	0.7042	0.2251	0.1806	0.0763	0.1076	0.0302	0.0653	0.0087
1992	5.8558	3.1608	2.8095	0.7042	0.2283	0.2214	0.0797	0.1246	0.0306	0.0653	0.0087
1993	6.9620	3.2849	2.6775	0.7042	0.1962	0.2146	0.0734	0.1397	0.0307	0.0601	0.0087
1994	6.9903	3.4015	2.4407	0.7042	0.2136	0.2726	0.0770	0.1466	0.0308	0.0637	0.0070
1995	7.3473	3.7383	2.5442	0.7042	0.2069	0.2702	0.0798	0.1574	0.0322	0.1048	0.0126
1996	7.6992	4.7541	2.0702	0.7042	0.3589	0.1857	0.0818	0.1720	0.0319	0.0467	0.0056
1997	7.6768	4.9252	2.0173	0.8110	0.3791	0.1878	0.0804	0.1559	0.0326	0.0275	0.0115
1998	6.5257	5.5780	2.5099	0.7470	0.3972	0.0726	0.0823	0.1710	0.0330	0.0250	0.0114
1999	6.5438	5.9036	2.9952	0.6401	0.4566	0.0000	0.0809	0.1598	0.0325	0.0137	0.0126
2000	7.5872	4.0520	2.6341	0.7503	0.4449	0.0000	0.0742	0.1452	0.0322	0.0159	0.0087
2001	6.4938	3.7003	1.8866	0.5726	0.4282	0.0000	0.0570	0.0978	0.0322	0.0126	0.0062
2002	5.8081	3.7334	2.0550	0.4400	0.4292	0.1042	0.0747	0.0739	0.0326	0.0135	0.0075
2003	5.7543	3.5117	1.5456	0.4286	0.3698	0.1395	0.0659	0.0771	0.0318	0.0110	0.0051
2004	5.6217	3.7288	1.7329	0.4294	0.4220	0.1308	0.0722	0.0973	0.0317	0.0122	0.0072
2005	6.2403	3.7037	1.4776	0.3403	0.4434	0.0194	0.0715	0.0948	0.0315	0.0141	0.0096
2006	5.5074	3.7211	1.5959	0.3640	0.4545	0.2476	0.0781	0.0829	0.0313	0.0134	0.0067
2007	5.8604	3.5983	1.3904	0.3687	0.4506	0.2163	0.0773	0.0717	0.0306	0.0125	0.0067
2008	5.5389	3.6238	1.4934	0.3651	0.3203	0.1567	0.0716	0.0601	0.0296	0.0136	0.0067

Data continued in Table 9 on next page

All emissions data are expressed in Million Metric Tons of Carbon Dioxide Equivalent ($MMTCO_2e$)

[41] Assignment to economic sectors has been done following EPA protocol in the national inventory. Some variations exist from the EPA approach due to lack of Oregon-specific data or where EPA assumptions are blatantly incorrect for application to Oregon.
[42] Electricity consumption data and emissions factors are generated by the Oregon Department of Energy and input into the SIT electricity consumption module.
[43] Waste and materials data are calculated by Oregon Department of Environmental Quality and are used in place of the default data in the EPA State Inventory Tool.

Table 9: Greenhouse Gas Emissions from the Industrial Sector, Part II: Methane, Nitrous Oxide and HGWP Greenhouse Gas Emissions

	Methane					Nitrous Oxide			HGWP[44]			
	Natural Gas Distribution & Production[45]	Industrial Landfills[46]	Combustion Byproducts	Food Processing Wastewater[47]	Pulp & Paper Wastewater[48]	Combustion Byproducts	Waste Incineration	Nitric Acid Production[49]	Semiconductor Manufacturing	Refrigerants, Foam, Solvents, Aerosol Use[50]	Aluminum Production[51]	Industrial Sector Emissions
1990	0.3740	0.0696	0.0289	0.0098	0.0004	0.0597	0.0031	0.0081	0.2913	0.0006	0.3129	**13.7279**
1991	0.3789	0.0717	0.0275	0.0094	0.0004	0.0566	0.0031	0.0081	0.2913	0.0011	0.3158	**13.8307**
1992	0.3843	0.0741	0.0226	0.0091	0.0004	0.0476	0.0031	0.0081	0.2913	0.0030	0.3075	**14.4399**
1993	0.3902	0.0748	0.0203	0.0096	0.0004	0.0431	0.0036	0.0081	0.3641	0.0098	0.2813	**15.5571**
1994	0.3960	0.0779	0.0211	0.0100	0.0004	0.0444	0.0042	0.0081	0.4006	0.0223	0.2499	**15.5827**
1995	0.4009	0.0812	0.0209	0.0098	0.0004	0.0438	0.0039	0.0081	0.4950	0.0519	0.2557	**16.5695**
1996	0.4067	0.0853	0.0244	0.0104	0.0004	0.0500	0.0072	0.0081	0.5498	0.0728	0.2703	**17.5958**
1997	0.4117	0.0898	0.0259	0.0099	0.0004	0.0530	0.0072	0.0081	0.5809	0.0932	0.2723	**17.8575**
1998	0.4305	0.0947	0.0235	0.0094	0.0004	0.0489	0.0093	0.0081	0.7649	0.1069	0.2793	**17.9290**
1999	0.4281	0.0992	0.0214	0.0100	0.0004	0.0447	0.0104	0.0081	0.8346	0.1214	0.2803	**18.6973**
2000	0.3735	0.1053	0.0224	0.0078	0.0004	0.0467	0.0091	0.0081	0.7761	0.1355	0.2720	**17.5016**
2001	0.3672	0.1100	0.0213	0.0070	0.0004	0.0436	0.0118	0.0081	0.5942	0.1467	0.1911	**14.7887**
2002	0.3724	0.1158	0.0187	0.0071	0.0004	0.0393	0.0125	0.0081	0.6195	0.1584	0.0000	**14.1245**
2003	0.3778	0.1220	0.0148	0.0083	0.0004	0.0312	0.0150	0.0081	0.6228	0.1692	0.0000	**13.3100**
2004	0.3909	0.1302	0.0200	0.0091	0.0004	0.0416	0.0168	0.0081	0.6238	0.1798	0.0000	**13.7070**
2005	0.3837	0.1411	0.0198	0.0082	0.0004	0.0410	0.0179	0.0081	0.6343	0.1897	0.0000	**13.8906**
2006	0.3865	0.1555	0.0211	0.0089	0.0004	0.0438	0.0221	0.0081	0.6847	0.1994	0.0000	**13.6333**
2007	0.3817	0.1737	0.0210	0.0106	0.0004	0.0431	0.0176	0.0081	0.6774	0.2048	0.0000	**13.6217**
2008	0.3784	0.1944	0.0188	0.0099	0.0004	0.0387	0.0173	0.0081	0.7719	0.2106	0.0000	**13.3283**

All emissions data are expressed in Million Metric Tons of Carbon Dioxide Equivalent ($MMTCO_2e$)

44 High Global Warming Potential Gases (HGWP) include hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6).

45 Emissions from natural gas distribution are based on that sector's proportional share of natural gas consumption in Oregon (according to EIA) for that year. In addition, emissions from natural gas production activities have been assigned to the industrial sector in accordance with US EPA practice in the national inventory.

46 Waste and materials data are calculated by Oregon Department of Environmental Quality and are used in place of the default data in the EPA State Inventory Tool.

47 Processed food data primarily from the Oregon Department of Agriculture's agricultural statistics service and the USDA national agricultural statistics.

48 No annual data are available. Point estimate is from that developed for the inventory in the 2005 *Oregon Strategy for Greenhouse Gas Reductions* report.

49 No annual data are available. Point estimate is from EPA's GhG reporting program's *Technical Support Document for the Nitric Acid Production Sector*, January 22, 2009.

50 This category represents the consumption of ozone depleting substances (ODS) in general. Specified uses in heading are examples relevant to this sector.

51 Termination of emissions in 2001 represents rough approximation of end of aluminum production in Oregon due to lack of more specific data.

Table 10: Greenhouse Gas Emissions from the Agricultural Sector[52]

	Carbon Dioxide		Methane			Nitrous Oxide			
	Urea Fertilization	Liming of Agricultural Soils	Enteric Fermentation	Manure Management	Agricultural Residue Burning	Agricultural Soil Management[53]	Manure Management	Agricultural Residue Burning	Agriculture Sector Emissions
1990	0.0628	0.0295	2.2924	0.2288	0.0033	2.0999	0.1021	0.0012	**4.8199**
1991	0.0623	0.0247	2.3091	0.2293	0.0027	2.0035	0.1015	0.0010	**4.7340**
1992	0.0635	0.0271	2.3150	0.2344	0.0028	1.8618	0.1030	0.0010	**4.6086**
1993	0.0652	0.0289	2.3073	0.2254	0.0037	2.1483	0.0898	0.0013	**4.8699**
1994	0.0707	0.0305	2.4641	0.2394	0.0034	2.0103	0.1109	0.0012	**4.9304**
1995	0.0718	0.0327	2.6035	0.2442	0.0034	2.1530	0.1191	0.0012	**5.2289**
1996	0.0742	0.0352	2.6784	0.2378	0.0038	2.3712	0.1098	0.0013	**5.5117**
1997	0.0785	0.0378	2.6579	0.2415	0.0035	2.1985	0.1107	0.0012	**5.3298**
1998	0.0850	0.0405	2.5939	0.2427	0.0034	2.3960	0.1237	0.0012	**5.4864**
1999	0.0703	0.0417	2.5935	0.2565	0.0022	2.0040	0.1317	0.0008	**5.1007**
2000	0.0525	0.0437	2.4959	0.2669	0.0032	2.0962	0.1427	0.0011	**5.1022**
2001	0.0803	0.0375	2.3500	0.2720	0.0019	2.1421	0.1480	0.0007	**5.0324**
2002	0.1292	0.0327	2.4501	0.3175	0.0020	2.3711	0.1505	0.0007	**5.4537**
2003	0.1440	0.0335	2.4068	0.3090	0.0030	2.3251	0.1529	0.0010	**5.3753**
2004	0.1202	0.0394	2.5686	0.3485	0.0032	2.4377	0.1625	0.0011	**5.6811**
2005	0.1169	0.0428	2.6152	0.3489	0.0029	2.2151	0.1381	0.0010	**5.4809**
2006	0.1218	0.0407	2.5693	0.3397	0.0025	2.4358	0.1447	0.0009	**5.6554**
2007	0.1281	0.0397	2.4208	0.3369	0.0025	2.7082	0.1421	0.0009	**5.7792**
2008	0.1264	0.0368	2.5403	0.3402	0.0029	2.2686	0.1428	0.0010	**5.4590**

All emissions data are expressed in Million Metric Tons of Carbon Dioxide Equivalent ($MMTCO_2e$)

[52] Assignment to economic sectors has been done following EPA protocol in the national inventory. Note that for the agricultural sector in particular the US EPA protocol could not be applied in its entirety due to the lack of state-specific data on electricity consumption, fuel consumption, and in other areas that are all used in the national inventory to partition things like irrigation energy use and farm equipment use to the agricultural sector. Therefore this sector is underestimated in the Oregon sector-based inventory relative to the national inventory and line items in other sectors (such as commercial electricity use) may be slightly overestimated since those sectors contain some portion of emissions that could be applied to the agricultural sector (e.g., farm equipment is in the transportation sector in this inventory).

[53] The fertilizer data used are from the Oregon Department of Agriculture. Those data are used in place of default data within the US EPA State Inventory Tool.

Table 11: In-State Electric Power Generation Emissions and Adjustment to Derive Production-Based Gross Inventory for Oregon[54]

	Carbon Dioxide[55]			CH_4	N_2O	HGWP[56]			Production-Based 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[57]	Electric Power Generation Sub-total	ADD POWER GENERATION SUB-TOTAL TO TOTAL	Remove Total Electricity Use Emissions	Gross GhG Emissions, Production Basis
1990	0.4021	1.3689	0.0241	0.0037	0.0132	0.4219	**2.2339**		(16.64)	**41.4337**
1991	0.6224	2.9778	0.0099	0.0035	0.0198	0.4033	**4.0367**		(16.90)	**45.0397**
1992	0.7917	3.7130	0.0080	0.0036	0.0232	0.3948	**4.9344**		(16.62)	**46.1009**
1993	0.9270	3.3585	0.0240	0.0034	0.0214	0.3840	**4.7183**		(20.67)	**46.2036**
1994	1.4347	4.0140	0.0047	0.0040	0.0253	0.3558	**5.8385**		(20.86)	**47.9929**
1995	1.0453	1.6742	0.0050	0.0040	0.0151	0.3247	**3.0683**		(21.21)	**45.8703**
1996	1.4236	1.7689	0.0044	0.0039	0.0152	0.3055	**3.5216**		(21.89)	**48.6230**
1997	1.3017	1.3885	0.0100	0.0037	0.0132	0.2770	**2.9941**		(22.08)	**48.4439**
1998	2.8563	3.3076	0.0253	0.0050	0.0242	0.2192	**6.4376**		(20.91)	**54.5342**
1999	2.6752	3.5390	0.0066	0.0040	0.0237	0.2239	**6.4724**		(22.06)	**55.6335**
2000	3.7458	3.5483	0.0450	0.0050	0.0254	0.2210	**7.5905**		(23.35)	**53.9349**
2001	4.4663	3.9760	0.0783	0.0054	0.0280	0.2037	**8.7576**		(22.77)	**52.5977**
2002	3.0103	3.3584	0.0060	0.0039	0.0226	0.1889	**6.5901**		(21.38)	**51.2072**
2003	4.0271	3.9775	0.0432	0.0052	0.0278	0.1806	**8.2614**		(21.76)	**51.3946**
2004	4.7993	3.2139	0.0171	0.0026	0.0189	0.1792	**8.2309**		(21.48)	**53.1572**
2005	4.7578	3.2472	0.0402	0.0063	0.0265	0.1770	**8.2550**		(22.86)	**53.2467**
2006	4.0834	2.2215	0.0049	0.0057	0.0206	0.1731	**6.5092**		(20.40)	**52.6794**
2007	5.5589	3.9546	0.0039	0.0062	0.0293	0.1643	**9.7171**		(21.78)	**56.2940**
2008	6.3092	3.6418	0.0092	0.0049	0.0252	0.1721	**10.1625**		(21.07)	**55.3891**

All emissions data are expressed in Million Metric Tons of Carbon Dioxide Equivalent ($MMTCO_2e$)

[54] Oregon, along with many states, has included the emissions associated with electricity use in its greenhouse gas inventory for many years primarily to recognize the fact that emissions occur with the use of fossil-fueled electricity regardless of the location of the power plant that generates that electricity. Using emissions attributable to in-state power generation (rather than power consumption) is done by the federal government for the US national inventory and by US DOE for state-level reporting. Data using this type of "production based" method are derived above from the full inventory for purposes of comparison. Please note that it is not correct to assume that the difference between electricity use emissions and in-state emissions equals electricity import emissions. Oregon exports some power emissions to other states.

[55] Data on electric power generation emissions are from the US EPA State Inventory Tool, but please note that US EPA and US DOE emission estimates frequently vary for the same source or sources. Please use caution when comparing these results with US DOE greenhouse gas data.

[56] High Global Warming Potential Gases (HGWP) include hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6).

[57] This sector-based inventory approach does not provide an obvious "fit" for electricity T&D emissions. Users of these data may wish to partition them to other sectors.

Table 12: Land Use, Land Use Change, and Forestry (LULUCF) Estimates for Emissions and Sequestration

	Carbon Dioxide				CH_4	N_2O					
	Forests (includes forest fire)[58] (3-yr rolling average)	Croplands (3-year rolling average)	Waste in Landfills Originating from Oregon[59]	Urban Trees	Forest Fires:[60] Methane from Burning	Forest Fires: Nitrous Oxide from Burning	LULUCF Sector Emissions (removals)	Oregon Net GhG Emissions	Sequestration as Percent of Oregon Inventory	Net GhG Emissions, Production-Based	Sequestration as Percent of Production Inventory
1990	(6.25)	2.30	(0.82)	(0.54)	0.31	0.06	(4.93)	50.91	8.84%	36.50	11.91%
1991	(5.74)	(1.44)	(0.82)	(0.55)	0.04	0.01	(8.51)	49.40	14.69%	36.53	18.89%
1992	(24.49)	1.26	(0.82)	(0.57)	0.27	0.05	(24.30)	33.48	42.06%	21.80	52.72%
1993	(22.08)	(2.63)	(0.83)	(0.58)	0.00	0.00	(26.12)	36.03	42.03%	20.08	56.54%
1994	(36.80)	1.45	(0.84)	(0.59)	0.34	0.07	(36.37)	26.64	57.72%	11.62	75.79%
1995	(22.75)	(1.20)	(0.85)	(0.60)	0.02	0.00	(25.38)	38.63	39.65%	20.49	55.33%
1996	(46.50)	2.48	(0.89)	(0.61)	0.92	0.18	(44.41)	22.58	66.29%	4.21	91.34%
1997	(30.20)	(0.71)	(0.93)	(0.63)	0.01	0.00	(32.45)	35.08	48.05%	15.99	66.98%
1998	(20.41)	(3.02)	(0.94)	(0.64)	0.04	0.01	(24.97)	44.03	36.19%	29.56	45.80%
1999	(11.82)	(1.72)	(0.94)	(0.65)	0.09	0.02	(15.03)	56.19	21.11%	40.60	27.02%
2000	(13.99)	(3.06)	(0.91)	(0.66)	0.19	0.04	(18.40)	51.29	26.40%	35.53	34.12%
2001	(6.86)	(3.27)	(0.84)	(0.67)	0.20	0.04	(11.41)	55.20	17.13%	41.19	21.69%
2002	6.85	(7.03)	(0.83)	(0.69)	3.80	0.76	2.87	68.86	0.00%	54.08	0.00%
2003	No Data	No Data	(0.84)	(0.70)	0.66	0.13					
2004	No Data	No Data	(0.92)	(0.71)	0.12	0.02					
2005	No Data	No Data	(0.99)	(0.72)	0.16	0.03					
2006	No Data	No Data	(1.09)	(0.73)	0.44	0.09					
2007	No Data	No Data	(1.13)	(0.75)	1.06	0.21					
2008	No Data	No Data	(1.03)	(0.76)	0.34	0.07					

All emissions and sequestration data are expressed in <u>Million Metric Tons of Carbon Dioxide Equivalent ($MMTCO_2e$)</u>

Carbon flux data for forests and croplands are derived from ongoing research at the Oregon State University. The data are subject to change. For more information on the use of this research: http://www.orclimatechange.gov/ENERGY/GBLWRM/docs/Oregon_Forests_GHG_Inventory_OGWC_Report_Final.pdf

[58] Emissions from forest fires are part of the larger flux of forest carbon involving both sequestration and release. Forest fire data should be viewed in this context.
[59] Waste and materials data are calculated by Oregon Department of Environmental Quality and are used in place of the default data in the EPA State Inventory Tool.
[60] The inclusion of non-CO_2 emissions from forest fire is controversial. US EPA includes it in the national inventory so these data are here for consistency. This follows international accounting practice, which presumes most forest fire is anthropogenic in origin. Whether the same assumption holds for Oregon is debatable.

Table 13: "Business as Usual" Forecast of Oregon Greenhouse Gas Emissions: 2010 through 2030

	2010	2015	2020	2025	2030
Energy					
Fossil Fuel Combustion (excludes in-state power generation)	34.788	38.465	39.491	41.503	42.411
Emissions Associated with the Use of Electricity	20.368	20.781	21.710	22.539	23.680
Stationary Combustion Byproducts (CH_4 & N_2O)	0.155	0.156	0.155	0.153	0.150
Mobile Combustion Byproducts (CH_4 & N_2O)	0.442	0.402	0.362	0.322	0.282
Natural Gas and Oil Systems	0.958	0.986	1.019	0.957	0.971
Industrial Processes	3.207	3.339	3.470	3.601	3.732
Agriculture					
Enteric Fermentation	2.473	2.405	2.290	2.174	2.059
Manure Management	0.512	0.529	0.542	0.555	0.568
Agricultural Soil Management[61]	2.662	2.790	2.919	3.048	3.177
Burning of Agricultural Crop Waste	0.003	0.003	0.003	0.002	0.002
Waste					
Solid Waste	1.840	2.153	2.330	2.532	2.735
Wastewater	0.388	0.414	0.440	0.467	0.493
"Business as Usual" Forecast Total (including emissions associated with the use of electricity)	**67.797**	**72.421**	**74.730**	**77.854**	**80.260**

All emissions data are expressed in Million Metric Tons of Carbon Dioxide Equivalent ($MMTCO_2e$)

The "business as usual" (BAU) forecast has been developed using the US EPA Projection Tool, which is part of the US EPA State Inventory Tool (SIT). Energy –based emissions are largely derived from the Energy Information Administration's Annual Energy Outlook forecast for 2010. Oregon data are derived by estimating Oregon's proportional share of the Pacific regional forecast based on 2008 energy consumption data for the states in the Pacific region. Electricity consumption is derived similarly, and BAU emissions are forecast using a 3-year average of Oregon's current net electricity mix (for 2007-2009). Industrial emissions are largely based on either trended historical data or Oregon's share of estimates developed for the national inventory (e.g., ODS substitutes). Waste forecast developed by Oregon DEQ, and is same as is used in the *Oregon Strategy for Greenhouse Gas Reductions*. Agricultural data are derived from a variety of USDA sources and linear forecasting. Wastewater is largely correlated with estimates of population growth.

The EPA Projection Tool is based on a traditional greenhouse gas emissions accounting framework, in contrast to the less traditional sector-based framework used for the inventory. For this reason, and others, the projection tool tends to produce discontinuities between the historical data and the forecast data. To better link the historical emissions data with the forecast data some data smoothing was done by trending data and linking it to the far reach of the forecast in 2030. Some additional emission categories were added through linear trending for categories not in the projection tool. This forecast, as with any forecast, is subject to numerous assumptions and a substantial margin of error (at least ± 10 percent) should be assumed when using and interpreting these data.

[61] Includes the application of lime and urea fertilization.