The Oregon Global Warming Commission

Interim Roadmap to 2020

Roadmap Elements as Adopted by the Oregon Global Warming Commission on October 28, 2010

The Interim Roadmap As Adopted Will Be Incorporated into the Commission's 2011 *Report to the Legislature*.

October 29, 2010

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The "Roadmap to 2020" Process

In 2010 the Oregon Global Warming Commission is undertaking a "*Roadmap to 2020*" Project that will offer 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.

Commission recommendations will be addressed to the next Governor, the Legislature, our Congressional delegation, local governments, businesses and Oregonians generally.

The initial work of describing scenarios, sifting through possible recommendations and evaluating them, has been done by six technical committees drawn from business, academia, non-governmental organizations, local government and state agency staff.

Technical committee draft recommendations were presented to the Commission on October 8. The Commission adopted the roadmap as an interim document on October 28. This is the compilation of all of the Roadmap elements adopted by the Commission at that meeting, including the resolution adopting the Interim Roadmap (see next page).

These Interim Roadmap elements will be incorporated into the Commission's upcoming Report to the Legislature due in early 2011.

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.

By the end of 2011 the Commission is planning to finalize all aspects of the Roadmap.

Please visit the Commission's web site at http://www.keeporegoncool.org for more information on the Roadmap process and the Commission.

Resolution Adopting the Interim Roadmap

Resolution of the Oregon Global Warming Commission

Resolution Number: 2010-3-014
Origin: Angus Duncan, Commission Chair

Adoption of an Interim "Roadmap to 2020" Report

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.

ADOPTED

Integrating Commission "Roadmap to 2020" Recommendations

(not sector-specific)

I. Greenhouse Gas Reduction Goal for 2030

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; NW Planning Council 20 year power plans; utility Integrated Resource Plans, etc.).

II. Greenhouse Gas Inventories

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.

III. Advocating for a national carbon cap or other equally effective national carbon reduction measure.

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.

IV. Energy and Infrastructure Research Funding Priority

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.

Energy Roadmap to 2020

Report to the Oregon Global Warming Commission

The following report, *Energy Roadmap to 2020*, was developed by the Energy Technical Committee of the Oregon Global Warming Commission (OGWC). Energy Committee members are listed in Appendix B of this report.

I. PURPOSE AND CONCLUSIONS

The purpose of the Committee was to develop and prioritize a set of strategies and actions for to reduce greenhouse gas (GHG) emissions from energy production and use in order to meet Oregon's 2020 greenhouse gas goal. The recommendations will be considered by the Oregon Global Warming Commission for inclusion in the Interim Roadmap to 2020/Report to the new Governor and Legislature, to state agencies, and to Oregon's Congressional delegation. Recommendations may also guide private sector investments and university research agendas.

After several months of deliberations the Committee narrowed the list of recommended actions down to the following Key Actions. Appendix A contains the consolidated Inventory of Actions developed by Energy Technical Committee. The Committee's Key Actions are more fully described in Section III – Key Actions For 2020. In summary they are:

- Develop State Energy and Climate Policy
- Energy Efficiency
- Support and Plan for New Transmission
- Phase Out Emissions Associated with Coal Generation
- Oregon University System (OUS) Energy Research Priorities
- Modern Gas Infrastructure
- Smart Grid and Integration of Resources

The Committee recognized that In all our state's greenhouse gas reduction strategies, while Oregon 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. 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.

II. FUTURE STATEMENTS

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 building, 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[1], 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

[1] Includes some new hydro capability resulting from efficiency investments in existing facilities.

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[2] 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[3] – 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

[2] The "Western Wind and Solar Integration Study" (NREL/SR-550-47781) published by the National Renewable Energy Laboratory (NREL) in May, 2010, estimated that a wind/solar (30%/5%) system penetration rate on the WestConnect Grid was technically and operationally feasible even without the hydro system flexibility available to the PNW grid. WestConnect includes utilities in AZ, NV, NM, CO and WY.

[3] See "Electrification Roadmap", The Electrification Coalition, November, 2009, p 99: estimates 10% to 12% increase in electricity load nationally from 60% LDV market penetration.

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).

III. KEY 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. 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

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

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

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 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

Coal-fired electricity generation to serve Oregon load emits a significant share of total CO2 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

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

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

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, and the improvements in the integration of renewable resources including tapping demand-side flexibilities as described in Recommendation 23.

APPENDIX A
Technical Committee Recommended Actions

	ACTIONS/RECOMMENDATIONS	DESCRIPTION			METRIC				COMMENTS
		Lead Gov, Agency, Private, etc.?	Type of Action (use word) Incentive, Tax/Fee, Regulation; Standard,	Timing of Impact (Short = 1-5 yrs) Medium = 5-10 yrs	GHG Savings? (Y/N, Quantity)	Fossil Fuel Savings? (Y/N, Quantity)	Cost (Savings)?	C/E (High, Medium, Low)	Co-benefits? Risks/Tradeoffs? Unintended Consequences? Politics? Adaptation Value? (use concise narrative)
Policy/Planning									
1	**Develop State Energy and Climate Policy:** 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 and social 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 should speak to statewide and sector-specific goals, and not apply to specific entities. 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	**Align Building Code with GHG Goals:** Oregon building and equipment energy codes should be aligned with its GHG reduction goals over a planning horizon of > 20 years to allow households and businesses to plan and budget with confidence.								
Codes and Standards									
3	**Fuel-blind Space/Water Heat Standard:** Oregon should establish a life-cycle fuel-blind carbon-efficiency standard (BTU's/tonne CO2e assuming the marginal generating resource) for residential and commercial space and water heating, and should systematically transition the standard from incentive into code.								
4	**Appliance and Lighting Codes and Standards:** Oregon should revisit its appliance and lighting incentive and code criteria at least every five years to capture the benefits of likely continuous improvements in efficiencies. For example, Oregon can adopt (initially for its incentive programs, then transitioning into code), the Association of Home Appliance Manufacturers 2010 standards for								

	refrigerators, freezers, washers, dryers, dishwashers and air conditioners. Oregon should look first to advocate for timely improvements in federal standards, then to cooperative initiatives with other States.								
5	**"Retrofit" Building Energy Efficiency Code:** Oregon should develop a "retrofit" energy efficiency code requirement, developed to reflect life-cycle cost-effectiveness (including a carbon adder) of retrofit measures, which will be different from cost-effectiveness in new construction. Oregon should require that any residential or commercial building be brought into compliance with this code at point of property transfer or major remodel/rehabilitation, with the State also providing access to financing through existing and new financing tools.								
6	**Carbon Efficiency Feebate:** Oregon should design and implement a GHG "feebate" for residential energy use that imposes a GHG surcharge (to the property tax) on homes exceeding a "full-time resident x energy consumption" metric. Revenues may be applied first to efficiency retrofits of affected dwellings, then to State energy efficiency programs generally.								
7	**Commercial Building Commissioning:** Oregon code should require that all new commercial buildings (> XX sq ft) undergo building energy systems commissioning as a condition of building inspector signoff; and to undergo recommissioning on schedules that are shown to be cost-effective.								
8	**Energy Management Equipment in Building Code:** Oregon building codes should establish minimum energy								

	management equipment requirements for new and retrofit residential and commercial buildings (e.g., setback thermostats; motion-detection light switches; "vampire" load controls; etc.).								
9	**Rental Housing:** Oregon should require third-party-owned rental housing to be brought into compliance with the Retrofit Efficiency Code at point of sale or major remodeling but not less often than every ten years.								
Finance/Economics/Incentives									
10	**Invest State Revenues in Energy Efficiency:** Oregon should assign priority, in its investment policies for State funds (revenues; pension funds), to investing those funds in Oregon energy efficiency on a showing of comparable risk-return.								
11	**State Energy Financing Platform**: Oregon should develop a State energy facilities financing platform that can attract and deploy capital investment (equity and debt) raised from multiple sources (State funds; bond revenues; private sector investment; utility investment; LID or neighborhood REIT investment; individual investment; etc.) on energy efficiency, infrastructure and distributed generation, relying first upon the Energy Trust of Oregon (in investor-owned utility territory) and consumer-owned utilities (in their territories) to deploy the funding. Homeowners and business owners could also qualify to access the funding.								
12	**Utility Investment in Energy Efficiency:** Where circumstances (e.g., market barriers; large "lumpy" investment requirements) suggest value can be added to Oregon's existing energy efficiency capture capabilities by								

	allowing direct utility investment, the Oregon Public Utility Commission should have authority to permit such investments by Investor-Owned Utilities in energy efficiency, distributed generation and related infrastructure (including controls and storage) in a manner that puts these investments on an even playing field with supply-side investments.								
13	**Incent High Performance Buildings**: Oregon should set a standard for high performance buildings that meet a goal of reducing life-cycle building related GHG emissions by 80 percent from the current baseline and provide a financial incentive (no property tax payments for 20 years?) for the first 1000 High Performance residences commissioned in the State; and the first 100 High Performance commercial structures.								
14	**Convert Energy Tax Credits into Grants:** Oregon and federal investment tax incentives (BETC; ITC) should be redesigned as grants (monetized) to allow third party facility development and non-profit institutional development of qualifying facilities to access these incentives without (as now) being obliged to transfer a significant share of the value to third-party financing, legal and other transaction costs.								
15	**Authorized RETC for Distributed Energy:** Oregon should allow taxpayers to claim Residential Tax Credits (RETC) for heat pump water heaters, solar photovoltaic systems and solar hot water systems and other distributed generation resources (e.g., Combined Heat/Power [CHP] systems; fuel cells).								
Infrastructure									
16	**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.								
17	**Support Combined Heat and Power (CHP) with Co-location and Other Incentives:** Oregon should support and incent, with land use/zoning variances and investment incentives, the co-location of industrial uses that in turn will support a doubling of CHP capacity by 2015, and a further doubling by 2020.		Standard						
18	**Support and Plan for New Transmission**: 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		Standard						

	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 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).								
19	**Modern Gas Infrastructure**: 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 "the best fuel for the best use;" these policies should in turn inform utility Integrated Resource Plans (IRPs). Where a showing is made of net greenhouse gas reduction potential from the direct use of natural gas for critical space and water heating, State policy should prioritize such use		Technical						
Fuels/Conversion Technologies and Operations									
20	**Phase Out Emissions Associated with Coal Generation:** Absent technological and economic breakthroughs in								

	Carbon Capture and Sequestration (CCS) or other carbon abatement technologies, it appears highly unlikely that an Oregon 2020 emissions goal (or a 2030 interpolated target) can be met without a phase-out of service from coal-fired power plants. Thus, subject to the conditions identified here, Oregon utilities should begin immediately the planning necessary to cease service to Oregon loads from coal-fired generation, with substantial progress achieved by 2020 and the task largely completed by 2030. Other conditions 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. The process of phasing out coal service should proceed within prevailing IRP processes for Oregon's utilities, including thorough IRP evaluations of the benefits, costs and effects on quality and reliability of service of alternate pathways to these goals.								
21	**New Generation Attributes**: PNW utilities, planners and regulators should place a priority on the *flexibility*								

	attributes of new generating and demand side resources to be introduced into the grid (e.g., ramp response rates; siting for system value)								
22	**Hydropower**: Subject to requirements to operate the Columbia River hydropower system to support healthy salmonid populations and overall ecosystem function, federal and non-federal operators should seek to maximize the generation and operations flexibility of the system to reliably serve utility loads, deliver low carbon power and integrate new low-carbon resource additions (including new capacity and storage capabilities where feasible).								
23	**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.								

24	**Regional Integration Services**: The State should collaborate with BPA and other regional parties to ensure that sufficient ancillary services are available to support the development of non-dispatchable/variable renewable resources, and to ensure that the provision of these services does not raise rates to Oregon consumers and does not impair electric reliability.								
25	**Solar Pre-Heating of Water**: Where economically competitive (when compared to other distributed renewable energy sources) and physically feasible (e.g., available installation space; solar access), solar water heating equipment should be a preferred and incentivized pre-heat treatment of residential and commercial hot water supplies. Incentives for this technology will be expected to broaden the market and lower both equipment and installation costs – as is the expectation for PV technology.								
Other									
26	**Support and Strengthen Existing State and Regional Energy Efficiency Tools:** Oregon and the Pacific Northwest have benefited greatly over the years from the planning and delivery capabilities of the NW Conservation and Power Planning Council, the NW Energy Efficiency Alliance, the Energy Trust of Oregon, CleanEnergyWorks (Portland), Battelle NW Laboratory and other entities. Oregon and its investor and consumer-owned utilities must continue to invest in, and extend the reach and capacity of, these institutions if it is to meet its climate and energy goals								
27	**Incent Urban Density, Design**: Oregon metropolitan areas should give preferential property tax treatment and other								

	incentives to encourage higher density common-wall residential developments that also offer energy efficient access to transit and urban services ("locational" efficiencies).								
28	**Water Efficiency**: Oregon should prioritize water efficiency in the supply, delivery, use and disposal of water supplies, to mitigate the energy consumption involved in water resource management.								
Research									
29	**Energy, Carbon Research Funding and Agenda**: Oregon should advocate, through its Congressional delegation and in national policy forums (e.g., WGA) for strengthened national energy and carbon research budgets, with funding allocated based upon least cost, most promising technological and behavioral pathways to achieving national energy and carbon goals.								
30	**OUS Energy Research Priorities:** Oregon should support, through the Oregon University System, 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.								
31	**Advanced Energy Research Initiative:** Oregon should consider an Energy Systems Advanced Research Center to attract and concentrate the science and engineering talent to take a leadership position in development and application of selected energy technologies and								

	applications where opportunities for Oregon businesses can be identified.								
32	**Equipment Replacement Protocols:** NEEA, ETO and utilities should develop and maintain protocols for commercial and industrial equipment replacement that weigh embedded carbon against evolving equipment efficiencies. The protocols should be easily accessible to companies deciding whether to keep or replace equipment.								

APPENDIX B

Energy Technical Committee Members

Name	Organization
Paul Norman	Chair
Jason Eisdorfer	BPA
Bob Jenks	CUB
Michael Armstrong	City of Portland
Terry Morlan	NW Power and Cons. Council
John Mohlis	ColPac Bldg Trades Council
Reuben Plantico	PGE
Tom O'Connor	Oregon Municipal Utilities Assoc.
Angus Duncan	Global Warming Commission
Bill Drumheller	ODOE
Phil Carver	OPUC
Erik Colville	OPUC
Bill Edmonds	NW Natural Gas
Robert Procter	Oregon PUC
Jason Heuser	EWEB
Dick Varner	EWEB

Transportation and Land Use Roadmap to 2020

Report to the Oregon Global Warming Commission

The following report, *Transportation and Land Use (T&LU) Roadmap to 2020*, was developed by the T&LU Technical Committee of the Oregon Global Warming Commission (OGWC). Technical Committee members are listed in Appendix A of this report.

I. PURPOSE AND CONCLUSIONS

The purpose of the Committee was to develop and prioritize a set of strategies and actions for reducing greenhouse gas emissions from transportation and land use choices to meet Oregon's 2020 greenhouse gas (GHG) goal. The recommendations will be considered by the Oregon Global Warming Commission for inclusion in the Interim Roadmap to 2020/Report to the new Governor and Legislature, to state agencies, and to Oregon's Congressional delegation. Recommendations may also guide private sector investments and university research agendas.

After several months of deliberations the Committee narrowed the Key Actions from a possible 120 actions down to 12. Appendix B contains the consolidated Inventory of Actions developed by T&LU Technical Committee. The Committee's "Clean Dozen" are more fully described in Section III – Key Actions For 2020 of this report. In summary they are:

1. Change the Way We Fund Transportation
2. Develop New Funding Sources
3. Expand Urban Transit
4. Create Complete Neighborhoods
5. Keep Urban Footprints Compact
6. Move Freight the Low-Carbon Way
7. Plan to Mitigate GHGs and Adapt to Climate Change
8. Expand Intercity Transportation Options/Choice
9. Reduce Demand by Increasing Options
10. Manage and Price Parking
11. Support Electric Vehicles
12. Adopt Low Carbon Fuel Standard

The Committee noted that the greater part of its recommendations are focused on transportation and land use choices in Oregon's urban areas, although many are applicable statewide (more

efficient freight and intercity transit, along with access to electric vehicle technologies, offer opportunities to urban and rural Oregonians alike). The focus was neither accidental nor reflecting an urban bias; rather it was recognizing that the majority of efficiency gains and greenhouse gas savings must be contributed by residents of Oregon's cities, where densities make options like transit more cost-effective and feasible. By contrast, access to shopping and services in many of Oregon's smaller communities is already relatively clustered and efficient.

II. FUTURE STATEMENTS

The following *Future Statements* are intended to describe what the year 2050 might look like with carbon reduction in alignment with Oregon State goals, based on the implementation of the Actions for 2020 noted above and throughout this document (i.e. back-casting exercise from 2050). It is critical to align these actions with our 2050 visions recognizing that these actions can be either enabling (funding shifts) or constraining (land use and other actions reducing VMT/demand) over the long-term. The Committee used these statements to guide our development of present day key actions that need to occur by 2020. The statements are categorized into four topic areas:

- How We Move Goods
- How We Move People
- How We Use Land
- How We Make Transportation Choices, and Fund Them

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.[4] 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

[4] 2012 is recognized as a transition year as current UGB analyses will be complete in both the Eugene-Springfield and Portland Metro regions. It's recommended that UGB reviews post-2012 include no expansion options together with Complete Community Plans.

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 operational 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. KEY 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:

1. Change the Way We Fund Transportation
2. Develop New Funding Sources
3. Expand Urban Transit
4. Create Complete Neighborhoods
5. Keep Urban Footprints Compact
6. Move Freight the Low-Carbon Way
7. Plan to Mitigate GHGs and Adapt to Climate Change
8. Expand Intercity Transportation Options/Choice
9. Reduce Demand by Increasing Options
10. Manage and Price Parking
11. Support Electric Vehicles
12. Adopt Low Carbon Fuel Standard

While this list represents the T&LU Technical Committee's top 12 actions, many more actions were considered (see Appendix B). 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

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

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

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.[5]

The Federal Transit Administration has also assessed the carbon footprint of transit agencies and compared their performance to that of other modes.[6] FTA's analysis found that "national averages demonstrate that public transportation produces significantly lower GHG emissions per passenger mile than private vehicles."[7] Analysis specific to TriMet found riders emitting 53% less GHG per passenger mile than the national average for single-occupancy private vehicles.[8]

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.[9]

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

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

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

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 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

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

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

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[10] requirements to develop a statewide strategy to reduce GHG emissions from the transportation sector, set targets for reduction of GHG

[10] 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.

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

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

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[11] 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.[12] 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.

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

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

9. Reduce Demand by Increasing Options

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.
- 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

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 USEPA 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.[13]

11. Support Electric Vehicles

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. [14]

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).

[13] US EPA (1997) "Opportunities to Improve Air Quality through Transportation Pricing Programs
[14] The EC-Vehicle Electrification Roadmap, published in 2010, projected a 5% by 2020 national target.

- 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.

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

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% by 2020. 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.

APPENDIX A

T&LU Technical Committee Members

T&LU Technical Committee	Email	Work	Cell
1. Mike Hoglund (Metro) *Co-chair*	Mike.Hoglund@ oregonmetro.gov	503.797.1743	503.477.0374
2. Alan Zelenka (City of Eugene /MPO) *Co-chair*	AlanZelenka@ KennedyJenks.com	541.338.8135	541.228.6331
3. Jim Edelson (Ecumenical Ministries)	edelson8@ comcast.net	503.231.4665	
4. Ethan Seltzer (Portland State University)	seltzere@ pdx.edu	503.725.5169	
5. Eric Hesse (TriMet)	hessee@ trimet.org	503.962.4977	
6. Peter Hurley (City of Portland)	peter.hurley@ trans.ci.portland.or.us	503.823.5007	
7. Dave Mayfield (Electric Transportation Engineering Corporation)	dmayfield@ etecevs.com	503.278-3455	503.919.0304
8. Chris Hagerbaumer (Oregon Environmental Council)	chrish@ oeconline.org	503.222.1963 ext 102	503.593.1537
9. Scott Drumm (Port of Portland)	Scott.Drumm@ PortofPortland.com	503.415.6540	503.568.4960
10. Bob Cortright (Department of Land Conservation and Development)	bob.cortright@ state.or.us	503.373.0050 x241	

11. Tom Schwetz (Lane Transit)	Tom.Schwetz@ ltd.org	541.682.6203	541.501.8474
12. Eric Lemelson (Oregon Global Warming Commission*)*	eric@ lemelsonvineyards.com	503.852.6419	503.951.7195
13. Margi Bradway (Oregon Department of Energy)	Marjorie.C.Lifsey@ state.or.us	503.986.3491	503.930.3064
Justin Klure (Pacific Energy Ventures) *Staff*	jklure@ peventuresllc.com	503.475.2999	503.475.2999

APPENDIX B

T&LU Inventory of Actions

ACTIONS/RECOMMENDATIONS	DESCRIPTION			METRIC				COMMENTS
CATEGORIES **I. Improve Light Duty, Transit and Government Fleet Technology** A. Fleets B. Passenger Cars **II. Reduce Carbon Content of Fuels** **III. Facilitate Fewer Miles Traveled by Passenger Cars** A. Land Use & Smart Growth B. Non-motorized Transportation C. Public Transportation D. Transportation Demand Management E. Pricing & Unbundling Fixed Costs **IV. Move Goods Efficiently** A. Freight Movement B. Vehicle Technology C. Vehicle Operations **V. Optimize Vehicular Flow & Operations** (i.e., improve efficiency of transportation network to optimize traffic speed & flow and ensure vehicles are maintained/operated to maximize fuel efficiency) A. Transportation System Management/Operations B. Vehicle Maintenance & Operations **VI. Enhance Decision-Making** (i.e., incorporate climate change metrics into decision-making, conduct research, involve public, enable best solutions implementation by modifying and expanding funding) A. Decision-Making Frameworks B. Public Involvement & Education C. Funding	**Lead** Gov, (G) Agency (A) , Private (P), etc.	**Type of Action** Incentive (Int), Tax/Fee,(T/F) Regulation (Reg), Standard (Stnd), Information (Info) , Technical Research (TR), etc.	**Timing of Impact** (Short = 1-5 yrs) Medium = 5-10 yrs. Long = > 10 yrs	**GHG Savings** (Y/N, Quantity)	**Fossil Fuel Savings** (Y/N, Quantity)	**Cost (High, Medium, Low)**	**C/E** (Y/N)	Co-benefits Risks/Tradeoffs Unintended Consequences Politics Adaptation Value (*use concise narrative*)
	The information above will continue to be collected and analyzed as it becomes available.							

I. Improve Light Duty, Transit and Government Fleet Technology									
	A. Fleets								
1	Convert Tri-Met, other bus transit fleets to hybrid or equivalent or better Low Emissions technology								
2	Develop, adopt and implement model "Green Fleet" policies for public and private sector fleets, including operational improvements, retrofits, and aggregated volume purchases for vehicles (light-duty, heavy-duty, and bus) fuels, tires to maximize purchasing power. Require adoption and compliance by public agencies.				0.1 CA				
3	Maximize state and local government purchase of clean diesel or non-diesel school buses and other heavy-duty vehicles.				0.1				
	B. Passenger Cars								
4	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. 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.								
5	Provide training for fleet managers on how to educate employees about fuel-efficient driving techniques.				0.12 OR 0.26* - 0.30 CA				
6	Prevent tampering with emission control systems on motor vehicles designed to reduce emissions of greenhouse gases and other pollutants.								
7	If and when mileage fee replaces gas tax, ensure that fuel efficiency is an overlay.								
8	Review and enhance state tax credits and local incentives for purchasing high efficiency vehicles.								
9	Adopt state and local incentives for high efficiency vehicles. (Vehicle registration fees, incentive/recognition).								
II.	**Reduce Carbon Content of Fuels**								
10	***Ensure an Oregon low-carbon fuels market*** through adoption of a low-carbon fuel standard				15 CA; 0.1				

	and local production of sustainable biofuels. 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.				PDX				
11	Educate consumers about the availability of and fuel-efficiency benefits of synthetic and re-refined oil.				2.8 CA		$5 20 M CA		
12	Mandate minimum biofuel content for all state-owned fueling stations.								
13	Evaluate renewable fuel standard to determine whether and when biodiesel and ethanol mandate should be increased.				0.1 M/ PDX				
III. Facilitate Fewer Miles Traveled by Passenger Cars									
	A. Land Use and Smart Growth								
14	***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.								

15	Better link leisure and recreation opportunities with transit, walking, and biking.								
	B. Non-motorized Transportation								
16	*Bicycling –related Strategies:* Create pedestrian & bicycle master plans and expand and improve pedestrian & bicycle infrastructure and connectivity. These improvements should include increasing the mileage of bicycle boulevards and shared-use paths to accommodate bicyclists of varying abilities. Require a minimum amount of long-term bicycle parking spaces for multi-dwelling development in areas other than the dwelling unit.								
17	***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 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).						M		

	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.								
18	Create pedestrian districts where only a very limited vehicle traffic is allowed in Central Business Districts and neighborhoods. These could be permanent or implemented at regular intervals.								
	C. Public Transportation								
19	***Provide efficient and reliable intercity transit, with higher-speed rail as a central component.*** 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[15] 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.								
20	***Provide efficient and reliable intercity transit,*** with higher-speed rail as a central component. Pursue its near-term plan (by 2017) to increase train speeds between Portland and Eugene 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								

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

	reducing the state's CO_2 emissions by nearly 70,000 pounds a year[16] 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.								
21	Provide free transit passes to students.								
	D. Transportation Demand Management								
22	***Implement cost-effective Transportation Demand Management (TDM) programs that increase use of travel options.*** Reward ODOT, MPOs, cities, counties and transit agencies that establish 2020 Demand Reduction targets and implement strategies to achieve the targets. 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								

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

	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.								
23	Invest in carpool vans and park and ride sites.								
24	Support investments to provide high-performance broadband connectivity to every business and residence to enable widespread e-commerce, telecommuting and improved emergency response.								
E. Pricing and Unbundling Fixed Costs									
25	***Encourage less single-occupancy vehicle travel and less travel during peak periods*** by implementing one or more parking management strategies. 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.								
26	Support federal tax credits for insurance companies that offer a pay-as-you-drive insurance product to supplement Oregon's tax credit. Court MileMeter, an insurance company in Texas that is offering a pay-as-you-drive insurance product.								
27	Develop a location-efficient mortgage program to help families buy houses close to where they work.								
28	Require developers to pay impact fees to help cover the cost of infrastructure improvements.								
IV. Move Goods Efficiently									
	A. Freight Movement								
29	***Reduce carbon emissions from freight movement*** in Oregon and help 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.).								
30	Increase the number of trucks participating in "Green Light" (weigh-in-motion) program.								

31	Review transponder and WIM requirements in CA and WA. Implement consistent equipment requirements along West coast.								
32	Develop new goals and strategies for efficient goods movement, including working with ports to adopt "green ports" goals.								
	B. Vehicle Technology								
33	Accelerate EPA regulations on diesel emissions from ships. Set and meet goals for reduced diesel consumption by ships at port by providing shore power.								
34	Design and maintain commercial harbor crafts (i.e. tugboats) to maximum efficiency.								
35	Remove Transport Refrigeration Units Cold Storage prohibition and to increase energy efficiency								
	C. Vehicle Operations								
36	Educate vessel operators about most fuel-efficient speeds to operate at.								
	V. Optimize Vehicle Flow and Operations								
	A. Transportation System Management and Operations								
37	Provide real-time information to drivers on optimal route and parking options utilizing Intelligent Transportation Systems. (i.e. –iPod apps, etc,] Utilize best practices including congestion pricing to optimize traffic flow for travel time, fuel efficiency, and GHG performance. Include speed limits, signal timing and other intelligent transportation system (ITS) solutions.								

38	Prioritize freight and non-single-occupancy vehicle movement at congestion choke-points.				0.08 CA				
B. Vehicle Maintenance and Operation									
39	Reduce the speed limit on interstates and highways.								
VI. Enhance Decision Making									
A. Decision Making Framework									
40	Include transportation emissions in any "cap-and-trade" or carbon tax mechanisms developed at a national, regional or state level.								
41	*Embed greenhouse gas mitigation and climate change adaptation goals into least cost transportation* ***and land use planning conducted by state, regional and local governments.*** 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 into the 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 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.								
42	Conduct the Household Survey not less often than every ten years, with tracking surveys to update critical data sets more frequently. Monitor statewide and local population growth rates to ensure population projections are accurate. Modify land use and transportation decisions accordingly.						M		
43	Incorporate "adapting to climate change impacts" and "reducing greenhouse gas emissions" as funding criteria for transportation investments in state, regional and local transportation decision-making venues.								
44	Require earmarks to be consistent with adopted transportation and land use plans.								
45	Partner with federal agencies, such as Housing & Urban Development, Environmental Protection Agency, and Department of Transportation, to apply new federal priorities (like the Interagency Partnership for Sustainable Communities) to support Oregon's sustainable transportation and								

	land use efforts.								
B. Public Involvement & Education									
46	Expand Safe Routes to Schools funding for improvements to existing schools and for new schools the maximize opportunities for walking and cycling. Expand outreach to students, parents and schools to encourage and promote walking and cycling. Conduct effective education campaigns, such as SmartTrips Portland and Safe Routes to School, to promote attractive alternatives to driving alone. Educate children on the personal and triple-bottom line benefits of SOV-travel.								
47	Require all new passenger vehicles sold in Oregon to be labeled as to their carbon output.								
48	Educate drivers, truckers and fleet managers about the fuel savings associated with not idling. Post signage where idling often occurs (railroad crossing, bridge lifts, etc.).								
49	Education, Training and Outreach Ensure replacement tires for cars are at least as fuel efficient (in rolling resistance) as original tires that come with the initial purchase of a vehicle. Educate drivers about the availability of and fuel savings associate with low-rolling resistance tires. Conduct public education campaigns to educate drivers on fuel-efficient driving and car maintenance techniques, including maintaining								

	adequate tire pressure. Expand outreach, marketing and education regarding climate-friendly transportation alternatives and eco-driving. For example, include eco-driving tips and information on transportation alternatives on driver registration materials. Offer drivers the opportunity to offset emissions at the same time.								
C. Funding									
50	As discussed in action #53 below, the state should adopt a "utility" methodology for assessing and charging Oregonians according to their efficient use of the transportation system. 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.								
51	***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.								

Industrial Use Roadmap to 2020

Report to the Oregon Global Warming Commission

The following report, *Oregon Industrial Use Roadmap to 2020*, was developed by the Industrial Technical Committee of the Oregon Global Warming Commission (OGWC). Technical Committee members are listed in Appendix A of this report.

I. PURPOSE AND CONCLUSIONS

The Industrial Technical Committee of the Oregon Global Warming Commission is to identify technologies, practices and policies required to contribute to meeting Oregon's greenhouse gas emission (GhG) reductions of 10% below 1990 levels by 2020 and 75% below 1990 levels by 2050. The committee's short duration did not allow for a more comprehensive development of a roadmap. Next steps recommended include: establishing intermediary goals, timeline, prioritization of strategies based on impact (emission reductions), implementation strategies, identification of implementing parties, establish follow up date to report progress. It is further recommended that environmental interests be represented on subsequent industrial committees.

The recommendations in this report will be considered by the Oregon Global Warming Commission for inclusion in the Interim Roadmap to 2020/Report to the new Governor and Legislature, to state agencies, and to Oregon's Congressional delegation. Recommendations may also guide private sector investments and university research agendas.

A summary of the key recommendations is below with a more detailed discussion in Section III. Key Actions for 2020:

1. Accelerate use of energy efficient technology and practice.
2. Establish GhG leadership recognition program.
3. Improve access to financing and incentives.
4. Build human capacity to innovate and execute industry process improvements.

Background

In 2005, Oregon industrial greenhouse gas emissions of 19.96 million metric tons represented 27% of all Oregon emissions in carbon dioxide equivalents. Those emissions include direct combustion, electricity consumption, industrial processes, methane from wastewater, nitrous oxide from waste incineration, high global warming potential gasses such as ozone-depleting substance substitutes and other CO_2 equivalent emissions from semiconductor and other manufacturing processes. The two largest categories are 1) direct combustion of petroleum and natural gas and 2)

consumption of electricity. These two categories totaled 13.2 $MMTCO_2e$ in 2005, roughly 66% of industrial emissions. In 1990, overall emissions were 16.3 $MMTCO_2e$. Reduction to 10% below 1990 levels by 2020 will require a 27% reduction of 5.3 $MMTCO_2e$ from the 2005 emissions level of 19.96 $MMTCO_2e$.

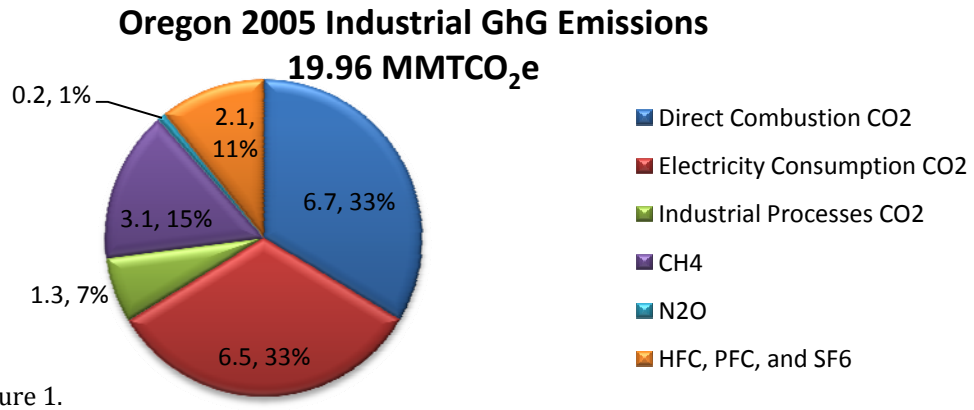

Figure 1.

Reduction of overall Oregon industry emissions to 75% below 1990 levels by 2050 would result in a reduction of 15.9 $MMTCO_2e$ or total industry emissions of 4.06 $MMTCO_2e$, which is the equivalent of more than half the emissions from direct combustion alone. Discussion with industry indicates that reduction of emission intensity per unit of production provides a manageable metric, encourages dramatic improvement, and addresses site or commodity specific processes, while positioning Oregon industry to compete globally based on environmental attributes.

Metrics of $MMTCO_2e$ intensity per unit of product from all Oregon industrial processes are not entirely known at this time. $MMTCO_2e$ benchmarking in industry, by unit of production, is nascent. Northwest Food Processors Association (NWFPA) has begun benchmarking products for energy intensity and $MMTCO_2e$, with product energy intensity as the metric for a commitment to its industry-wide energy reduction efforts.

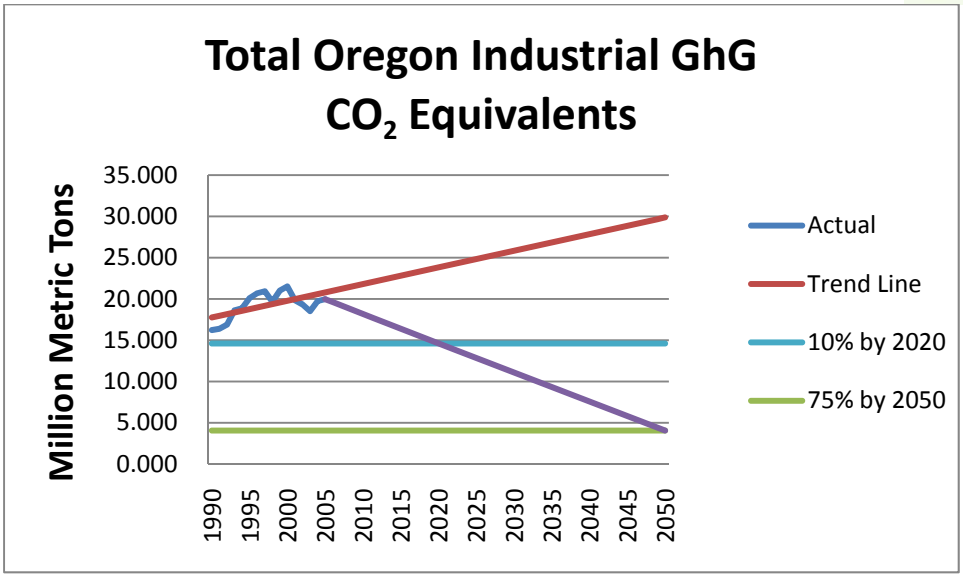

Figure 2. *Oregon Gross Greenhouse Gas Emissions Report,* Oregon Department of Energy, 2006

II. FUTURE STATEMENTS

In order to guide the recommendations, the group defined what the state of industry could be in 2020 and 2050 if Oregon Greenhouse goals were met. The following are visions and projections of the future for such a case.

Industrial Practices in 2050

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.

Industrial Practices in 2020

In 2020 Oregon industry is a national leader in applying and sharing best practices in energy efficiency, waste reduction and by-product utilization. In 2020, primary GhG emission reductions are being accomplished through stringent management, upgrade and replacement of direct natural gas using equipment. Other emissions reductions

strategies from substitutes for greenhouse gas depleting refrigeration gases and process gasses are being developed. Lean manufacturing processes are being implemented and reduce overall energy use per unit of production.

The marketplace in 2020 shows substantial progress towards addressing these market barriers. The following conditions are accelerating industries GhG reductions. Industry is sharing best practices in ways that do not threaten their competitiveness. Third parties are vetting technologies and identifying successful applications with thorough case studies, workshops and technology transfer forums readily available to industry. Industry confidence in vetted technologies is high and the characteristics of plant specific applications are readily understood and communicated. Industry sectors are collaborating on technology and practice applications. Industry and product benchmarking and metrics are being used at Oregon facilities using national level data to provide more efficacy, and broader data sets. Industries are setting energy and GhG goals to compete nationally and internationally. The state and other third parties are providing recognition and promotion of industries in the upper twentieth percentile performance on GHG emissions and energy use per unit of production. Additional capital inside and outside industry is pursuing investment in cost effective energy savings and GhG emissions reductions. Industry is realizing lower cost of production from efforts and gaining competitive advantage. The education and training available to industry is providing them with a world-class workforce fully prepared to implement continuous improvements in GhG emissions reductions, lean manufacturing, energy savings and renewable resource use. Higher education, industry associations and utility efficiency advocacy organizations provide a coordinated and complimentary array of efficiency training opportunities. Successful models of business co-location for energy systems operations, energy savings performance contracts, thermal energy sharing and combined heat an power operations exist and are details of that success are available for industry consideration.

III. KEY ACTIONS FOR 2020

To accomplish GhG reductions of 10% by 2020 requires a 27% reduction from 2005 emissions levels. 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, improvement needs to be made in streamlining and providing 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 are required to assure the capacity to lead substantive industry process change.

The following actions need to be implemented immediately to even meet the 2020 goal. It is believed these actions provide the supportive framework necessary for industry to accomplish GhG emissions reductions through voluntary participation. These actions will provide additional employment, reduce industry waste, improve their productivity

and improve their competitiveness. Achieving GhG reductions to 10% below 1990 levels by 2020 will require eliminating some 5.3 million metric tons of GhG emissions from Oregon industry per year. That is a 27% reduction in industrial emissions from 2005 levels!

Note: *More details for each of the actions below are discussed in more detail in Appendix B.*

1. Accelerate use of energy efficient technology and practice

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

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 Appendix C) 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 Appendix C).
- Assign state government to focus goals and action implementation on the top nine emissions and top ten industry sectors.

3. Improve access to financing and incentives

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

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. 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.

Impacts to Oregon's Industry

The following table estimates the possible range of investment and cost savings should Oregon GhG reduction goals be accomplished by 2020. Emissions are shown in millions of metric tons of $C0_2$ emission equivalents per year. Energy savings in the natural gas direct use and industrial process category are shown in millions of therms per year and average megawatt hours for electricity consumption. Costs are in millions of dollars by 2020 for investments. Energy cost savings is shown in millions of dollars per year for energy cost savings in 2020 at 2005 cost for energy.

Table 1.

GhG Emissions Categories	MMTCO$_2$e			Annual Energy Saved	Investment		Net Energy Savings (annual)
	1990	2005	2020 Reduction		Low Cost	High Cost	
Direct Gas Use	5.308	6.711	1.934	387 Mthm	$388	$1,163	$155
Electricity Use	6.022	6.517	1.097	265 aMW	$397	$530	$100
Processes	1.380	1.343	0.101	20 Mthm	$20	$60	$ 8
Methane	2.776	3.081	0.583	-			
Nitrous Oxides	0.132	0.172	0.053	-			
CFC,HFC SF4	0.612	2.145	1.594	-			
Sums	**16.23**	**19.97**	**5.364**	**-**	**$805**	**$1,753**	**$263**

Capital cost for implementing GhG reduction projects and practices in Oregon industry that accomplish the 2020 goal of 10% below 1990 levels will be between $800 million and $1.7 billion dollars. The measure cost estimates and any simple payback based on those costs does not take into account any federal, state local or utility incentives. Conservative energy cost savings from that reduction is expected to be at least $265 million. The range of simple rate of return on these investments is from 3 to 6.6 years. Incentives will lower this simple payback range and improve the attractiveness of industrial efficiency investments. The natural gas savings is a third of all industrial natural gas use and some 18 times the annual natural gas savings implemented by the Energy Trust of Oregon (21 million therms per year) in over a half dozen years work with all market sectors. The electric energy savings is just over all of the potential cost-effective electric energy savings identified in the NW Power and Conservation Council 6th plan for Oregon industry.

Note that energy savings and costs are not shown for Methane, Nitrous Oxides and greenhouse gas depleting gasses and their substitutes (CFC, HFC, SF4). Less is known about the costs and reduction strategies for those emissions. In the case of Nitrous Oxide emissions it is expected that addressing industry direct gas use and industrial processes will result in some reduction. Even though, it is expected that the aforementioned actions will address those emissions sources through establishment of

industry specific goals, sharing of best practices and development of Oregon specific action plans by industry segment.

Some assumptions for consideration of these estimates include:

- 2,205 pounds per metric ton of emissions
- 11 lbs CO_2 per therm of natural gas
- .96 pounds of CO_2 per kilowatt hour
- Natural gas efficiency cost range is $1 and $3 per therm saved
- Electric efficiency cost is between $1.5 million and $2 million per average megawatt hour (8,760,000 kilowatt hours)
- Natural gas cost savings assume $0.40 per therm
- Electric energy cost savings assume $44 dollars a megawatt hour

There are numerous, economic, environmental and future potential benefits to Oregon industry from accomplishment of 2020 industry GhG reduction goals. Up $1.7 billion dollars in new capital projects will create more jobs. Over $200 million in projects will have to be undertaken each year to meet these reduction goals at the estimated high cost. Given that approximately one third of industrial capital investments are for labor, we can estimate that more than $70 million per year would be spent on a technical workforce earning more than family wage jobs. At an average of $70,000 per person with all indirect costs included, employment could exceed 1,000 per year. Granted, some of those jobs will be currently employed construction and technical workers that are retained. However, this investment represents a more than threefold increase per year in industry capital investment in efficiency and GhG reductions. Energy cost savings to industry is very conservatively estimated at just over a quarter of a billion dollars per year in 2020. The simple return on investment to industry is 6.6 years without accounting for depreciation, incentives that buy down their cost or the likely escalation of energy costs over the next nine years. A simple internal return on investment of 15% or greater can be expected from the energy efficiency related investments in GhG reduction which accounts for nearly 60 percent of GhG reductions called for by industry, should we accomplish 2020 goals. The air quality improvements from reduced direct natural gas use, reductions in other GhG's and the indirect reduction in emissions from electric generation will result. No estimate for the resulting positive health impacts is determined at this time. Oregon industry reductions in GhG will position them to be more globally competitive in future energy supply and carbon constrained markets.

Conclusions

We call upon stakeholders, including government and elected officials, business leaders, environmental advocates and others to work together to make our energy use as productive and efficient as possible. We recommend that our community embrace and implement the actions that we discuss and use this approach to meet emission reduction goals from the industrial sector. This suite of actions provides a broader array

of services and resources specifically targeting expressed business needs. These strategies build on recent voluntary initiatives that are making gains (e.g. NW Food Processors).

APPENDIX A

Industrial Technical Committee

Committee Members:

Lisa Adatto, Climate Solutions, Co-Chair
Dale Gehring, ESCO, Co-Chair
Pam Barrow, Northwest Food Processors
Sergio Dias, Sergio Dias Consulting, LLC
Al Dorgan, USW
Angus Duncan, Oregon Global Warming Commission
Brendan McCarthy, Portland General Electric
Ruben Plantico, Portland General Electric
Elaine Prause, Energy Trust of Oregon
Marty Sedler, Intel
Victor Shestakov, Climate Solutions
John Wallner, Northwest Energy Efficiency Alliance

Staff:

Mark Kendall, Kendall Energy Consulting, LLC
Justin Klure, Pacific Energy Ventures, LLC
Bill Drumheller, ODOE

APPENDIX B

Industrial Inventory of Actions

ACTIONS/RECOMMENDATIONS	DESCRIPTION			METRIC				COMMENTS
CATEGORIES **V. Accelerate use of Energy Efficient Technology and Practice** **VI. Establish GhG Leadership Recognition Program** **VII. Improve access to Financing and Incentives** **VIII. Build Human Capacity to Innovate and Execute Industry Process Improvements**	**Lead** Gov (G), Agency (A), Private (P), etc.?	**Type of Action** Incentive (Int), Tax/Fee,(T/F) Regulation (Reg), Standard (Stnd), Information (Info), Technical Research (TR), etc.	**Timing of Impact** (Short = 1-5 yrs) Medium = 5-10 yrs.	**GHG Savings?** (Y/N, Quantity)	**Fossil Fuel Savings?** (Y/N, Quantity)	**Cost (High, Medium, Low)?**	**C/E** (Y/N)	Co-benefits? Risks/Tradeoffs? Unintended Consequences? Politics? Adaptation Value? (*use concise narrative*)

		The information above will continue to be collected and analyzed as it becomes available.							
I. Accelerate use of Energy Efficient Technology and Practice									
1	**Implement an aggressive boiler and direct natural gas direct efficiency initiative targeting industry.**								Natural gas boilers account for over a third of industrial GhG emissions in Oregon. Annual maintenance standards, boiler efficiency upgrades and replacement standards should be readily available to all Oregon industry use efficiency forums, case studies, promotions and technical assistance
2	**Provide cross-cutting industry efficiency training, analysis and implementation technical assistance.**								Routine in-plant training with specific assessment examples industry is not available. Dedicated service with implementer performance goals will accelerate

									adoption
3	Double the capacity of the Oregon State University (OSU) Energy Efficiency Center.								OSU industrial Assessment Center work has proved valuable and motivating for industry. It develops the next generation industrial workforce while providing direct service.
4	**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.**								Combined heat and power directly addresses the largest direct industry emission of natural gas combustion. Utilization of available renewable resources for power generation provides multiple benefits, crossing into the utility sector plan.
II. Establish GhG Leadership Recognition Program									
5	**Create a Recognition, branding and marketing "Oregon Top Twentieth" or "Leaders" program that includes primary industry and the services. Integrate into**								Industry leadership, with planned and directed government, utility, higher

	Oregon marketing programs (see Appendix C).								education, USDOE and national laboratory support will provide self-determined goals and objectives
6	**Assign state government to focus goals and action implementation on the top nine emissions and top ten industry sectors.**								The top ten industry sectors and top nine emissions represent over 95% of industrial emissions. Focus on the largest industries that are most prepared to reduce GhG first.
7	Industries, State, ETO and NEEA collaborate to develop voluntary GHG Benchmarks by industry sector.								Use national and international standards of practice and benchmarking to establish GHG baselines and metrics by industry type and for specific technologies
8	Recognize and help brand Oregon industry accomplishing GhG objectives.								Recognition, branding and marketing "Oregon Top Twentieth" or "Leaders" products and services to

									include primary industry and the services sectors (i.e. technical contractors, architectural design, engineering, other service providers)
III. Improve access to Financing and Incentives									
9	**Maintain and expand state incentives and financing that target industry GHG.**								Retain BETC with priority on GHG outcomes. Make state bonding authority available for qualifying/participating facilities. Develop terms and conditions for State co-signing or otherwise securing part or all of needed debt financing.
10	**Review, evaluate and adopt the most effective emerging or innovative funding mechanisms.**								National and international organizations and governments are innovating efficiency and GhG reduction financing.
11	**Increase Energy Trust of Oregon (ETO) initiatives for industry.**								Promote, educate, conduct analysis, and

									increase the Public Purpose Charges to the allowable 5% with dedicated to industry
12	Help Oregon industry get USDOE co-funding for plant wide assessments and support implementation with direct link to available incentives and required follow-up component.								Co funding up to $50k is available and underutilized in Oregon
13	**Encourage congressional delegation to expedite energy legislation with expansion of invest tax credit to GHG.**								Process efficiency as well as energy efficiency and renewable resource investments should earn federal incentives
14	Provide property tax exemption for capital investments in projects that reduce GhG emissions.								Significant process improvements and technology platform transitions need to be recognized as sustainable investments
15	Local Government provides a freeze on incremental property tax for qualifying facilities.								Investment in efficiency and systems changes that reduce GhG emissions are exempt from future property

									tax for participating industry
16	Review and consolidate industry permitting and reporting for various emissions.								Multiple requirements and inventories and reporting on criteria pollutants, water, emerging MACT and GHG, can be more efficient and easier to manage if consolidated
17	Provide property tax exemption for capital investments in projects that reduce GHG emissions.								Significant process improvements and technology platform transitions need to be recognized as sustainable investments
IV. Build Human Capacity to Innovate and Execute Industry Process Improvements									
18	Engage USDOE and National Laboratories to actively participate in industry services in Oregon.								Develop Oregon specific science based technologies and applications for the specific needs of our industry. Develop local industry support that attracts national attention

									and research interest. Deliver proven technology to industry.
19	**Partner with industry to direct multi-discipline teams from agencies and higher education to develop a center of excellence to help industry sectors.**								Develop policy, incentives and outreach service to collaboratively respond to industry needs. An industry efficiency and manufacturing "*Center of Excellence*" is essential to building leadership confidence in moving forward.
20	Expand NEEA, ETO and NWFPA work to other industry sectors.								Duplicate the NWFPA market transformation intervention (training, expertise, services, and research) in other Industry segments.
21	**Develop Oregon industry specific plans and roadmaps for 2020 and 2050.**								Assemble industry opinion leader workgroups to review regulations, policies and national

									roadmaps to advise state government.
22	**Build lean manufacturing practices into standard engineering programs at state universities and community colleges.**								Require environmental and energy policy curriculum to prepare manufacturing managers of the future.

APPENDIX C

Example Industry Process Related GhG Reduction Technologies

Pulp and Paper Roadmap Technologies and Processes

APPENDIX A. NATIONAL ENERGY SAVINGS AND CARBON DIOXIDE EMISSIONS REDUCTIONS RESULTS

Table A-1 National Energy Savings And Carbon Dioxide Emissions Reductions

	CASE A (Excluding increased use of recycled paper)			CASE B (Including increased use of recyled paper)		
	Throughput	Primary Energy Savings	Carbon Savings	Throughput	Primary Energy Savings	Carbon Savings
	Mt	PJ	MtC	Mt	PJ	Mtc
Raw Materials Preparation						
Ring style debarker	241.5	1.1	0.02	205.2	0.9	0.01
Cradle Debarker	241.5	1.8	0.03	205.2	1.5	0.02
Enzyme-assisted debarker	241.5	1.5	0.02	205.2	1.3	0.02
Bar-type chip screens	49.5	4.9	0.03	42.0	4.2	0.03
Chip conditioners	49.5	4.4	0.03	42.0	3.8	0.02
Screen out thick chips	49.5	4.9	0.03	42.0	4.2	0.03
Belt conveyors	239.4	2.0	0.03	203.5	1.7	0.03
Fine-slotted wedge wire baskets	5.3	0.7	0.01	4.5	0.6	0.01
Pulping Mechanical						
Refiner Improvements	3.2	1.1	0.02	2.8	0.9	0.01
Biopulping	5.3	3.6	0.06	4.5	3.1	0.05
Pulping Thermomechanical						
RTS	3.0	2.0	0.03	2.5	1.7	0.03
LCR	3.0	0.2	0.00	2.5	0.1	0.00
Thermopulp	3.0	1.0	0.02	2.5	0.8	0.01
Pressurized groundwood	3.0	1.6	0.02	2.5	1.4	0.02
Heat recovery in TMP	3.0	4.4	0.02	2.5	3.8	0.02
Improvements in CTMP	3.0	1.3	0.02	2.5	1.1	0.02
Pulping Chemical						
Continuous digesters	49.5	103.9	0.59	42.0	88.3	0.51
Continuous digester modifications	49.5	34.3	0.22	42.0	29.1	0.18
Batch digester modifications	49.5	33.8	0.21	42.0	28.7	0.18
Chemical Recovery						
Falling film black liquor evaporation	53.2	18.2	0.16	45.2	15.5	0.14
Tampella recovery system	53.2	3.0	0.02	45.2	2.5	0.01
Lime kiln modifications	53.2	4.9	0.08	45.2	4.2	0.07
Bleaching						
Ozone bleaching	29.6	0.2	0.00	25.1	0.1	0.00
Brownstock washing	29.6	0.5	0.01	25.1	0.4	0.01
Washing presses	29.6	2.4	0.02	25.1	2.1	0.01
Papermaking						
Gap forming	82.5	8.6	0.13	82.5	8.6	0.13
High consistency forming	70.6	34.3	0.26	70.6	34.3	0.26
Extended nip press (shoe press)	82.5	75.1	0.48	82.5	75.1	0.48
Hot Pressing	82.5	7.2	0.05	82.5	7.2	0.05
Direct drying cylinder firing	82.5	6.2	0.04	82.5	6.2	0.04
Reduced air requirements (closing hoods and optimizing ventilation)	82.5	37.0	0.25	82.5	37.0	0.25
Waste heat recovery	82.5	17.6	0.11	82.5	17.6	0.11
Condebelt drying	82.5	100.0	0.69	82.5	100.0	0.69
Infrared profiling	82.5	10.4	0.05	82.5	10.4	0.05
Dry sheet forming	82.5	69.2	0.26	82.5	69.2	0.26
General Measures						
Pinch Analysis	82.5	41.9	0.27	82.5	41.9	0.27
Optimization of regular equipment	82.5	5.4	0.08	82.5	5.4	0.08
Energy-efficient lighting	82.5	1.7	0.03	82.5	1.7	0.03
Efficient motors	82.5	103.0	1.61	82.5	103.0	1.61
Steam Production and Efficiency						
Boiler maintenance	82.5	29.4	0.19	82.5	29.4	0.19
Improved Process Control	82.5	31.4	0.20	82.5	31.4	0.20
Flue Gas Heat Recovery	82.5	14.7	0.09	82.5	14.7	0.09
Blowdown Steam Recovery	82.5	11.2	0.07	82.5	11.2	0.07
Steam trap maintenance	82.5	104.7	0.66	82.5	104.7	0.66
Automatic Steam Trap Monitoring	82.5	52.4	0.33	82.5	52.4	0.33
Leak Repair	82.5	7.5	0.05	82.5	7.5	0.05
Condensate Return	82.5	6.3	0.04	82.5	6.3	0.04
Fiber Substitution						
Increased use of recycled paper	60.0	202.0	1.67	60.0	202.0	1.67

Steel and Iron Roadmap Technology and Processes

Process	Production (Mtonne)	Fuel Saving (GJ/tonne crude steel)	Electricity Savings (GJ/tonne crude steel)	Primary Energy Saving (GJ/tonne crude steel)	Annual operating Costs(US$/tonne crude steel)	Retrofit Capitol Costs(US$/tonne crude steel)	Carbon Dioxide Emission Reduction (kgC/t)
Iron Ore Preparation (Sintering)	12.1	0.19	0	0.19	0	0.75	5.58
Coke Making	16.6	0.51	0	0.51	0.15	35.84	3.12
Iron Making - Blast Furnace	49.4	2.82	0.1	3.12	-4.45	35.29	51.1
Steelmaking – Basic Oxygen Furnace	55.4	0.92	0	0.93	0	22.2	12.69
Integrated Casting	49.5	3.39	0.65	5.38	-36.68	146.25	213.93
Integrated Hot Rolling	48.3	1.85	0.01	1.88	-1.09	25.92	25.86
Integrated Cold Rolling and Finishing	31.7	0.28	0.13	0.68	0	3.79	9.79
Primary Steel General	55.4	0.57	0.4	1.79	0.02	15.98	35.13
Steelmaking Electric Arc Furnace	35.9	-0.7	1.59	4.22	-18.3	45.2	61.51
Secondary Casting	32.1	2.88	0.57	4.64	-31.33	134.34	64.95
Secondary Hot Rolling	31.3	1.33	0.01	1.36	0.06	12.83	18.69
Secondary Steel General	35.9	0.11	0.06	0.3	0.02	0.16	5.11

APPENDIX D

"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 includes:

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:
    a. Reduction of carbon emissions by 10-25% over 10 years or
    b. Reach the top x percentile in their industry within x years
    c. Go beyond what is required
5. Initial 10 companies would sign an MOU with:
    a. The Governor
    b. 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

APPENDIX E

Barriers to Accomplishing Industrial GhG reduction Goals

The state, industry, industry associations, higher education, local government and industry service providers are collaboratively addressing a number of barriers to the successful reduction of industry GHG emissions. Those include:

- Value in GhG reduction actions is diffuse
- Access to capital for longer return investment is limited
- Risk management in unproven or questionably reliable emerging technologies
- Human resources training education and technical resources
- Access to reliable, industry vetted information is not consistent
- Access to technology and quality standards for application vary
- Lack of confidence in technology
- Value added is not always clear or consistent
- Other business priorities distract from energy and GhG reduction investment
- Time available for implementation is limited and competed for by other process changes or maintenance
- Industry experience with the technology or application may be limited or
- Motivation around GhG reduction alone may not compete with other priorities
- Leadership and championship for energy and GHG reductions from outside and inside industry varies

APPENDIX F

Industry Characteristics in 2020 and 2050

More than 90% of the carbon emissions from the Oregon industrial sector are associated with the conversion and use of energy. The future portends a gradual restructuring of industry toward knowledge-intensive rather than materials/energy-intensive products, because of improved computer controls, gains in process efficiency, just-in-time manufacturing methods, more efficient conversion and use of energy supplies, application of advanced technologies, and resource recovery and optimized resource use.

2020

All boilers over 1 million British Thermal Units per hour capacity are maintained and tuned annually, stack heat recovery is installed, steam trap and pressure reduction are continuously maintained and use the best available technology. Other gas thermal systems use efficient radiant or fluidized bed drying technologies with the highest efficiency available. A coordinated, multi agency boiler efficiency program serves all industry throughout the state. This program coordinates resources (human and financial), marketing, information, technical support and measurement techniques in order to very quickly help industry reduce carbon emissions and develop research ideas in the technical area that has the highest carbon reduction potential, boilers. The largest boiler systems are targeted and marketed to for participation. Participants get over 100% rate of return on their investment in annual boiler tuning. Heat recovery and steam distribution energy savings are targeted, identified, quantified and internal business cases made for capital improvements to boilers made.

Industry associations, the ETO, NEEA and utilities regularly share best available practices through onsite education, project implementation workshops, industry staff training and case studies. Industry groups and higher education collaboratively develop areas of research to solve technical problems and to develop applied solutions to industry process management and GHG reduction.

Industries across Oregon all have energy managers who have benchmarked production energy, cost and emissions by facility and commodity. Targets are set for GHG emissions reductions in each industry and at each facility and specific technology applications are identified by process or system.

State and local government continue to provide access to low cost capital, incentives and property tax abatement that incent industry investment in GHG and energy reductions. Those include publically bonded financing, income and property tax credits, regulatory streamlining for air, water and structural permitting.

2050

Various and complimentary industry are co-located throughout the state, optimizing use of all feedstock's, energy and water supply. All production residues (materials, water, chemicals, thermal…) become feedstock for other complimentary industry. Nano-technology conversion systems are used in

all industries to create unique products with superior qualities at low or no GHG emissions. Advanced separation systems use ambient temperature fractionation and cellulose fiber membranes to improve segregation, purity and use of chemicals and organics alike. Renewable energy supplies are either extracted from feedstock materials or scheduled for use based on real-time renewable energy supply forecasts and production schedules for just-in-time, on-time delivery at programmed costs.

Oregon institutions of higher education, and state, federal and local government provide industry advancement support by routinely sponsoring and convening industry market segment and cross-cutting technology, pre-competitive research, education, marketing and application implementation. Education institutes directly provide applied research for continuous improvement, rapidly, toughly and solution specific to each of Oregon's major industry sectors. State government provides policies that promote the use of best available practice (BAP) and technology (BAT) through workforce readiness, research of best available practice and technology, promotion of benefits, standards setting with achievable reach goals and education. State agencies have specific targets, and technical and policy staff to help industry accomplish GHG intensity targets through value-added field, policy and regulatory services. Local government provides land use and transportation infrastructure support that grows industry co-location, resource sharing and integration to continually improve local industry efficiency.

Quality. Oregon's, paper, wood products, metals, foods, microelectronics, chemicals, membranes, non-metallic minerals, machinery, transportation equipment, plastics and fabricated metals and wood products set global standards for production performance, specification tolerances, safety and durability. Oregon commodities are known for their low or net-zero carbon content, lean resource and manufacturing processes, metrics for accountability and performance reliability. The methods for accounting are transparent and published and available for adaptation by others in pre-competitive formats.

Energy. All natural gas, petroleum, electrical energy and renewable energy use per unit of production is 75% of 1990 levels. Thermal energy processes in industry require half the energy they did in 1990 and are twice as thermally efficient. Thermal energy reductions result from use of ambient temperature organic chemical catalysts, ceramic thermal management, and low vacuum forming. All remaining thermal processes use advanced gasification, pyrolysis and Fisher-Tropsh methods recovering all syn-gasses as higher added-value commodities or energy supplies. All feedstock materials are efficiently mined for all energy, fiber, mineral and chemical properties and the predominant volume of feedstock comes from renewable resources. Advanced energy and resource management telemetry enables industry to source the lowest GhG emission materials and energy supplies in real-time.

Technology. Full enterprise management systems optimize the use of all industry resources from raw material to product delivery (materials, resources, human resource, energy, services, technology, processes). Learning controls systems rewrite algorithms for systems optimization in reliable, replicable and accountable ways. All BAT and BAP are implemented in all industry. Advanced combustion, thermal, refrigeration, materials conversion and refining, conveyance, lean packaging, and multimodal transportation systems are in use industry wide. Cooling towers are all but eliminated as businesses co-locate with industry to optimize use of any of the remaining waste heat.

Principal Emissions. Natural gas, petroleum and coal combustion emissions in 2050 are less than 20% of the 6.711 $MMTCO_2e$ it was in 2005, when it was 40% of all industrial emissions. That reduction is due to the adoption of ambient temperature processing, unique chemicals and catalysts, enzyme use, vacuum environment production, application of nano-technology and improved thermal management (ceramic insulators) systems. Little or no direct combustion is used and is replaced by gasification, pyrolysis and Fisher-Tropsh processes where products are more efficiently fractionated, all gasses recovered and each element used at its highest and best value. Rankine cycle low temperature heat recovery is used throughout industry to generate electricity.

Emissions from electric energy consumption are likewise reduced to 20% of 2005 levels through transformation of conveyance, controls, refrigeration, adhesion and product processing technologies and systems. Pumping, fans and motors are re-designed through bio-mimicry efficiency replication (e.g. vortical versus centifugal). Refrigeration has been transformed by using non-condensing CO_2 or inert gas refrigerant cycles with higher heat transfer rates, better dimpled heat exchange with nano-engineered surfaces Overall refrigeration demand is less through more use of aseptic vacuum packaging. Organic light emitting diodes have reduced illumination and light sterilization processes energy use to less than 5% of their 2005 energy intensity levels. It provides improved color rendition, nanometer management, tuneable illumination levels, ten times longer equipment life and lower overall GhG life cycle footprint. Space conditioning and air filtering loads dramatically reduced through low fan speed air exchange, better filtration and reduced particulate production in plant processes. Rare gasses used in microelectronics production (solvents, catalysts, cleaning agents) are replaced with organic and naturally occurring solutions, methods and materials, further reducing high global warming potential gasses.

All ozone depleting substance substitutes are now replaced by no or low GHG producing gasses and solutions to include CO_2 refrigeration, organic thermo-chemicals, or no-refrigeration or rankine cycle production requirements. Refrigeration of Oregon industrially produced commodities is entirely replaced by all aseptic vacuum packaging, increasing product qualities, shelf life and percent raw materials to product ratios.

Practice. Industry associations, higher education and government collaborate on best practices and production management by industry sector with regard to cross-cutting technologies and approaches as well as industry specific and unique processes.

The Market Transformation approach taken by Northwest Food Processors to reduce energy intensity by 25% by 2020 is widespread across all industry sectors and includes: 1) Operational Improvements, 2) Operational Management Improvements, 3) Business and Quality Process Improvements, and 4) Waste and Natural Resource Utilization [optimization]. Best available management and production processes are detailed and practiced for each industrial facility in Oregon and metrics are managed on a per product basis. Staff are trained, monitoring systems use common platforms and open sourced software and input output controls and sensors to assure uniform data quality throughout industry. Protocols are shared, and trained into place with industry associations sponsoring training in

conjunction with higher education and government. International and national benchmarking by industry, product and industrial process are available, reliable and updated in real-time so that industry can compete in the global marketplace without revealing competitive details specific to their firm or commodities.

Multiple businesses operate at each single facility. Businesses that just manage energy, feedstock's, packaging, marketing or process control have emerged, are successful and enhance the transfer of best available practice and lowest cost of production considering all product attributes. Five nines, Six Sigma and Lean Manufacturing, international Standards Organization (ISO) standards have evolved into a digital information statistical process control realm where they fully integrate all industry actions into the entire industrial enterprise in such a way that each element is not distinctly distinguishable from standard practice.

Policy. Government's statutory and administrative role and relationship with industry is as a partner. Goals and targets are set by industry on a site and product specific basis. Governments' role is adopting law, policy and services necessary to accomplish those goals. A regulatory stance is only adopted for determining minimum expected standards of practice and realizable reach goals. Government's role is in helping industry to organize, plan, research, train, adapt, afford and acquire changes in practice and technology that advance their competitive position and accomplishment of GhG reduction goals. Permitting and evaluating next generation or new applications is collaborative, affordable and uses the best available information to identify consensus or compromise plans, practices or designs.

Market(s). International and global markets recognize the value of low GhG products and they are priced to prefer those with the lowest environmental cost with the highest qualities. Oregon's industrial products are sought after locally, nationally and to the extent they have low GhG contributions. Local demand for local products, with the lowest GHG impact, makes Oregon industry more competitive with higher margins through lower cost of delivery. A fully integrated multi-modal transportation system serves Oregon industry with maximally designed back-hauling, lowest carbon routes, timing, just-in-time logistics and co-shipment allowing them more affordability of the best available technologies and practices. State government and industry associations have a globally recognized and deemed highly credible branding campaign with third party verified performance.

Energy Conversion and Utilization. Energy efficiency could be improved through incorporating the best technologies in a systems approach. Technologies include solid oxide fuel cells, higher combustion efficiencies, and using thermal energy in a systems approach to mill/plant design. In the longer term, non-combustion technologies are likely to have a significant impact, such as fuel cells and gasification of biomass and in-plant residues (e.g., black liquor in the forest products industry).

Increased on-site power generation using materials currently sent for disposal and non-combustion technologies, such as fuel cells and gasification, will also play a crucial role in reaching energy reduction targets in the industrial sector. Within manufacturing, materials and process industries account for about 80% of the hazardous and toxic wastes and about 95% of nonhazardous wastes.

These wastes often impose high cleanup and disposal costs but offer the potential for recovering the "embedded" energy and materials value. Steam and thermal system efficiencies can be improved by more than 20% using cross-cutting and proved technologies including better boiler technology, improved burners and controls, better insulation, steam trap repair sizing and replacement, condensate return and more efficient, lower chemical use water treatment.

Electric energy conversion technologies in lighting, pumping, fans, conveyance, power voltage transformation and process systems can likewise be improved using cross-cutting available technologies. Fewer than 20 % of electric motors in Oregon industry are rated as premium efficiency motors. Most motors under 50 horsepower in Oregon, with variable loads, have no variable speed or frequency drives or controls. Latest generation, electronic ballast fluorescent lighting provides higher lumens per watt that most industrial high intensity discharge lighting, allows for more switching control and is underrepresented in industry applications. Electronic or organic light emitting diode fixtures will soon provide even more energy efficiency, longer life and equivalent illumination qualities to fluorescent systems.

Industrial Process Efficiency. The industrial sector is extraordinarily complex and heterogeneous. The needs are diverse: hundreds of different processes are used to produce millions of different products. Improving process efficiency will be done through implementation of site-specific processes and protocols with management directive to manage process and procedure controls to meet GHG reduction targets and goals specific to products and facilities.

Some of the more broadly applicable industry process changes include: selective catalysts, advanced separations, improved measurement and control systems, improved materials, and improved electric motor systems, such as large motors with superconductivity wires, low temperature processing, forming and . A particularly attractive longer-term opportunity is the use of biotechnology and bioderived materials.

The need exists to identify various industries collective high-risk, high-payoff technology needs. This analysis allows higher education, U.S. Department of Energy (USDOE) and other federal research and development (R&D) organizations to align their resources to best meet those needs. Industry segments and local government need to align these interests and attract the participation of the national laboratories, Department of Commerce–National Institute of Standards and Technology Advanced Technology Program to focus resources specifically on GHG reduction strategies.

Emerging Technologies. Increased understanding in the fundamentals of chemistry, metallurgy, and biotechnology will allow the development of innovative manufacturing processes. This knowledge, along with advanced modeling and simulation, improved industrial materials, and measurements (sensors) and intelligent control systems, will result in major incremental improvements and lead to fundamental break-throughs.

Resource Recovery and Utilization. This is a technological pathway is built on industrial ecology,

wherein a community of producers and consumers perform in a closed system. Fossil energy is conserved and/or energy is obtained from non-GhG sources; materials are reused or recycled. Through technological advances, the raw materials and resources needed for manufacturing can be obtained by designing products for ease of disassembly and reuse.

Strategic Partnership. Strategic public–private R&D alliances for achieving GHG reduction goals in energy- intensive industries is needed. These alliances need to be extended to embrace climate change mitigation goals. Different types of public–private R&D partnerships are needed to reduce GhG emissions in the light-manufacturing sector. Finally, utility restructuring may challenge industrial self-generation and power sales using advanced industrial turbines integrated with combined-cycle generation or with non-combustion generation techniques such as fuel cells.

Cross-cutting energy efficiency solutions exist to cost effectively get GhG 10% below 1990 levels by 2020 in all Oregon industry sectors.

Cross-Cutting Technologies. Technologies, applicable across all industry sectors, are ready for deployment, proved and have demonstrated cost effectiveness. Manufacturing process controls include all systems and software that exert control over production processes. Control systems include process sensors, data processing equipment, actuators, networks to connect equipment, and algorithms to relate process variables to product attributes. These controls enable more comprehensive analysis of process systems so that systems can be prioritized for cross-cutting technology evaluation and applications. Cross-cutting applications include: Process Integration (pinch analysis), Combined heat and power, Condensing package boilers (Super Boiler), Lower fan speed air filtration and facilities HVAC, Advanced lighting technologies, Advanced lighting design, Advance adjustable speed drive (ASD) designs, Advanced compressor controls, Compressed air system management, Motor diagnostics, Motor system optimization, Pump efficiency improvement, Switched reluctance motors, Advanced lubricants, Anearobic waste water treatment, High efficiency/low NOx boiler burners, Membrane technology for wastewater treatment, Advanced Sensors and controls, Advanced cooling tower controls, Advanced CHP turbine systems, Advanced reciprocating engines, Fuel cells Microturbines,

Industry Specific Approaches. National industry directed technology "roadmaps" exist in the pulp and paper, wood products, steel and iron, aluminum, chemicals, microelectronics, and food processing sectors that address the technology needs both near and long-term to reduce Oregon industrial energy use and GhG emissions. Indexing the cost and emissions reductions attributable to these process shifts, technology leaps and game changing applications is not done comprehensively at this time.

Food Processing. Northwest Food Processors Association (NWFPA) has adopted an industry-wide goal to reduce product energy intensity by 25% by 2020. NWFPA has developed a Roadmap to assist the food processing industry in achieving this goal. The most definitive selection of food processing technologies that reduce energy and GHG is the emerging technologies database developed by Lawrence Berkeley National Laboratory and the NWFPA. In addition to the cross-cutting industry technologies, it identifies the leading edge and emerging technologies specific to most all food manufacturing processes. In addition, the following, next generation technologies, will take the food

processing industry a long way towards 2050 GhG Reduction goals. Those technologies include: Low temperature processing and aseptic packaging, Electron Beam Sterilization, biotechnology processing, Heat recovery - low temperature, Membrane technology – food, Cooling and storage management, ultrasonic drying, and Closed-cycle air refrigeration (CCAR).

Pulp and Paper. A 2006 report sponsored by the U.S. Department of Energy (DOE) concluded that the U.S. pulp and paper industry could cost-effectively reduce energy consumption from 2.36 quads to 1.75 quads, a 25 percent reduction from 2002 levels, by broadly implementing the best available industry cross cutting technologies. Those savings could be greater by black liquor gasification, condebelt drying, direct electrolytic causticizing, dry sheet forming, heat recovery – paper, high consistency forming and impulse drying.

Chemicals. The chemical Industries Vision2020 Technology Partnership (Vision 2020) is an industry-led collaboration in the chemical and allied industries to leverage financial resources and technical expertise. The goal is to accelerate innovation and technology development resulting in superior materials, lower energy intensity and lower greenhouse gas emissions. Clean fractionation - celluose pulp, gas membrane technologies- chemicals, heat recovery technologies – chemicals, levulinic acid from biomass (biofine), liquid membrane technologies – chemistry, new catalysts, and autothermal reforming-ammonia. Advancements are being applied in Nanotechnology and Nanomaterials, Environmental, Safety, and Health Issues for Nanotechnology, R&D for Nanotechnology and Nanomaterials, Alternative Feedstocks, Corrosion Reduction, Advanced Separations, Distillation, Ionic Liquids, Process Intensification, Process Equipment Materials (Materials of Construction), and Computational Fluid Dynamics.

Steel and Iron. BOF gas and sensible heat recovery, Near-net shape casting/strip casting, New EAF furnace processes, Oxy-fuel combustion in reheat furnace, and Smelting reduction processes.

Ozone Depleting Substance Substitutes. The U.S Environmental Protection Agency (USEPA) is leading national efforts to implement replacement of ozone depleting substance substitutes (ODSS). In 2007 ODSS contribute nearly 20% to Oregon industrial direct emissions. Those include: Hydro Fluro Carbons (HFC) including some 16 compounds, Per Fluro Carbons (PFC) including some seven compounds, Sulfur hexaflouride (SF6), and to a lesser extent NF3 and HFE 7100 and 7200. The USEPA goal is to phase out all ODSS by 2050. Substitutes exist for most of these refrigerants and cleaning agents but applications are underdeveloped. Acceptance of water, air and CO_2 as refrigerants gasses is emerging. Lower energy Stirling cycles and evaporative/desiccant or straight evaporative cooling exist and can be commercialized for industrial application. Water lithium bromide absorption, or ammonia water absorption are replacements for many CFC's and HCFC's, known ozone depleting substances, that still exist in legacy systems. Direct nitrogen expansion, propane, propylene, CO_2 or butane is all applied as refrigerants. Non-mechanical heat transfer and electronics cleaning can be accomplished with methyl siloxanes and/or water to replace aerosol solvents. Powder coat deposition, ultraviolet and electron beam curing replace or eliminate the need for solvent processes in coatings and finishes. Mechanical cleaning and thermal vacuum de-oiling processes currently replace solvents in metals and electronics cleaning.

Agriculture Roadmap to 2020

Report to the Oregon Global Warming Commission

The following report, *Agriculture Roadmap to 2020*, was developed by the Agriculture Technical Committee of the Oregon Global Warming Commission (OGWC). Agriculture Committee members are listed in Appendix B of this report.

I. PURPOSE AND CONCLUSIONS

The purpose of the Committee was to develop and prioritize a set of strategies and actions for minimizing Greenhouse Gas (GHG) emissions and increasing carbon storage in the Agriculture sector to meet Oregon's 2020 greenhouse gas (GHG) goal. The recommendations will be considered by the Oregon Global Warming Commission for inclusion in the Interim Roadmap to 2020/Report to the new Governor and Legislature, to state agencies, and to Oregon's Congressional delegation. Recommendations may also guide private sector investments and university research agendas.

After several months of deliberations the Committee narrowed the Key Actions to the list below. Appendix A contains the complete list of Recommended Actions developed by Agriculture Technical Committee. The Committee's Key Actions are more fully described in Section III – Key Actions For 2020. In summary they are:

- Increase Nutrient Use Efficiency
- Increase Carbon Sequestration in Crop Management
- Develop Manure to Energy Methods
- Proactively Prepare for and Adapt to Climate Change Impacts on Water Supply

II. FUTURE STATEMENTS

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.

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 it's 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.

III. KEY 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

1.1. Create targeted research, outreach programs, technical assistance and tools that increase nutrient use efficiency in Oregon agriculture.

1.2. Research soil emission coefficients to establish baseline and future emissions data.

1.3. 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

2.1. Determine irrigated soil carbon sequestration rates.

2.2. Encourage practices that sequester carbon in the soil and build soil quality.

2.3. Increase outreach and incentives to protect and restore native vegetation, habitats and riparian areas along agricultural lands.

3. Develop Manure to Energy Methods

3.1. 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

4.1. Promote irrigation efficiency.

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

APPENDIX A
Technical Committee Recommended Actions

According to national data and data provided by the Oregon Department of Energy to the Global Warming Commission Agriculture Committee, the two areas that contribute the highest volume of direct GHG emissions in Oregon agriculture, and therefore present opportunities for meaningful reductions are animal agriculture and soil management. We also know that there is an opportunity for significant reductions in indirect GHG emissions from energy and nutrient use efficiency on farm, and renewable energy generation. Finally, there is an opportunity for carbon sequestration through improved soil management. The following actions present opportunities to most significantly reduce direct and indirect GHG emissions and to sequester carbon in Oregon agriculture.

1. **Maintain and Build Technical Assistance Capacity**
    a. **Maintain Current Capacity**
        i. Maintain full appropriations and stable funding for agricultural technical assistance entities.
        ii. Advocate for continued and higher funding for farm conservation funding programs that assist with mitigation and adaptation of climate change.
    b. **Expand and Build Capacity**
        i. Develop capacity for voluntary emissions/sequestration audits.
        ii. Provide hands-on training and implementation support for mitigation and adaptation measures.

2. **Improve Markets and Financing for GHG investments**
    a. **Incentives/Funding**
        i. Advocate for tax credits for capital costs associated with agricultural efficiency projects (i.e. irrigation efficiency, nutrient applications)
        ii. Develop incentives that encourage the producers to internalize business management to address GHG considerations.
        iii. Increase research funding for agricultural practices that reduce and sequester GHGs.
    b. **Marketing**
        i. Support agriculture's documentation of GHG reductions and carbon sequestration to access carbon offset and ecosystem markets and as an agricultural product marketing tool for developing new markets and keeping existing markets.
        ii. Reduce transaction costs for participating in ecosystem markets.
    c. **Financing**
        i. Well-established and easy to navigate financing structure for research and practices that reduce or sequester GHGs.

3. **Crop Management**
    a. **Soil Management**
        i. Nutrient Use Efficiency
            1. Create targeted research, outreach programs, technical assistance and tools that increase nutrient use efficiency in Oregon agriculture .
            2. Promote water application methods that increase nutrient use efficiency.
            3. Update general and crop-specific fertilizer recommendations to accurately meet plant nutrition needs, reduce N2O emissions, and protect water quality.
            4. Quantify the costs and benefits, recommend policy, program and incentive changes to provide a true economic incentive to increase nutrient efficiency.
            5. Support farmer access to incentives for nutrient use efficiency (i.e., cost share assistance, direct payments, tax credits, carbon credits).

6. Determine soil emission coefficients to establish baseline and future N2O emissions data.
7. Develop accurate longer range regional and local weather forecasts to permit more accurate nutrient recommendations.

ii. 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.

b. Building Soil Carbon

i. Determine irrigated soil carbon sequestration rates .

ii. Encourage practices that sequester carbon in the soil and build soil quality.

1. Research and outreach to provide information on best practices for building soil organic carbon and soil quality such as adding organic matter and increasing cropping intensity.
2. Quantify the costs and benefits, recommend policy, program and incentive changes to provide a true economic incentive to build soil quality and soil organic carbon.
3. Support farmer access to tools, technical assistance and incentives for building soil organic carbon (i.e., cost share assistance, direct payment, tax credits, carbon credits).

4. Animal Agriculture

a. Feed/Diet management

i. Develop, enhance, and promote use of tools that help livestock growers calculate and reduce GHG emissions from diet management strategies.

ii. Maintain and enhance access to USDA incentives for feed best management practices to reduce GHG emissions.

b. Manure

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

ii. Increase use of manure as an organic amendment to enhance soil and plant quality.

c. Range Lands

i. Assist range managers with adoption of practices to quantify and increase sequestration of carbon in rangeland soils.

ii. Continue research in rangeland carbon sequestration opportunities.

5. Energy

a. Energy Use

i. Assessment of opportunities for reducing energy intensity in Oregon agriculture(ODA is working on a report; NEEA has commissioned a market study).

ii. Provide greater energy efficiency technical assistance to agricultural producers.

iii. Encourage development of web-based, standardized energy efficiency evaluation tools to reduce the need for individual energy audits and help growers identify opportunities on their operations.

iv. Implement tools that allow for measurement of energy use.

v. Partner with serving utilities and public benefits administrators for support in incorporating energy efficiency products, practices and services into Ag operations.

vi. Irrigation efficiency strategies

1. Conduct landscape-scale analyses to identify and evaluate groundwater and surface water supply issues, water supply constraints, optimal irrigation water systems and management for specific landscapes.
2. Identify ways to increase water use efficiency by plants will reduce irrigation demands to improve management of irrigation water.
3. Identify current policy and economic barriers the adoption of water conservation, irrigation efficiency and other proposed solutions.
4. Promote economic incentives for growers to adopt more efficient irrigation and water management technologies – for both, irrigation capital expenses as well as management expenses (subscribing to irrigation scheduling service).

vii. Fuel use efficiency
1. Support tractor and other farm equipment efficiency demonstration projects
2. Help growers get incentives for fuel reduction capital expenses
3. Increase the adoption of carbon efficient operations
4. Increase access to carbon efficient transportation for agricultural products
5. Outreach and incentives for improved heating/cooling efficiency
6. Promote crop management strategies that minimize fuel use.

b. Renewable Energy Generation

i. Support farmer access to technical assistance and incentives for renewable energy generation.
ii. Co-location of agriculture with industry to utilize methane and biomass for energy and heat. Identify and evaluate appropriate technologies with respect to scale and complexity.
iii. Infrastructure and policies to support local and grid connected renewable energy generation on farms

6. Adaptation Specific Actions

a. Adapting to a CO2-enriched atmosphere

i. Develop models that predict how CO2/climate interactions may affect Oregon crops
ii. Research into how to maintain crop quality under greater CO2 concentrations

b. Invasive species

i. Model changes into key pests including insect, diseases, and weeds in key Oregon crops and develop minimum GHG impact strategies for addressing them

c. Evaluate alternatives for meeting Oregon's water supply needs.

i. Help facilitate water storage projects at all scales that are protective of Oregon's watersheds and natural resources
1. Support a streamlined "filtering" process that could help pre-evaluate potential irrigation or other agricultural water storage projects and minimize the costs of studies and regulatory reviews.
2. Support competitive grant program or matching fund program that would help identify good projects and work with applicants through review and permitting.
3. Evaluate strategies to promote low-impact on-farm water storage ponds.

ii. Promote irrigation efficiency
1. Support a tax credit program for water efficiency and irrigation efficiency savings.

d. Regional Food Systems

i. Investing in local food and regional food production, processing, and distribution capacity and infrastructure for a more resilient food system

e. Native Vegetation

i. Increase outreach and incentives to protect and restore native vegetation and habitats along agricultural lands.

7. General Outreach/Technical Assistance

a. Education

i. Demo projects with other Oregon agricultural sectors similar to carbon neutral challenge for wineries/climate friendly nurseries project
ii. Provide information to growers on GHG accounting tools that are available, and if needed, create better tools
iii. Conduct more outreach to agricultural producers about energy efficiency, renewable energy, mitigation and adaptation practices and incentives
iv. Outreach and technical assistance in the major recommendation categories.

8. Research

a. Maintain existing research and expand research funding in the following areas:

i. Increased nutrient use efficiency
ii. Best practices for building soil organic carbon and soil quality such as adding organic matter and increasing cropping intensity
iii. Methods for maintaining crop quality under greater CO2 concentrations
iv. Measurement of GHG emissions resulting from animal feeding management.
v. Determine irrigated soil carbon sequestration rates.
vi. Determine soil emission coefficients to establish baseline and future N2O emissions data.

APPENDIX B

Agriculture Technical Committee Members

Name	Organization
Stephanie Page	Oregon Department of Agriculture
Allison Hensey	Oregon Environmental Council
Tammee Dennee	Oregon Wheat Growers League
Steve Petrie	OSU
Shanna Brownstein	Climate Trust
Sharon Peterson	NW Energy Efficiency Alliance
Lori Rhodig	NW Energy Efficiency Alliance
Bill White	USDA
Kumar Venkat	Clean Metrics Corp
Whitney Rideout	Oregon Association of Nurseries

Forestry Roadmap to 2020

Report to the Oregon Global Warming Commission

The following report, *Forestry Roadmap to 2020*, was developed by the Forestry Technical Committee of the Oregon Global Warming Commission (OGWC). Forestry Committee members are listed in Appendix B of this report.

I. PURPOSE AND CONCLUSIONS

The purpose of the Committee was to develop and prioritize a set of strategies and actions for primarily increasing carbon storage in forest ecosystems and long-lived forest products to meet Oregon's 2020 greenhouse gas (GHG) goal. The recommendations will be considered by the Oregon Global Warming Commission for inclusion in the Interim Roadmap to 2020/Report to the new Governor and Legislature, to state agencies, and to Oregon's Congressional delegation. Recommendations may also guide private sector investments and university research agendas.

After several months of deliberations the Committee narrowed the Key Actions from a possible 31 to 4. Appendix A contains the consolidated Inventory of Actions developed by Forestry Technical Committee. The Committee's Key Actions are more fully described in Section III – Key Actions For 2020. In summary they are:

- Establish a Carbon Inventory for Oregon Forests
- Invest in Key Research to understand the impacts of climate change on carbon storage in forests
- Pursue Reforestation/Afforestation
- Advance Energy and Forest policies supporting biomass facilities

The Committee recognized that "Oregon's forests" and "Federal forests" are often used interchangeably; the error is understandable, since Oregon is substantially (61%) federally-owned17, mostly by the US Forest Service and the US Bureau of Land Management. But State and privately-owned forests are extensive, are generally more productive, often include critical ecosystems, and are frequently contiguous with or interspersed among the federal lands. Other, non-forested private lands are also placed such that what occurs on those lands affects the adjacent forest in significant ways (fire occurring in the urban/wild interface is one example; effects in watersheds critical to endangered species is another).

Thus carbon policy addressing and affecting forestlands, forest practices and forest products require particular attention to common strategies and collaborative practices. The

[17]Oregon Forest Ownership: 61% Federal, 19% Industrial Private, 15% Non-industrial Private, 3% State, and 2% Tribal and other public lands

recommendations in this section of the Oregon Roadmap to 2020 are meant to be read in that context. Policies on Federal, State and private lands do not need to be identical – in fact they must often be different but complementary. But each ownership type must inform and be informed by the others. Policies must be developed collaboratively, and executed across jurisdictional lines when ecosystems and carbon outcomes stretch across those lines.

II. FUTURE STATEMENTS

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[18], enabling a measurable gain in statewide carbon storage. Cooperative and effective implementation

[18] Intended to be consistent with current forest land composition and not a changed composition that includes less desired types, such as juniper woodlands.

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 CO2 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[19].

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.

[19] For example, the policy tradeoffs would have to be seriously evaluated if research were to consistently show that the forest sector could reach higher overall carbon storage densities, while protecting ecosystem function and species biodiversity, by allowing some conversion from the live tree pool to the products pool on federal forest lands to raise sequestration levels on non-federal forests.

- 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, O2 production, and forest productivity (CO2 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.

III. KEY 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 Appendix A.

- 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[20], 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.

2. Carbon Inventory

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

3. Reforestation/Afforestation/Acquisition

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

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

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

3.4. 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").

4. Research

4.1. 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

[20] 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.

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.

4.2. 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.

4.3. 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.

4.4. 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 in Section 1.1.

5. Biomass

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

APPENDIX A

	ACTIONS/RECOMMENDATIONS	DESCRIPTION			METRIC				COMMENTS
		Lead Gov, Agency, Private, etc.?	Type of Action (use word) Incentive, Tax/Fee, Regulation; Standard, Information, Technical Research, etc.	Timing of Impact (Short = 1-5 yrs) Medium = 5-10 yrs. Long = > 10 yrs	GHG Savings? (Y/N, Quantity)	Fossil Fuel Savings? (Y/N, Quantity)	Cost (Savings)?	C/E (High, Medium, Low)	Co-benefits? Risks/Tradeoffs? Unintended Consequences? Politics? Adaptation Value? (use concise narrative)
CARBON INVENTORY									
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 inventory system. Based on these data, establish baselines and both long-term and intermediate goals for carbon storage that account for different forests types and ownerships, including overall storage gains in public forests.	ODOF	Technical	Short					
PUBLIC FORESTS									
2	Use the Oregon carbon inventory, defined in 1.1 above, to establish a baseline and a carbon storage goal for public lands.		Standard	Long					

	ACTIONS/RECOMMENDATIONS	DESCRIPTION			METRIC				COMMENTS
		Lead Gov, Agency, Private, etc.?	Type of Action (use word) Incentive, Tax/Fee, Regulation; Standard, Information, Technical Research, etc.	Timing of Impact (Short = 1-5 yrs) Medium = 5-10 yrs. Long = > 10 yrs	GHG Savings? (Y/N, Quantity)	Fossil Fuel Savings? (Y/N, Quantity)	Cost (Savings)?	C/E (High, Medium, Low)	Co-benefits? Risks/Tradeoffs? Unintended Consequences? Politics? Adaptation Value? (use concise narrative)
3	All timber management planning and public forest transactions (e.g., timber sales, offset sales) should include net impact on Oregon's carbon account.		Standard	Short					
	Federal Forestlands Management (West/moist)								
4	Federal Westside (moist) forests should be managed for carbon storage gains consistent with *public benefits and other ecosystem values*. Priority strategies should include strategic management supporting that carbon storage outcome, including longer rotations, minimum disturbance to soils and forest floor, sustained growth potential and preservation.		Standard						
	Federal Forestlands Management (East/dry)								
5	Federal Eastside (dry) forests should be managed for stability of long-term carbon storage and minimum carbon debt (loss) consistent with other		Standard						

	ACTIONS/RECOMMENDATIONS	DESCRIPTION			METRIC				COMMENTS
		Lead Gov, Agency, Private, etc.?	Type of Action (use word) Incentive, Tax/Fee, Regulation; Standard, Information, Technical Research, etc.	Timing of Impact (Short = 1-5 yrs) Medium = 5-10 yrs. Long = > 10 yrs	GHG Savings? (Y/N, Quantity)	Fossil Fuel Savings? (Y/N, Quantity)	Cost (Savings)?	C/E (High, Medium, Low)	Co-benefits? Risks/Tradeoffs? Unintended Consequences? Politics? Adaptation Value? (use concise narrative)
	ecosystem values. Priority strategies should include thinning and other fuel load reductions, restoration of historic fire cycles, and restoration and protection of forest ecosystem function.								
6	Consistent with the minimum carbon debt objective in 2.4.1, fuel load reduction strategies should establish (1) durable products and (2) fuel supply for biomass conversion, as priority uses of removed materials. To support private capital investment in biomass-to-energy facilities, firm, ten to twenty year fuel supply contracts should be made available.		Standard						
	Existing State Forestlands Management								
7	Oregon State forestlands should be managed to increase carbon stores over time, consistent with ecosystem values and yield of durable forest product.		Standard						

	ACTIONS/RECOMMENDATIONS	DESCRIPTION			METRIC				COMMENTS
		Lead Gov, Agency, Private, etc.?	Type of Action (use word) Incentive, Tax/Fee, Regulation; Standard, Information, Technical Research, etc.	Timing of Impact (Short = 1-5 yrs) Medium = 5-10 yrs. Long = > 10 yrs	GHG Savings? (Y/N, Quantity)	Fossil Fuel Savings? (Y/N, Quantity)	Cost (Savings)?	C/E (High, Medium, Low)	Co-benefits? Risks/Tradeoffs? Unintended Consequences? Politics? Adaptation Value? (use concise narrative)
8	The Oregon Department of Forestry should explore opportunities to act on behalf of private small woodlot owners in offering aggregated private and public forest carbon offsets to the ecosystem services market.		Technical						
PRIVATE FORESTLANDS MANAGEMENT									
9	Private forestlands in Oregon should be managed for yield of durable product consistent with ecosystem values and no net loss of forested acreage at current overall carbon storage levels.		Standard						
10	Voluntary, state, regional and/or federal regulatory markets should *develop incentives* that are attractive to both investors and landowners (relative to other carbon reduction opportunities) for increasing carbon stores on private forestlands in ways that are additional, measurable and verifiable. Establish innovative incentive programs		Incentive						

ACTIONS/RECOMMENDATIONS		DESCRIPTION			METRIC				COMMENTS
		Lead Gov, Agency, Private, etc.?	Type of Action (use word) Incentive, Tax/Fee, Regulation; Standard, Information, Technical Research, etc.	Timing of Impact (Short = 1-5 yrs) Medium = 5-10 yrs. Long = > 10 yrs	GHG Savings? (Y/N, Quantity)	Fossil Fuel Savings? (Y/N, Quantity)	Cost (Savings)?	C/E (High, Medium, Low)	Co-benefits? Risks/Tradeoffs? Unintended Consequences? Politics? Adaptation Value? (use concise narrative)
	for private forests to promote carbon sequestration and/or offsets.								
11	State of Oregon energy and forest policies should encourage private landowners to develop forest and range biomass production capabilities supporting biomass energy facilities where this can be done consistent with or enhancing ecosystem values.		Regulation/Incentive						
URBAN FORESTS									
12	Oregon urban areas should act to increase urban forest canopy cover, while selecting species and locating plantings to maximize opportunities for co-benefits (e.g., cooling/shading homes, businesses, streams and riparian areas).		Standard						

		DESCRIPTION			METRIC				COMMENTS
	ACTIONS/RECOMMENDATIONS	Lead Gov, Agency, Private, etc.?	Type of Action (use word) Incentive, Tax/Fee, Regulation; Standard, Information, Technical Research, etc.	Timing of Impact (Short = 1-5 yrs) Medium = 5-10 yrs. Long = > 10 yrs	GHG Savings? (Y/N, Quantity)	Fossil Fuel Savings? (Y/N, Quantity)	Cost (Savings)?	C/E (High, Medium, Low)	Co-benefits? Risks/Tradeoffs? Unintended Consequences? Politics? Adaptation Value? (use concise narrative)
REFORESTATION/AFFORESTATION/ACQUISITION									
13	The Federal government, the State and Oregon communities should seek reforestation opportunities on lands previously forested, irrespective of ownership.		Standard						
14	The Federal government should assure sufficient resources for reforestation on Federal forestlands.		Funding						
15	The State and Oregon communities should seek to acquire forestlands that can be conserved, restored and managed.		Standard						
16	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”).								

	ACTIONS/RECOMMENDATIONS	DESCRIPTION			METRIC				COMMENTS
		Lead Gov, Agency, Private, etc.?	Type of Action (use word) Incentive, Tax/Fee, Regulation; Standard, Information, Technical Research, etc.	Timing of Impact (Short = 1-5 yrs) Medium = 5-10 yrs. Long = > 10 yrs	GHG Savings? (Y/N, Quantity)	Fossil Fuel Savings? (Y/N, Quantity)	Cost (Savings)?	C/E (High, Medium, Low)	Co-benefits? Risks/Tradeoffs? Unintended Consequences? Politics? Adaptation Value? (use concise narrative)
RESEARCH									
17	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 and function of Oregon's forested ecosystems as well as changes in the geography of forest biodiversity that are anticipated from changes in climate		Research						
18	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.		Research						

	ACTIONS/RECOMMENDATIONS	DESCRIPTION			METRIC				COMMENTS
		Lead Gov, Agency, Private, etc.?	Type of Action (use word) Incentive, Tax/Fee, Regulation; Standard, Information, Technical Research, etc.	Timing of Impact (Short = 1-5 yrs) Medium = 5-10 yrs. Long = > 10 yrs	GHG Savings? (Y/N, Quantity)	Fossil Fuel Savings? (Y/N, Quantity)	Cost (Savings)?	C/E (High, Medium, Low)	Co-benefits? Risks/Tradeoffs? Unintended Consequences? Politics? Adaptation Value? (use concise narrative)
19	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.		Research						
20	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 in Section 1.1.		Research						
OTHER									
21	The Global Warming Commission should convene, in 2011, a work group that includes members of the Materials/Waste Management and Forestry Technical Subcommittees, together with other		Information						

ACTIONS/RECOMMENDATIONS		DESCRIPTION			METRIC				COMMENTS
		Lead Gov, Agency, Private, etc.?	Type of Action (use word) Incentive, Tax/Fee, Regulation; Standard, Information, Technical Research, etc.	Timing of Impact (Short = 1-5 yrs) Medium = 5-10 yrs. Long = > 10 yrs	GHG Savings? (Y/N, Quantity)	Fossil Fuel Savings? (Y/N, Quantity)	Cost (Savings)?	C/E (High, Medium, Low)	Co-benefits? Risks/Tradeoffs? Unintended Consequences? Politics? Adaptation Value? (use concise narrative)
	stakeholders as appropriate, to further explore the question of valuing carbon content in forest products that are used as construction materials or otherwise are included in durable goods with a measurable life span, including substitution effects and long-term persistence of durable products. The team will also consider whether recommendations for incentives or policies are appropriate.								
22	The Global Warming Commission will also, in 2011, take up the question of substitution effects on net atmospheric carbon resulting from different biofuels strategies.		Information						

APPENDIX B

Forestry Technical Committee Members

Name	Organization
Brian Kernohan	Forest Capital Partners
Andrew Yost	Oregon Department of Forestry
Angus Duncan	Global Warming Commission
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

Materials Management Roadmap to 2020

Report to the Oregon Global Warming Commission

The following report, Materials Management Roadmap to 2020, was developed by the Materials Management Technical Committee of the Oregon Global Warming Commission (OGWC). Materials Management Committee members are listed in Appendix B of this report.

I. PURPOSE AND CONCLUSIONS

The purpose of the Committee was to develop and prioritize a set of strategies and actions for reduce greenhouse gas emissions associated with materials use to meet Oregon's 2020 greenhouse gas (GHG) goal. The recommendations will be considered by the Oregon Global Warming Commission for inclusion in the Interim Roadmap to 2020/Report to the new Governor and Legislature, to state agencies, and to Oregon's Congressional delegation. Recommendations may also guide private sector investments and university research agendas.

After several months of deliberations the Committee developed the 9 Key Actions listed below from a brainstormed list of over 100 that was distilled down to a recommended list of approximately 40. Appendix A contains the Recommended Inventory of Actions developed by Materials Management Technical Committee. The Committee's Key Actions are more fully described in Section III – Key Actions For 2020. In summary they are:

- 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).
- Research and integrate a consumption-based GHG inventory methodology with the State's conventional inventory, and identify high-carbon product categories
- Develop and disseminate information: easy-to-use life cycle metrics for different food types
- Establish standards, incentives, and/or mandates for carbon footprinting, labeling of products
- Focus product stewardship on upstream emissions and design for appropriate durability, repairability, reusability, efficiency, and recovery
- Establish higher standards for new buildings: "net zero" plus offset of materials
- Provide consumer education, information, outreach on consumption, materials use, and prevention/reuse, including low-GHG food and diet choices
- Reduce (prevent) waste of food at the retail and consumer level by 5-50%
- Conduct research on highest/best use for organic wastes and the carbon impact of different conversion technologies

"Materials Management" refers to how we manage material resources as they flow through the economy, from extraction or harvest of materials and food, production and transport of goods, reuse of materials, and recycling, composting, and disposal. Approximately 42% of GHG emissions in the U.S. are associated with these activities, primarily manufacturing.[21] Emissions are even larger if the impacts of imported goods are considered.[22] Emissions occur across the entire life cycle of these goods, although most occur "upstream" of the consumer, primarily in manufacturing.

The Materials Management Committee considered opportunities to reduce GHG emissions associated with the life cycle of materials used in Oregon. This perspective results in some overlap with all other committees convened as part of the Commission's 2020 Vision project. However, an important difference is that while the Materials Management Committee focused on products used in Oregon, committees such as Industry, Agriculture, and Materials Management focused on products produced in Oregon. This combination of demand- and supply-side perspectives provides the Commission with an unusually broad and comprehensive view of how Oregon contributes to climate change.

Many of the emissions associated with materials used in Oregon do not occur in Oregon, and as such, are not included in Oregon's current greenhouse gas inventory. A separate project by DEQ, involving the development of a supplemental, consumption-based greenhouse gas inventory for Oregon, will shed more light on the impact of materials – and all other goods and services – consumed in Oregon. That project is not yet complete. In the meantime, it is important to understand that actions in Oregon can reduce emissions occurring in other states and nations. Some of the emissions reductions resulting from the recommendations contained herein may not be counted by Oregon's greenhouse gas inventory, but are nonetheless just as real, and just as impactful to Oregon's climate, as reductions of in-state emissions.

II. FUTURE STATEMENTS

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.

[21] US EPA, Opportunities to Reduce Greenhouse Gas Emissions through Materials and Land Management Practices, September 2009.
[22] Joshuah Stolaroff, Ph.D., for the Product Policy Institute, Products, Packaging, and US Greenhouse Gas Emissions, September 2009.

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 significant 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.

III. KEY 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.

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)

Summary: 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.

Lead: Oregon Congressional delegation, Governor's Office, Global Warming Commission.

Type of Action: Regulation (federal and/or international).

Timing of Impact: Likely medium-term (5-10 years) or long-term (10+ years). Although legislation might pass in the short-term (1-5 years), implementation of most key elements is expected to not occur for several years.

GHG Savings? Yes. Potentially 3.39 – 20.57 million MTCO2e in 2020, excluding direct use of fuels and electricity by consumers.[23]

[23]Two estimates of emissions associated with the life cycle of materials (excluding use phase) are developed. The first draws on EPA and Carnegie Mellon University research that suggests that production, transport, and disposal of materials used in the US contribute emissions (some overseas) equal to 49% of the domestic GHG inventory. This is applied to Oregon's GHG inventory (2005) and scaled upward to 2020 for an estimate of

Fossil Fuel Savings? Yes; not evaluated.

Cost (Savings)? Not evaluated.

Cost/Effectiveness? Not evaluated.

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

Summary: 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 and 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 fact 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, will meet in September and October of 2010 to review 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

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41.1 million mTCO2e. Alternatively, DEQ's preliminary draft consumption-based emissions inventory (unpublished) estimates life cycle emissions (excluding use) of materials *consumed* in Oregon; scaling upward to 2020 results in an estimate of 33.9 million mTCO2e. These provide a low and high estimate of materials-related GHG emissions. These low and high estimates are then multiplied by low (10%) and high (50%) estimates of the potential reductions in GHG emissions that would result from a carbon cap and/or tax, including some kind of border adjustment mechanism. This represents an exceptionally crude estimate for the purpose of estimating the order of magnitude of potential reductions, and in no way should be interpreted as a critical evaluation of the likely results of either a carbon cap or a carbon tax. Actual emissions reductions are highly dependent on the actual design and implementation of the cap and/or tax. Additionally, the estimate includes only life cycle emissions of materials/products excluding use of appliances, devices, vehicles, etc. by consumers, so the potential emissions reductions in transportation and building energy sectors associated with a carbon cap and/or tax are significantly underestimated here.

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.

Lead: Global Warming Commission, DEQ

Type of Action: Research, Standard

Timing of Impact: Short-term (1-5 years).

GHG Savings? Not evaluated.

Fossil Fuel Savings? Not evaluated.

Cost (Savings)? Not evaluated.

Cost/Effectiveness? Not evaluated.

Comments:

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

Summary: 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.

Lead: Unknown, possibly DEQ and/or ODA.

Type of Action: Research, Education

Timing of Impact: Short-term (1-5 years).

GHG savings? Yes. Approximately 0.07- 0.68 MMTCO2e in 2020.[24, 25] *(Sensitivity analysis: 0.07 – 0.69 MMTCO2e in 2020.)*

[24] Special thanks to Kumar Venkat and CleanMetrics for provision of food-related GHG emissions factors and assistance in evaluating GHG reduction potential of food-related recommendations.

[25] This estimate is a range of 1-10% reductions in total food-related GHG emissions in 2020, assuming that simply providing this type of information in an accessible format will lead to some changes by producers, retailers, and consumers, with resulting emissions reductions.

Fossil Fuel Savings: Yes. Quantity unknown and dependent upon how food choices and quantity of consumption shift.

Cost (savings?): Unknown, but some cost associated with collecting, reviewing, and summarizing data in standard form; maintaining (and adding to) the data; and creating and promoting the information distribution vehicles (website, cards, etc.).

Cost effectiveness: Unknown

Comments: Providing life cycle information on food products is fundamental to any practice which affects consumer choice/demand. This practice is largely foundational and enables targeted efforts (such as education, see recommendation #7) to achieve reductions.

4. Standards, incentives, and/or mandates for carbon footprinting, labeling of products

Summary: 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.

Lead: Standards, incentives, and mandates would be most efficient if harmonized nationally. Lacking a national standard, Oregon could request the Western Climate Initiative to develop a harmonized carbon footprinting and/or labeling initiative. There might be an opportunity to involve other regional climate groups (RGGI, Midwest GHG Reduction Accord) in this effort. Alternatively, the Global Warming Commission could sponsor/convene an Oregon working group to study alternatives and recommend an approach to implementing this recommendation, or the Legislature could commission a study. DEQ could also research approaches as a product stewardship initiative (see recommendation #5).

Type of Action: Standard, Incentives, Regulation

Timing of Impact: Carbon footprinting (and very limited labeling) is already underway in the US, and some US companies have experience with footprinting because of labeling requirements in France, Japan, and Sweden, and initiatives in the UK and elsewhere. However, a uniform state or regional initiative developed in the short term (1-5 years) would probably not be fully implemented until the medium- (5-10 years) or long-term (10+ years).

GHG Savings? Yes. Approximately 0. 18 – 1.89 million MTCO2e in 2020 for voluntary approaches with incentives.[26] Approximately 0. 71– 3.31 million MTCO2e in 2020 for limited mandatory approaches.[27]

Fossil Fuel Savings? Yes. An evaluation by The Carbon Trust (UK) of 20 leading companies that pilot-tested the draft PAS 2050 footprint standard found that carbon footprinting helped some companies to identify opportunities to reduce energy use.

Cost (Savings)? Administrative costs to develop and implement incentives and/or regulations; costs of incentives; costs to businesses to conduct and report carbon footprints. Carbon footprinting also identifies opportunities for cost reductions (savings) associated with supply chain management and procurement, energy consumption, product transport, and waste.

Cost/Effectiveness? Not evaluated.

Comments: The Carbon Trust report (2008) identified the following benefits to businesses that developed carbon footprints:

- Revealed true sources and drivers of emissions, leading to more effective carbon reduction strategies.

[26]Two estimates of emissions associated with the life cycle of materials (excluding use) are developed. The first draws on EPA and Carnegie Mellon University research that suggests that production, transport, and disposal of materials used in the US contribute emissions (some overseas) equal to 49% of the domestic GHG inventory. This is applied to Oregon's GHG inventory (2005) and scaled upward to 2020 for an estimate of 41.1 million mTCO2e. Alternatively, DEQ's preliminary draft consumption-based emissions inventory (unpublished) estimates life cycle emissions (excluding use) of materials *consumed* in Oregon; scaling upward to 2020 results in an estimate of 33.9 million mTCO2e. These provide a low and high estimate of materials-related GHG emissions. Low and high assumptions are then made about the percentage of these emissions that might be represented by products for which carbon footprints/labels are developed (5-20% for voluntary initiatives with incentives) and the resulting reduction in product-level GHG emissions (10-20%). For reference, a 2008 evaluation by The Carbon Trust (UK) of 20 leading companies that pilot-tested the draft PAS 2050 footprint standard found that some companies were able to quickly reduce product-level GHG emissions by 15-20%. Low and high estimates are then scaled upwards by 5-15% (respectively) to account for additional emissions reduction potential not included in the base estimate of materials-related emissions. These include product use emissions (for example, if producers reformulate laundry detergents to work well in cold water, or consumers improve maintenance of proper tire pressure, etc.), forest carbon impacts, and indirect land use impacts.

[27] Mandatory approaches are evaluated using a framework similar to incentives (above), except that we assume 40-70% of materials-related emissions are associated with products for which footprinting/labeling is required, and that these producers of these products reduce product-level GHG emissions by 5-10%.

- Identified and implemented high-impact cost-saving opportunities across the supply chain.
- Built stronger, more collaborative relationships with suppliers.
- Developed better management practices in general.

Also, to the extent that domestically-produced goods have lower GHG footprints than competing goods produced elsewhere (this is true in some although not all instances), carbon labeling would provide an advantage to domestic producers.

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

Summary: 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, which focuses downstream).[28] 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 #4), and then to achieve an emissions reduction goal by a certain date in the future.

Lead: Oregon Legislature, DEQ

Type of Action: Regulation

Timing of Impact: Probably medium- (5-10 years) or long-term (10+ years) given the foundational work required to achieve a large change.

[28] 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.

GHG Savings? Yes. Potentially 0.04 – 0.45 million MTCO2e in 2020.[29] *(Sensitivity analysis: 0.05 – 0.46 MMTCO2e in 2020.)*

Fossil Fuel Savings? Yes; not evaluated.

Cost (Savings)? Not evaluated.

Cost/Effectiveness? Not evaluated.

Comments: See also recommendations #4, #17, and #21 for other possible examples of "upstream" product stewardship.

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

Summary: "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.

Lead: Oregon Legislature; Building Codes Division, with support from ODOE and DEQ.

Type of Action: Regulation

Timing of Impact: Short-term (1-5 years).

GHG savings? Approximately 7.25 MMTCO2e in 2020.[30]

Fossil Fuel Savings: Yes, not evaluated.

Cost (savings?): There will be a significant cost premium for constructing these buildings, but over time, there is also likely to be substantial cost savings associated with eliminating utility costs.

Cost effectiveness: Unknown.

Comments: As an alternative to requiring "net zero," the State and possibly local governments might incent it through tax credits and/or other means.

7. Provide information and outreach to consumers on product impacts and opportunities to reduce those impacts.

Summary: 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.

[29]According to the rough model of life cycle greenhouse gas emissions of materials and wastes developed by DEQ for this report, the broad categories of materials contributing the most to life cycle GHG emissions are (in order) computers/monitors, food, carpet/rugs, newspaper, plastic products, and tires. These top six categories contribute roughly 4.5 million MTCO2e in life cycle emissions (excluding emissions associated with use). (Expressed on the basis of emissions per ton of waste generated, the highest-impact materials are [in order]: computers/monitors, tires, carpet/rugs, other rubber products, food, and steel cans. These top six categories contribute roughly 4.1 million MTCO2e in life cycle emissions.) A reduction in these emissions in the range of 1-10% would reduce emissions by 0.04 – 0.45 million MTCO2e in 2020.

[30]The energy and materials-related impacts for all buildings from 2013 were estimated to stay neutral through 2020. All new buildings built between 2013 and 2020 are modeled as having no energy- or materials-related impacts.

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.

Lead: Global Warming Commission; potential roles for various agencies

Type of Action: Education

Timing of Impact: Effective in the short-term (1-5 years) but may take longer to achieve full potential.

GHG Savings? Yes. Potentially 0.02 – 0.71 million MTCO2e in 2020.[31]

Fossil Fuel Savings? Likely yes; not evaluated.

Cost (Savings)? Yes, to operate an effective outreach effort.

Cost/Effectiveness? Not evaluated.

Comments: This recommendation includes changes in both food- and non-food consumer behavior. Specific to food, opportunities to reduce emissions associated with over-purchasing of food (production of food that goes uneaten) is evaluated separately, as recommendation #8. It is worth noting that the total number of calories the average American consumes daily has increased by about 18% over the last 30 years. High levels of consumption impact both the environment and health. Other organizations (such as those in public health) are already developing strategies to reduce overconsumption (primarily focused on "bad" calories such as fats and sugars). Climate protection is an important potential co-benefit of moderate, healthful consumption. Shifts in diets will also impact both the climate and the health of people consuming the food. As such, proposed changes in food choices need to be evaluated in the context of the nutritional and other benefits provided by foods. For example, a shift in consumption from lean beef to bacon might reduce GHG emissions, but have unwanted health impacts. Conversely, a shift from other foods to vegetables would, on average, reduce emissions and rates of

[31]Low and high estimates are developed for both food and non-food products. For non-food consumption, the evaluation begins with the low and high estimates of materials-related emissions derived for recommendation #1, discounted to remove emissions associated with food. 78% of consumption-based emissions in Oregon are estimated to be associated with household consumption, according to DEQ's draft consumption-based emissions inventory research. The food-discounted estimates are scaled accordingly. For the low estimate for non-food products, we assume market penetration to 1% of Oregon households and per-household reductions (of non-food materials-related emissions) of 5%. For the high estimate, we assume market penetration to 20% of Oregon households and per-household reductions of 10%. For food-related consumer changes, we review the GHG reduction potential associated with three different scenarios. The first models a moderate (~14%) per-capita reduction in consumption of meat, with the equivalent calories (accounting for 2.2% of total caloric intake) equally redistributed to higher consumption of grains and vegetables. Meat, for the purposes of this scenario, includes all meats. The second scenario models an overall reduction in caloric intake by 10% - 20%, distributed evenly across all food categories. The third scenario involves shifting 10% of total calories from food categories with above-average GHG emissions/calorie to food categories with below-average GHG emissions/calorie. From these evaluations, a low-impact and high-impact potential are identified. (The scenario where some meat is replaced with grains and vegetables is the lowest-impact measure, at ~0.4 MMTCO2e; the shift of 10% calories is the highest-impact measure, at ~1.6 MMTCO2e; 10% and 20% across-the-board reductions in caloric intake represent ~0.7 and ~1.4 MMTCO2e emissions reduction potential. Interestingly, maintaining a constant caloric intake but shifting 10% of calories from high- to low-carbon foods leads to a larger emissions reduction than even a 20% across-the-board reduction in caloric intake.) The low and high potentials are multiplied by 1% and 20%, respectively, as a range of likely participation/adoption rates. Non-food and food-related estimates are then summed together for a total. Potential reductions in use-phase emissions are not included in these estimates.

obesity, with significant co-benefits in reduced health costs (estimated at $781 million in 2003 for obesity-related medical costs in Oregon[32]).

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

Summary: 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 2003 Americans wasted ~1,400 kcal per person per day.[33] 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.

Lead: Unknown, possibly Global Warming Commission, DEQ, and/or ODA.

Type of Action: Research (initially), then potentially Education, Standards, Incentives, Regulation, additional Research

Timing of Impact: Potentially effective in the short-term (1-5 years) but will take longer to achieve full potential.

GHG savings? Yes. Approximately 0.12-1.13 MMTCO2e in 2020.[34] *(Sensitivity analysis: 0.12 – 1.19 MMTCO2e in 2020.)*

Fossil Fuel Savings: Yes. By one estimate, the energy required to produce the food that is subsequently wasted in the US is equivalent to ~300 million barrels of oil per year.

Cost (savings?): Yes. Less waste may mean slightly less food is purchased.

Cost effectiveness: Unknown

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[32] Oregon Department of Human Services, Public Health Division, SB 931: Task Force for a Comprehensive Obesity Prevention Initiative: Policy Recommendations, 2009.

[33] 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/journalpone.0007940.

[34] This scenario provides an estimate of the benefits of reducing food waste between 5-50%. Full life cycle emissions for these wasted foods are included (not just waste disposal emissions, which tend to be small relative to production), as the reduction in waste is assumed to be a result of reduced over-purchasing. 50 percent was used as the upper bound because the exact quantity of edible vs. non-edible food waste is unknown.

Comments: Some strategies to reduce food waste may also result in health co-benefits. Reducing food waste (overproduction) will also reduce the many other environmental impacts associated with agriculture and food processing.

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

Summary: 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.[35] 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.

Lead: DEQ; possible roles for ODOE, Oregon University System

Type of Action: Research

Timing of Impact: Short-term (1-5 years).

GHG Savings? No direct impact, but better information should lead to better policy outcomes.

Fossil Fuel Savings? Not evaluated.

Cost (Savings)? $50,000 - $200,000.

Cost/Effectiveness? Not evaluated.

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

APPENDIX A
Technical Committee Recommended Actions

Tier One Recommendations

	ACTIONS/RECOMMENDATIONS	DESCRIPTION			METRIC				COMMENTS
		Lead Gov, Agency, Private, etc.?	**Type of Action** (*use word*) Incentive, Tax/Fee, Regulation; Standard, Information, Technical Research, etc.	**Timing of Impact** (Short = 1-5 yrs) Medium = 5-10 yrs. Long = > 10 yrs	**GHG Savings?** (Y/N, Quantity)	**Fossil Fuel Savings?** (Y/N, Quantity)	**Cost (Savings)?**	**C/E** (High, Medium, Low)	Co-benefits? Risks/Tradeoffs? Unintended Consequences? Politics? Adaptation Value? (*use concise narrative*)
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)	Oregon Congressional delegation, Governor's Office, Global Warming Commission	Regulation (federal and/or international)	Likely medium- or long-term	Yes. Potentially 3.4 – 20.6 MMTCO2e in 2020.[36]	Yes			
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	Global Warming Commission, DEQ	Research, Standard	Short-term	Not evaluated.	Un-known			Enabling activity; supports other actions.
3	Develop and disseminate information: easy-to-use	Unknown; possibly DEQ	Research,	Short-term	Yes. 0.07 – 0.68	Yes			Enabling activity; supports other

[36] Not including direct use of fuels and electricity by consumers.

	ACTIONS/RECOMMENDATIONS	DESCRIPTION			METRIC				COMMENTS
		Lead Gov, Agency, Private, etc.?	**Type of Action** (*use word*) Incentive, Tax/Fee, Regulation; Standard, Information, Technical Research, etc.	**Timing of Impact** (Short = 1-5 yrs) Medium = 5-10 yrs. Long = > 10 yrs	**GHG Savings?** (Y/N, Quantity)	**Fossil Fuel Savings?** (Y/N, Quantity)	**Cost (Savings)?**	**C/E** (High, Medium, Low)	Co-benefits? Risks/Tradeoffs? Unintended Consequences? Politics? Adaptation Value? (*use concise narrative*)
	life cycle metrics for different food types	and/or ODA	Education		MMTCO2e in 2020.				actions.
4	Establish standards, incentives and/or mandates for carbon footprinting, labeling of products	Global Warming Commission; Oregon Congressional delegation and/or Western Climate Initiative, Oregon Legislature, DEQ	Standard, Incentives, Regulation	Developed in short-term; implemented in medium- or long-term	Yes. Incentives: 0.18 – 1.89 MMTCO2e in 2020. Mandates: 0.71 – 3.31 MMTOC2e in 2020.	Yes			• Enabling activity. • May be evaluated and/or implemented on a regional or state basis. • Footprinting, labeling are forms of product stewardship. • Provides level playing field to all producers (in- and out-of-state).
5	Focus product stewardship on upstream emissions, and design for appropriate durability, repairability, reusability, efficiency, and recovery	Oregon Legislature, DEQ	Regulation	Probably medium- to long-term	Yes. 0.04 – 0.45 MMTCO2e in 2020.	Yes			• See also recommendation 28. • Potential for other

	ACTIONS/RECOMMENDATIONS	DESCRIPTION			METRIC				COMMENTS
		Lead Gov, Agency, Private, etc.?	**Type of Action** (*use word*) Incentive, Tax/Fee, Regulation; Standard, Information, Technical Research, etc.	**Timing of Impact** (Short = 1-5 yrs) Medium = 5-10 yrs. Long = > 10 yrs	**GHG Savings?** (Y/N, Quantity)	**Fossil Fuel Savings?** (Y/N, Quantity)	**Cost (Savings)?**	**C/E** (High, Medium, Low)	Co-benefits? Risks/Tradeoffs? Unintended Consequences? Politics? Adaptation Value? (*use concise narrative*)
									environmental benefits.
6	Establish higher standards for new buildings: "net zero" plus offset of materials	Oregon Legislature, Building Codes Division	Regulation	Short-term	Yes. 7.25 MMTCO2e in 2020.	Yes			• Requiring an offset for materials would incent selection of "low-carbon" materials.
7	Provide consumer education, information, outreach on consumption, materials use, and prevention/reuse, including low-GHG food and diet choices	Global Warming Commission, DEQ, others	Education	Short-term	Yes. 0.02 – 0.71 MMTCO2e in 2020.	Un-known			
8	Reduce (prevent) waste of food at the retail and consumer levels by 5 – 50%	Unknown. Possibly Global Warming Commission, DEQ, and/or ODA	Research, then potentially Education, Standards, Incentives, Regulation	Short-term	Yes. 0.12 – 1.13 MMTCO2e in 2020.	Yes			• Some strategies to reduce food waste may also result in health co-benefits. • Potential for other environmental

ACTIONS/RECOMMENDATIONS		DESCRIPTION			METRIC				COMMENTS
		Lead Gov, Agency, Private, etc.?	**Type of Action** (*use word*) Incentive, Tax/Fee, Regulation; Standard, Information, Technical Research, etc.	**Timing of Impact** (Short = 1-5 yrs) Medium = 5-10 yrs. Long = > 10 yrs	**GHG Savings?** (Y/N, Quantity)	**Fossil Fuel Savings?** (Y/N, Quantity)	**Cost (Savings)?**	**C/E** (High, Medium, Low)	Co-benefits? Risks/Tradeoffs? Unintended Consequences? Politics? Adaptation Value? (*use concise narrative*)
									benefits.
9	Conduct research on highest/best use for organic wastes and carbon impact of different waste conversion technologies	DEQ, possibly ODOE, Oregon University System	Research	Short-term	No direct impact.	Un-known			Enabling activity.

Tier Two Recommendations

Descriptions of these recommendations are provided in Appendix C.

	ACTIONS/RECOMMENDATIONS	DESCRIPTION			METRIC				COMMENTS
		Lead Gov, Agency, Private, etc.?	**Type of Action** (*use word*) Incentive, Tax/Fee, Regulation; Standard, Information, Technical Research, etc.	**Timing of Impact** (Short = 1-5 yrs) Medium = 5-10 yrs. Long = > 10 yrs	**GHG Savings?** (Y/N, Quantity)	**Fossil Fuel Savings?** (Y/N, Quantity)	**Cost (Savings)?**	**C/E** (High, Medium, Low)	Co-benefits? Risks/Tradeoffs? Unintended Consequences? Politics? Adaptation Value? (*use concise narrative*)
General Policy (Tier Two)									
10	Change BETC from an energy tax credit to a carbon (life cycle) reduction tax credit	Oregon Legislature, ODOE	Incentives	Medium-term	Not evaluated.	Un-known			
11	Provide funding and resources necessary to achieve existing statutory prevention and recovery goals	Oregon Legislature	Tax/Fee to fund Incentives, Education, Regulation	Short-term	Yes. Prevention: 1.15 MMTCO2e in 2020. Recovery: 0.13 MMTCO2e in 2020.	Yes.			Other environmental benefits.
12	Shift from a "waste management" to a "materials management" focus and give consideration to greenhouse gas reduction potentials, when updating the state's "Integrated Resource & Solid Waste	DEQ, Environmental Quality Commission	Planning	Short-term	Not evaluated.	Un-known			

	ACTIONS/RECOMMENDATIONS	DESCRIPTION			METRIC				COMMENTS
		Lead Gov, Agency, Private, etc.?	**Type of Action** (*use word*) Incentive, Tax/Fee, Regulation; Standard, Information, Technical Research, etc.	**Timing of Impact** (Short = 1-5 yrs) Medium = 5-10 yrs. Long = > 10 yrs	**GHG Savings?** (Y/N, Quantity)	**Fossil Fuel Savings?** (Y/N, Quantity)	**Cost (Savings)?**	**C/E** (High, Medium, Low)	Co-benefits? Risks/Tradeoffs? Unintended Consequences? Politics? Adaptation Value? (*use concise narrative*)
	Management Plan"								
13	Include the cost of GHG emissions in policy-making considerations (e.g., "economic test" for recycling)	Oregon Legislature; Environmental Quality Commission and/or DEQ	Regulation	Short-term	Yes, but not evaluated.	Yes			
14	Initiate state and local government low-carbon purchasing requirements (including buildings)	Oregon Legislature; DAS	Regulation, Information	Short-term	Yes. 0.01 – 0.11 MMTCO2e in 2020.	Yes			
15	Conduct research to evaluate alternative economic models (e.g., steady-state, sustainable)	Global Warming Commission	Research	Short-term	Not evaluated.	Un-known			
Low-Carbon Production and Consumption: General Products and Food (Tier Two)									
16	Create or advocate for a "do-not-mail" registry (unwanted mail)	Oregon Legislature and/or Congressional delegation	Regulation	Short-term	Yes. 0.03 – 0.12 MMTCO2e in 2020.	Yes			

	ACTIONS/RECOMMENDATIONS	DESCRIPTION			METRIC				COMMENTS
		Lead Gov, Agency, Private, etc.?	**Type of Action** (*use word*) Incentive, Tax/Fee, Regulation; Standard, Information, Technical Research, etc.	**Timing of Impact** (Short = 1-5 yrs) Medium = 5-10 yrs. Long = > 10 yrs	**GHG Savings?** (Y/N, Quantity)	**Fossil Fuel Savings?** (Y/N, Quantity)	**Cost (Savings)?**	**C/E** (High, Medium, Low)	Co-benefits? Risks/Tradeoffs? Unintended Consequences? Politics? Adaptation Value? (*use concise narrative*)
17	Create incentives, regulations to reduce carbon impacts of packaging	Oregon Legislature, DEQ	Incentives and/or Regulations	Medium- or long-term	Yes. 0.02 – 0.09 MMTCO2e in 2020.	Yes			
18	Reduce use of single-use retail carry-out bags; ban plastic single-use bags	Oregon Legislature	Regulation, Incentive	Short-term	Unknown.	Un-known			Co-benefits include reduced litter, impacts on marine life, contamination at compost facilities, and recycling losses.
19	Identify low-carbon methods of home food production, then increase adoption of these methods	Unknown. Possible role for OSU Extension Service	Research, then potentially Education, Incentives	Short-term	Unknown.	Un-known			
Building Materials and Practices (Tier Two)									
20	Create/require a carbon footprint score for buildings,	Oregon	Regulation	Short-term	Yes. 0.43 MMTCO2e	Yes			

	ACTIONS/RECOMMENDATIONS	DESCRIPTION			METRIC				COMMENTS
		Lead Gov, Agency, Private, etc.?	**Type of Action** (*use word*) Incentive, Tax/Fee, Regulation; Standard, Information, Technical Research, etc.	**Timing of Impact** (Short = 1-5 yrs) Medium = 5-10 yrs. Long = > 10 yrs	**GHG Savings?** (Y/N, Quantity)	**Fossil Fuel Savings?** (Y/N, Quantity)	**Cost (Savings)?**	**C/E** (High, Medium, Low)	Co-benefits? Risks/Tradeoffs? Unintended Consequences? Politics? Adaptation Value? (*use concise narrative*)
	including materials	Legislature			in 2020.				
21	Provide incentives for lower-carbon building materials	Oregon Legislature, Global Warming Commission, DEQ, DOE, others	Incentives and/or Regulations	Medium- or long-term	Yes. 0.34 – 1.72 MMTCO2e in 2020.	Yes			
22	Encourage/incent changes in urban form	Possibly DCLD and local governments	Incentives and/or Regulations	Short-term	Yes. 0.98 MMTCO2e in 2020.[37]	Yes			
23	Change code: larger homes must also be more energy-efficient	Oregon Building Codes Division	Regulation	Short-term	Yes. 0.23 MMTCO2e in 2020.	Yes			
24	Require all State construction (including Institutional) to apply the SEED program to materials	Oregon DOE	Standard	Short-term	Yes. 0.02 MMTCO2e in 2020.	Yes			

[37] Not including reductions in transportation-related emissions.

	ACTIONS/RECOMMENDATIONS	DESCRIPTION			METRIC				COMMENTS
		Lead Gov, Agency, Private, etc.?	**Type of Action** (*use word*) Incentive, Tax/Fee, Regulation; Standard, Information, Technical Research, etc.	**Timing of Impact** (Short = 1-5 yrs) Medium = 5-10 yrs. Long = > 10 yrs	**GHG Savings?** (Y/N, Quantity)	**Fossil Fuel Savings?** (Y/N, Quantity)	**Cost (Savings)?**	**C/E** (High, Medium, Low)	Co-benefits? Risks/Tradeoffs? Unintended Consequences? Politics? Adaptation Value? (*use concise narrative*)
25	Expand/incentivize infrastructure for salvaged goods, use of salvaged materials	Unknown	Incentives, possibly Regulation	Short-term	Yes. 0.02 – 0.07 MMTCO2e in 2020.	Un-known			
Waste Recovery (Tier Two)									
26	Use carbon-based metrics for measuring recycling	Oregon Legislature, DEQ	Standards	Short-term	Likely yes, but not evaluated.	Un-known			
27	Implement policies to reduce loss of recyclables at processing facilities	DEQ, possibly Oregon Legislature, local governments	Regulation and/or Incentives	Short-term	Yes. 0.02 – 0.03 MMTCO2e in 2020.	Yes			Potential for significant benefits to end-users (markets) of recycled materials.
28	Expand product stewardship focusing on end-of-life management to cover additional materials; include life cycle GHG emissions as a primary product selection criteria	Oregon Legislature, DEQ	Regulation	Short-term	Yes. 0.07 – 0.11 MMTCO2e in 2020.	Yes			• See also recommendation 5. • Potential for other environmental

	ACTIONS/RECOMMENDATIONS	DESCRIPTION			METRIC				COMMENTS
		Lead Gov, Agency, Private, etc.?	**Type of Action** (*use word*) Incentive, Tax/Fee, Regulation; Standard, Information, Technical Research, etc.	**Timing of Impact** (Short = 1-5 yrs) Medium = 5-10 yrs. Long = > 10 yrs	**GHG Savings?** (Y/N, Quantity)	**Fossil Fuel Savings?** (Y/N, Quantity)	**Cost (Savings)?**	**C/E** (High, Medium, Low)	Co-benefits? Risks/Tradeoffs? Unintended Consequences? Politics? Adaptation Value? (*use concise narrative*)
									benefits.
29	Expand bottle bill to cover additional materials; increase deposit to ten cents if 80% recovery rate not achieved	Oregon Legislature, OLCC	Incentive	Short-term	Yes. 0.05 MMTCO2e in 2020.	Yes			
30	Increase funding by $1.20 per household-year for recycling outreach	Oregon Legislature, DEQ	Education	Short-term	Yes. 0.04 – 0.12 MMTCO2e in 2020.	Yes			
31	Require garbage and recycling service parity (residential curbside)	DEQ	Regulation	Short-term	Yes. 0.01 – 0.03 MMTCO2e in 2020.	Yes			
32	Develop markets for compost products	ODOT, DAS, city and county governments	Standards	Short-term	Yes, but not evaluated.	Yes			Several environmental co-benefits.
33	Require communities over a certain population to collect for recovery food waste from residences and certain categories of non-residential waste generators	Oregon Legislature, DEQ	Regulation	Short-term	Yes. 0.01 – 0.04 MMTCO2e in 2020.	Yes			

	ACTIONS/RECOMMENDATIONS	DESCRIPTION			METRIC				COMMENTS
		Lead Gov, Agency, Private, etc.?	**Type of Action** (*use word*) Incentive, Tax/Fee, Regulation; Standard, Information, Technical Research, etc.	**Timing of Impact** (Short = 1-5 yrs) Medium = 5-10 yrs. Long = > 10 yrs	**GHG Savings?** (Y/N, Quantity)	**Fossil Fuel Savings?** (Y/N, Quantity)	**Cost (Savings)?**	**C/E** (High, Medium, Low)	Co-benefits? Risks/Tradeoffs? Unintended Consequences? Politics? Adaptation Value? (*use concise narrative*)
34	Implement a feed-in tariff to support anaerobic digestion	Oregon Legislature, PUC	Incentive	Short-term	0.01 – 0.05 MTCO2e in 2020.	Yes			
Landfills (Tier Two)									
35	Conduct improved research into methane emissions, as well as opportunities to reduce emissions through better surface monitoring	Landfill industry, DEQ, ASTSWMO, and/or EPA	Research	Short-term	Possibly.	Un-known			
36	Require intermediate covers to be designed as oxidation covers at areas of landfills without active gas collection	DEQ	Regulatory/ Permitting	Short-term	Yes. 0.03 MMTCO2e in 2020.	No			
37	Require installation of gas collection as waste is placed (reduced installation delay), consistent with current technologies	DEQ	Regulatory/ Permitting	Short-term	Yes. 0.002 – 0.05 MMTCO2e in 2020.	Yes			
38	Require that alternative final covers be designed to reduce GHG emissions	DEQ	Regulation	Long-term	Yes, not evaluated.	No			

APPENDIX B

Materials Management Technical Committee Members

Name	Organization
Angus Duncan	Global Warming Commission (chair)
David Allaway	Oregon DEQ (staff)
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 DEQ (staff)
Timm Schimke	Deschutes County
Tim Spencer	Oregon DEQ (staff)
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

APPENDIX C
Tier Two Recommendations

10. Change BETC from an energy tax credit to a carbon (life cycle) reduction tax credit

Summary: Oregon's Business Energy Tax Credit currently provides an incentive to certain business activities that reduce energy consumption in Oregon. One of the co-benefits is a reduction in GHG emissions. However, the criteria exclude other projects in Oregon that might reduce GHG emissions via non-energy pathways (e.g., methane destruction, or reductions in nitrous oxide emissions) or from materials management practices in Oregon that reduce fossil energy consumption upstream in the life cycle, but outside of Oregon.

A workgroup should evaluate how BETC could be reoriented from an energy tax credit to a "GHG reduction tax credit." Recommendations should be made to the Legislature and ODOE for consideration.

Lead: Oregon Legislature, Oregon Department of Energy

Type of Action: Incentives

Timing of Impact: Likely medium-term (5-10 years).

GHG Savings? Potentially yes, but not evaluated.

Fossil Fuel Savings? Not evaluated.

Cost (Savings)? Not evaluated.

Cost/Effectiveness? Not evaluated.

11. Provide funding and resources necessary to achieve existing statutory prevention and recovery goals

Summary: Both waste prevention ("reduce, reuse") and waste recovery (recycling, composting, and some forms of energy recovery) offer potential for GHG reductions.

For recovery, the existing statutory goal is 50% recovery in 2009. The State's recovery rate has hovered in the range of 46.3% - 49.2% between 2001 and 2009. The State's rate in 2009 was 48.4%, just shy of the goal. This goal has since expired but may be renewed or revised by the Legislature.

The statutory goal for waste prevention is no increase in total waste generation in 2009 and all subsequent years. Waste generation is the sum of recovery and disposal; it is a measure of all materials discarded into the recovery/solid waste system, and a very crude measure of material consumption. Because the goal is expressed in absolute terms, increasing population requires that per-capita generation decline. (Although the goal is expressed in terms of waste generation, achievement of the goal requires waste prevention, so it is referred to here as a "waste prevention goal.") Generation rose steadily until 2006 and has declined since then, so the State achieved this goal in 2009 – although a return to economic growth may generate countervailing "headwinds" that make this goal more difficult to maintain.

The State has been unable to achieve 50% recovery, and lacks resources necessary to maintain downward pressure on per-capita waste generation. Funding should be provided as necessary to meet these goals.

Lead: Oregon Legislature

Type of Action: Tax/Fee, used to fund Incentives, Education, Regulation

Timing of Impact: Short-term (1-5 years).

GHG Savings? Yes. Approximately 0.13 million MTCO2e in 2020 if a recovery rate of 50% is achieved (relative to the baseline scenario of ~48%).[38] Approximately 1.15 million MTCO2e in 2020 if total waste generation in 2020 does not exceed waste generation in 2008.[39] *(Sensitivity analysis: 0.16 MMTCO2e in 2020 for recovery; 1.56 MMTCO2e in 2020 for generation/prevention.)*

Fossil Fuel Savings? Yes; not evaluated.

Cost (Savings)? Yes. Not evaluated.

Cost/Effectiveness? Not evaluated.

12. *Shift from a "waste management" to a "materials management" focus and give consideration to greenhouse gas reduction potentials, when updating the state's "Integrated Resource & Solid Waste Management Plan"*

Summary: Oregon's "Integrated Resource & Solid Waste Management Plan" expired in 2005. DEQ has plans to update or rewrite the plan in the near future. As the Materials Management Committee's evaluation of alternatives for the Global Warming Commission illustrates, the frame of "materials management" offers the potential for much larger climate protection benefit than the traditional frame of "waste management." The existing policy framework that DEQ operates under – which is tied to the solid waste management hierarchy – at times constrains DEQ's ability to work for optimal protection of the environment. The Global Warming Commission should express to DEQ and the Environmental Quality Commission (which will adopt the new plan) its interest that DEQ shift focus from "waste management" to "materials management" and give consideration to greenhouse gas reduction potentials.

Lead: DEQ, Environmental Quality Commission

Type of Action: Planning

Timing of Impact: Short-term (1-5 years).

GHG Savings? Not evaluated.

Fossil Fuel Savings? Not evaluated.

Cost (Savings)? Policy shift: no. Implementation: possibly.

Cost/Effectiveness? Not evaluated.

Comments: Such a shift would be generally consistent with policy shifts underway at the federal level, for example, EPA's reports Beyond RCRA: Waste and Materials Management in the Year 2020 (commonly called "the 2020 Vision") and Sustainable Materials Management: The Road Ahead.[40]

13. *Include the cost of GHG emissions in policy-making considerations (e.g. ,"economic test" for recycling)*

Summary: Some policy decisions mandate the use of economic evaluation. An example is the "economic test" that is used to determine if materials must be collected for curbside recycling in different areas of the state. Rule and/or statute could be revised to clarify that the determination of whether an action is "economic" or not should be viewed broadly as "economic to society," as opposed to narrowly (e.g., "impact on collection service rates"). The impact of GHG

[38]This was estimated by increasing recycling, composting (for yard and food waste), and energy recovery (for wood waste and tires) tonnages for a variety of different materials until the recovery goal was achieved. Tonnage increases were based on professional judgment regarding the "recovery potential" for different materials. An overall tonnage increase necessary to achieve the state goal was allocated across individual materials in proportion to the margin between recovery tonnages at current recovery rates and recovery tonnages under the "recovery potential" scenario. Thus, materials with large gaps between current and potential recovery (such as food waste and wood waste) were assumed to contribute more tonnage towards achieving the goal.

[39]This may underestimate the potential benefit of prevention due to limitations in data and modeling.

[40] See http://www.epa.gov/wastes/inforesources/pubs/vision.htm.

emissions should be monetized (expressed in terms of dollars based on cost to society) and included in economic decisions that inform policy implementation.

Lead: Oregon Legislature, Environmental Quality Commission, and/or DEQ

Type of Action: Regulation

Timing of Impact: Short-term (1-5 years).

GHG Savings? Yes, but not evaluated. An example of a likely change would be to require more curbside programs to add scrap metal to their list of materials accepted.

Fossil Fuel Savings? Yes; not evaluated.

Cost (Savings)? Some administrative costs; may add to costs passed to ratepayers.

Cost/Effectiveness? Yes, by definition.

Comments: This recommendation is consistent with a recommendation from the 2004 Governor's Advisory Group on Global Warming, which said "The State should create incentives that will contribute to achievement of the waste generation and recovery goals in a cost-effective manner. 'Cost effectiveness' should recognize all costs, including externalities, and quantify them where possible."

See also recommendation #31 for another example of how this policy might be implemented.

14. Initiate state and local government low-carbon purchasing requirements (including buildings)

Summary: The Oregon Legislature should revise statute and direct state government to give preference to products and services that have a demonstrated lower-carbon impact across the full life cycle. This preference could be expressed as a price preference or in some other form.

Given the diversity of products and services purchased, a phased approach is most appropriate. The Department of Administrative Services should identify categories of products with high GHG emissions potential. (DEQ's Consumption-Based Emissions Inventory, currently under development, may be very helpful in this task.) A process should be established for requiring potential vendors of products in high-impact categories to report full or partial life cycle GHG emissions, using a reporting standard (such as PAS 2050, or the new GHG Protocol product life cycle standard; see also recommendation #4), to be determined by the State. Reporting may be optional for several years in order to give industry time to prepare. Over time, additional product categories should be added. Whole-building life cycle analysis may be required for construction projects over a certain size.

DAS might work with sister agencies in other states to implement this information-gathering system. Results should be shared with other state agencies and local governments. Other state agencies (including the Oregon University System) should be required to participate. Local governments (including school districts?) could be required to participate as a condition of receiving state funds over a certain amount.

To be effective, the Legislature will need to specify a level of emphasis given to GHG emissions in purchasing decisions (so that it isn't an optional or minor consideration). The policy would be strengthened further by requiring periodic reporting of results, perhaps expressed in the context of an expanded state government operations GHG inventory that includes "scope 3" emissions associated with purchased goods.

Lead: Oregon Legislature, Department of Administrative Services; support by DEQ; implementation by all agencies

Type of Action: Regulation, Information

Timing of Impact: Effective in the short-term (1-5 years), but will require longer (~10 years?) to achieve full potential.

GHG Savings? Yes. Approximately 0.01 – 0.11 million MTCO2e in 2020.[41]

Fossil Fuel Savings? Yes (related to GHG savings), but not quantified.

Cost (Savings)? Not estimated. Depends on price premium (if any), administrative costs (to state and local governments), and compliance costs by potential contractors. Some labor costs required (DAS and possibly supporting role at DEQ, plus involvement by other agency procurement staff) to implement this effectively.

Cost/Effectiveness? Not estimated.

Comments: State government "leads by example." A well-organized state purchasing initiative might spur private-sector innovation and also provide valuable information to other institutional and business purchasers.

15. Conduct research to evaluate alternative economic models (e.g., steady-state, sustainable)

Summary: Although the Committee's charge was to focus on materials management (and not consumption more broadly), the demand-side focus of the Committee led to several discussions about consumption, and whether or not ever-increasing consumption (expressed as "economic growth") is in fact sustainable (not to mention whether it would allow the state's GHG goals to be achieved). Several leading economists (as well as the government of France) are engaged in the evaluation of "steady-state" economics, to determine under what circumstances such a model could provide for society's needs and what other impacts it would have on society.

The Global Warming Commission should convene – or support – a state or regional panel to review existing research into "steady-state" economic models and evaluate them for their potential impact on greenhouse gas emissions, and potential policy ramifications.

Lead: Global Warming Commission

Type of Action: Research

Timing of Impact: Review could be conducted in the short-term (1-5 years), with results applied beginning immediately but likely most impact would occur later.

GHG Savings? Not evaluated; potentially very large depending on results.

Fossil Fuel Savings? Not evaluated.

Cost (Savings)? Not evaluated.

Cost/Effectiveness? Not evaluated.

16. Create or advocate for a "do-not-mail" registry (unwanted mail)

Summary: This idea is modeled on the "do-not-call" registry, which Oregon created and which was then supplanted by a federal registry. In this option, Oregonians should be given an opportunity to sign up for a "do-not-mail" registry. Mailers of unsolicited commercial materials would then be prohibited from mailing these households.

[41] Once completed, DEQ's CBEI-LCA model will be able to estimate the life cycle GHG emissions associated with state and local government procurement. In the meantime, we use as a proxy an estimate of the "scope 3" supply chain emissions for the Oregon University System (OUS) in 2008. Using Carnegie Mellon's EIOLCA tool, these were estimated by Good Company to be 244,000 MT CO2e based on expenditures of $612 million. This results in an emissions intensity of 379 MTCO2e/million dollars. While the emissions intensity for broader state and local government materials purchases may be different, we use this is a first-order estimate, and multiply it by estimated 2005 state and local expenditures of $2.4 billion for goods (excluding direct purchase of fuels) and construction services and materials, for an estimated 2005 emissions of 0.93 million MTCO2e associated with producing and transporting goods and construction services purchased by state and local governments in Oregon. (This excludes emissions associated with the use of products, as well as most other services.) This should be viewed as a very rough estimate. Assuming that these emissions grow proportional with population to 2020, a 1-10% reduction in emissions resulting from this action would reduce emissions by 0.01 – 0.11 million MTCO2e in 2020. These GHG savings estimates do not include potential savings associated with energy efficiency attributes (use-phase emissions).

Lead: Oregon Legislature and/or Congressional delegation. Unclear if Oregon has the legal authority to create a state-level registry; may require a national approach. If a state-level registry is created, agencies charged with administration and enforcement will need to be identified.

Type of Action: Regulation.

Timing of Impact: Short-term (1-5 years).

GHG Savings? Yes. Approximately 0.03 – 0.12 million MTCO2e in 2020.[42, 43] *(Sensitivity analysis: 0.06 – 0.24 MMTCO2e in 2020.)*

Fossil Fuel Savings? Yes, not evaluated.

Cost (Savings)? Cost-savings to households. Some administrative cost.

Cost/Effectiveness? Not evaluated.

Comments: A legislated registry would supplant elements of several existing voluntary initiatives, including the Direct Marketing Association's "DMAchoice" service. Presumably, a legislated registry would also be more effective.

17. Create incentives, regulations to reduce carbon impacts of packaging

Summary: The State should create incentives or regulations that would reduce the carbon impacts of packaging.[44] Reductions could be realized through source reduction (lightweighting), reuse, recycling, or changing to lower-carbon materials. The exact nature and scope of these incentives or regulations would need further study. This might take the form of product stewardship (see recommendation #5).

Lead: Oregon Legislature, DEQ

Type of Action: Incentives and/or Regulations

Timing of Impact: Probably medium- (5-10 years) or long-term (10+ years), given the foundational work required to achieve a large change.

GHG Savings? Yes. Potentially 0.02 – 0.09 million MTCO2e in 2020.[45]

Fossil Fuel Savings? Yes.

Cost (Savings)? Not evaluated.

Cost/Effectiveness? Not evaluated.

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[42] EPA estimates generation of 5,510 million tons of standard (third class) mail in the US in 2008. This is pro-rated to Oregon and assumed to maintain a constant per-capita generation rate through 2020. For a low estimate, we assume that the registry only covers households, that 70% of the mass of mail is sent to households, 25% participate, and their mail delivery (third class mail) drops by 60%. For a high estimate, we assume that the registry covers both households and businesses, that 50% participate, and their mail delivery (third class mail) drops by 80%. For reference, one survey in 2007 found a 77% participation rate in the national do-not-call registry (see Box 9-1 of the Economic Report of the President, 2009).

[43] Not included in this estimate is the potentially much larger changes in GHG reductions that may occur if the reduction of advertising mail causes households to shift or reduce purchases of consumer goods. This could work to increase or decrease GHG emissions and may merit additional research.

[44] Including but not limited to retail single-use take-out bags; see recommendation #18.

[45] Based on EPA estimates of waste generation of packaging in 2008, pro-rated to Oregon and scaled upward to 2020, assuming constant per-capita generation. Life cycle greenhouse gas emissions for Oregon's share of national packaging use are estimated at 470,000 metric tons CO2e in 2020 (1.40 million MTCO2e for production, credits of 0.93 million MTCO2e for recycling, and a very small credit for disposal). Interestingly, packaging contributes only 8% of estimated GHGs for all municipal waste generation in 2020, even as it contributes roughly 16% to Oregon's solid waste by weight. Potential GHG reductions for this recommendation are estimated as 5-20% reductions across all packaging-related GHGs. To put this in context, Wal-Mart is considering a performance goal for its packaging sustainability initiative whereby the production-related GHG intensity (emissions per unit of sale) of packaging decreases 5-10%.

Comments: For many products, the "carbon footprint" of packaging is considerably lower than the impact of the product itself. To the extent that packaging protects the product from damage during transport and storage, care must be taken to avoid reducing or changing packaging in a manner that is "penny wise and pound foolish," causing higher rates of product damage.

18. Reduce use of single-use retail carry-out bags; ban plastic single-use bags

Summary: The State should ban the use of single-use plastic carry-out bags and require a five-cent fee on all single-use carry-out bags distributed by retailers. The fee would incent customers to bring their own bags.

Lead: Oregon Legislature

Type of Action: Regulation, Incentive

Timing of Impact: Short-term (1-5 years).

GHG Savings? Possibly yes; preliminary evaluation inconclusive.[46]

Fossil Fuel Savings? Yes; not evaluated.

Cost (Savings)? Expected to be minimal.

Cost/Effectiveness? Not evaluated.

Comments: Reducing plastic bag use will also address concerns with litter, impacts on marine life, and contamination at compost facilities. It will also reduce processing losses and contamination at recycling sorting facilities, with resulting benefits for end-markets (manufacturers) of recycled materials (see recommendation #27).

19. Identify low-carbon methods of home food production, then increase adoption of these methods

Summary: Home food production can potentially reduce the carbon impacts of an individual's diet. The level of reduction, if any, is highly dependent upon gardening practices. Overall, the reduction in machinery use and electricity use can achieve the biggest carbon reductions for home gardening. Other factors that can affect the level of benefit for this practice are the type of compost used, fertilizer use, building garden beds, driving distances avoided or incurred, percent of garden produced food wasted, and method, quantity and efficiency of home food-preserving techniques.

Initially, the State should conduct or support research to evaluate the carbon impact of home food production, to compare it against commercial food production, and to identify which variables are particularly impactful as well as recommended best practices for low-carbon at-home food production.

Lead: Unknown. Potential roles for OSU Extension Service (research, dissemination of results), Master Gardener Programs (outreach).

Type of Action: Initially Research, then potentially Education, Incentives

Timing of Impact: Potentially effective in the short-term (1-5 years) but will take longer to achieve full potential.

GHG savings? Unknown.

Fossil Fuel Savings: Unknown.

Cost (savings?): Unknown.

[46]Evaluation by DEQ and the Materials Management Committee proved to be inconclusive, due to significant uncertainty and variability. Major sources of uncertainty and variability include: the overall rate of reduction in carry-out bag use; the rate at which carry-out bags are replaced with the purchase of plastic bags for other uses (for example, by consumers seeking plastic bags as trash can liners); forest carbon impacts associated with potential for increased wood harvesting; number and type of reusable bags purchased and rate and manner of washing them; and impacts on material recovery facilities (MRFs) and recycling losses.

Cost effectiveness: Unknown

20. Create/require a carbon footprint score for buildings, including materials

Summary: In the 2009 Oregon Legislative Session, Senate Bill 79 proposed that an Energy Performance Score (EPS) be attributed to any new or existing home being sold in Oregon. The EPS was proposed as akin to a "miles-per-gallon" energy rating for homes that rated the total operational energy consumption of a home on a common scale. The intent was that home owners have a means of understanding the energy impact of a home, and that efficiency upgrades and operating costs be included in the value of a home. The mandatory EPS portion of SB 79 was rejected and a task force comprised of a diverse set of members was set up to study the potential of both a voluntary and mandatory EPS program. The task force report is expected to be presented to the Legislature in 2011. A pilot program, led by the Energy Trust, is still in pilot stage as of September 2010.

This scenario extends this concept to include the materials used for home construction and maintenance (replacement of roofs, windows, carpet, etc.). The revised EPS should include the carbon footprint of both operational energy and materials consumption to more fully reflect the life cycle impacts of buildings – specifically, the materials used to make them.

Lead: Oregon Legislature.

Type of Action: Regulation

Timing of Impact: Short-term (1-5 years).

GHG savings? Approximately 0.43 MMTCO2e in 2020.[47]

Fossil Fuel Savings: Yes, not evaluated.

Cost (savings?): Possible savings over time through avoided utility costs, but not evaluated.

Cost effectiveness: Unknown

21. Provide incentives for lower-carbon building materials

Summary: Typically, over the 50-100 year lifetime of average residential and commercial buildings, the impacts of original and replacement materials production account for roughly 15% of the GHG emissions. As our buildings become more operationally energy efficient due to more stringent building codes, high utility costs, and consumer demand, the relative impact of materials production may become even greater. Additionally, many efficiency upgrades to buildings involve using more materials (e.g., insulation). Therefore, the State should provide some form of incentive (currently undefined, but see recommendation #10) that reduces the life cycle GHG impacts of construction materials by 20%. The exact nature and scope of these incentives would need further study. This might take the form of product stewardship.

Lead: Unknown. Possible roles for Oregon Legislature, Global Warming Commission, DEQ, DOE, others.

Type of Action: Incentives and/or Regulations

Timing of Impact: Probably medium- (5-10 years) or long-term (10+ years).

GHG savings? Approximately 0.34 - 1.72 MMTCO2e in 2020.[48]

[47] This scenario assumes that all new homes constructed between 2013 and 2020 are 10% more efficient than the average Oregon home today. Additionally, 25% of all existing homes sold between 2013-2020 will be 25% more efficient in energy and materials emissions due to EPS-prompted efficiency upgrades.

Fossil Fuel Savings: Yes, not evaluated.

Cost (savings?): Unknown.

Cost effectiveness: Unknown.

22. Encourage/incent changes in urban form

Summary: The structure of our urban areas affects housing, food, transportation, and land use, among other things. Generally, increasing density in urban centers is thought to decrease GHG emissions from housing (including materials), transportation, and land use conversions. Oregon has been progressive in establishing urban growth boundaries, which are aligned with increasing density in urban areas and preserving farm and forest land. To that extent, the State and local governments should support and implement policy changes to increase density in urban areas, decrease the rate of new construction, increase density in existing structures, increase use of small accessory dwelling units, and incent a reduction in the size of housing units.

Lead: Possibly DCLD and local governments.

Type of Action: Incentives and/or Regulations

Timing of Impact: Effective in the Short-term (1-5 years) but will require longer to achieve full potential.

GHG savings? Approximately 0.98 MMTCO2e in 2020, not including reductions in transportation-related emissions.[49]

Fossil Fuel Savings: Yes, not evaluated.

Cost (savings?): Yes, not evaluated. Smaller homes cost less money to build, operate, and maintain.

Cost effectiveness: Likely high.

23. Change code: larger homes must also be more energy-efficient

Summary: Large homes consume more energy and materials than smaller homes built to the same level of efficiency. The State should require a more stringent building code for both operational energy and materials related energy impacts of large homes. For example, three tiers of homes could be created; any home below 1,950 square feet only would need to meet the standard building code. Homes 1,950-2,850 square feet would be required to be built 20% more energy and materially efficient than a smaller code home. Homes over 2,850 square feet would be required to be 40% more energy and materially efficient than a smaller code home.

This tiered building code is not a new concept. The City of Boulder, CO has had a similarly structured code in place since 1996. Additionally, the recent revisions to Washington State's residential building code include a similar provision related to home size and efficiency.

Lead: Oregon Building Codes Division.

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[48] Carbon intensity of building material production reduced between 5-25% for all building materials purchased for use in Oregon in 2020. Since not all building materials consumed in Oregon are produced in Oregon, the production-based Oregon GHG inventory may not reflect reductions to the degree estimated here.

[49] Estimated by assuming that new construction between 2014-2020 decreases by 20% each year to account for people pursuing housing within the existing housing stock. The GHG reduction potential is discounted by 50% because of the increased impacts felt on the existing stock (e.g., more people using electricity in a home) or new accessory dwelling units being constructed and occupied. Additionally, all new housing is modeled as if it were 1200 square feet in size (both multi-family and single-family), which increases density and reduces the life cycle impacts of the new residences' materials and energy by approximately 50% compared with the average newly constructed home in Oregon. This scenario does not include any increases in building efficiency, but simply shows the benefits of adding density to the existing stock and decreasing the size of newly constructed homes. Benefits of increased density (on transportation-related emissions) are not included in this estimate.

Type of Action: Regulation

Timing of Impact: Short-term (1-5 years).

GHG savings? Approximately 0.23 MMTCO2e in 2020.[50]

Fossil Fuel Savings: Yes, not evaluated.

Cost (savings?): Unknown.

Cost effectiveness: Unknown.

Comments: While building codes are one method to incent smaller houses and efficiency improvements at larger houses, another means to do this is through a progressive building fee structure. However, state standards restrict the ability of local governments to offer progressive fees. When local governments are required to set permit fees based on the value of a building or retrofit, it disincents capital improvements (such as efficient HVAC units) that have higher up-front costs.

24. Require all State construction (including Institutional) to apply the State Energy Efficient Design program to materials

Summary: The State Energy Efficient Design (SEED) is a State of Oregon program administered by the Oregon Department of Energy that applies to all state agencies and state higher education institutions that are authorized to finance the construction, purchase or renovation of buildings or other structures to be used by the State of Oregon. It is not an optional program. SEED requires that buildings exceed the energy conservation provisions of the Oregon State building code by 20 percent or more.

The State should require that the materials-related impacts of SEED buildings also be 20% below a typical code building, or alternatively, be compensated through even higher GHG reductions associated with energy during occupancy, so that the life cycle energy impacts (or GHG impacts) of the whole building (energy + materials) represent a 20% improvement when compared to code.

Lead: Oregon Department of Energy

Type of Action: Standard

Timing of Impact: Short-term (1-5 years).

GHG savings? Approximately 0.02 MMTCO2e in 2020.[51]

Fossil Fuel Savings: Yes, not evaluated.

Cost (savings?): Unknown.

Cost effectiveness: Unknown.

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[50]The code change is enacted in 2013. All new homes built in 2014 or later are affected. Medium-sized homes (1950-2850 square feet) need to be 20% more energy and materials efficient than code and large homes (>2850 square feet) need to be 40% more energy and materials efficient than code. The estimate was made based on the reductions gained relative to a 2008 average code house. The benefits may be higher as/if energy code becomes more efficient. There are currently no standards in building code for the embodied energy efficiency of building materials. Foundational work from other recommendations (such as #20 and #21) could help establish performance guidelines for materials efficiency.

[51]This scenario is estimated by taking the State portion of commercial materials-related emissions in 2020 and reducing them by 20%. The State portion of material-related emissions is estimated by first estimating the proportion of government-related commercial material emissions using gross demand (in dollars) data from the 2005 IMPLAN database. That portion is then further divided into state and local emissions by proportioning the value according to number of employees in state and local government. The employment data was simply used a proxy for the proportion of money (and emissions) spent on buildings.

25. Expand/incentivize infrastructure for salvaged goods, use of salvaged materials

Summary: Salvage is the act of recovering a material for reuse without any reprocessing or change in the material's identity. Reuse is the act of using a salvaged material. The acts of salvage and reuse are complementary and are evaluated together in this scenario. By reusing materials, one decreases the demand for new (virgin) materials and thereby eliminates all of the impacts of producing and transporting that material. While reuse can have significant benefits for some materials, the act of salvage and reuse of building materials can also have impacts if the material is transported far distances, has decreased durability, or takes more energy or time to salvage or use. The State should expand the reuse and salvage infrastructure, and provide incentives for reuse and salvage. This scenario estimates the potential benefit of a high rate of salvage for 25% of all residential and commercial buildings in 2020. Finally, this practice does have its practical limitations in that an increase in the demand for salvaged materials must be met with an increase in supply from deconstructed or remodeled buildings.

Lead: Unknown

Type of Action: Incentives, possibly Regulation

Timing of Impact: Short-term (1-5 years).

GHG savings? Approximately 0.02 - 0.07 MMTCO2e in 2020.[52]

Fossil Fuel Savings: Possible, not evaluated.

Cost (savings?): Unknown.

Cost effectiveness: Unknown.

26. Use carbon-based metrics for measuring recycling

Summary: The State currently evaluates an annual waste recovery rate for the state as a whole, as well as individual "wastesheds." Wastesheds and the state as a whole have been held to recovery goals through 2009. The goals and rates are a measure of the percentage of waste generated (discarded) that is recovered. (For example, Metro's goal was to recover 64% of its waste in 2009.)

The State should add a greenhouse gas element to the recovery goals and rates. (Recovery goals for years following 2009 will need to be set by the Legislature; see recommendations #11 and #12 for related details.) Viewing recycling as a greenhouse gas reduction measure might lead communities to place higher emphasis on higher-impact materials and programs, and might also change how the public understands the benefit of recycling.

Lead: Oregon Legislature (new goals), DEQ (implementation)

Type of Action: Standards

Timing of Impact: Short-Term (1-5 years).

GHG Savings? Likely yes, but not evaluated.

Fossil Fuel Savings? Likely yes; not evaluated.

Cost (Savings)? Some cost to DEQ (staff time) to program, maintain, and explain a GHG emissions calculator for recovery.

Cost/Effectiveness? Not evaluated.

[52]The lower estimate was developed for a similar alternative evaluated for the Governor's Advisory Group on Global Warming in 2004. For the higher estimate, we assume that 25% of residential homes and commercial buildings pursue a high level of salvage in 2020 where approximately 2/3 of all materials used over the life cycle are salvaged. Salvage increases end-of-life benefits by 20% and increases construction and maintenance impacts by 25%. There were no estimates made on the feasibility of this scenario due to supply and demand scenarios. This higher estimate may be regarded as an upper bound of the potential of building material reuse.

Comments: While waste recovery is a valuable approach for reducing GHG emissions, there are additional benefits to recovery. There is some risk in associating recovery closely with climate change actions, and effectively de-emphasizing other benefits.

27. Implement policies to reduce loss of recyclables at processing facilities

Summary: Many recyclables are collected commingled (mixed together) and must be sorted prior to being sent to end markets for use in making new products. The processing facilities (also called "material recovery facilities" or "MRFs") use a combination of manual and mechanical methods to sort recyclables. Loss rates (percentage of incoming recyclables that don't get to the proper final market) range widely, from an estimated 0.16% for newsprint, to 20% or higher for plastic containers.[53]

In 2009, DEQ convened the Oregon Commingled Recycling Systems Improvement Project. The purpose of the project is to identify opportunities to improve Oregon's commingled recycling system at all levels, from collection and consumer education to processing and end-markets. This state-wide project follows a Contamination in Commingled Recycling Systems Standards & Guidelines Initiative that EPA Region 10 facilitated in 2008 among stakeholders in the Pacific Northwest. Workgroup meetings are currently on hold while DEQ completes a 2009/2010 study of MRF loss rates.

Options for reducing processing losses include improving inputs (less contamination by waste generators) and changes to how processing is conducted. Several other recommendations (e.g., #28, #29, and #30) address inputs to the MRFs. This recommendation focuses on how processing is conducted. The processing industry competes for feedstock in part on price; the only effective standard on quality is what end-markets are willing to accept and how much they're willing to pay for it. Due in part to intense demand from China and tolerance there for higher contamination, domestic mills are limited in their ability to pay much of a premium for higher quality materials. As a consequence, if processors incur higher costs associated with better sorting, any costs not recouped through higher revenue from end-markets must be passed up the supply chain to the waste collectors. This limits the ability of the MRFs to reduce mis-sorting and contamination. State law prohibits the intentional disposal of source-separated recyclables, but DEQ has only used this to enforce against a MRF operator on one occasion.

A policy or policies should be implemented to incent quality and reduce the mis-sorting of materials by MRFs. Examples of possible approaches include financial resources for MRFs, the development of MRF standards (which would be used by local governments in directing the flow of collected recyclables), permitting MRFs, and/or more aggressive enforcement by DEQ. These (and potentially other) options may be considered by the Oregon Commingled Recycling Systems Improvement Project when it reconvenes this fall.

Lead: Oregon DEQ, possibly Oregon Legislature, local governments, processing facilities.

Type of Action: Regulation and/or Incentives.

Timing of Impact: Short-term (1-5 years).

GHG Savings? Yes. Approximately 0.02 – 0.03 million MTCO2e in 2020 if a 50% reduction in MRF losses can be attained.[54] *(Sensitivity analysis: 0.04 – 0.06 MMTCO2e in 2020.)*

Fossil Fuel Savings? Yes.

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[53] These estimates were provided by Metro and are based on a study at MRFs in the mid-2000s. A more recent study was conducted by Metro and DEQ in 2009-2010 but results are not yet available.

[54] DEQ reviewed materials collected in 2008 and reported under the statewide material recovery survey in the categories of "on-route (residential)," "multi-family," and "commercial" collections. Simplifying assumptions were made regarding the percentage of each material, by collection mode, sent to MRFs. (All residential materials were assumed to be sorted at MRFs except for 50% of glass; most commercial materials were assumed to be sorted at MRFs except for 50-90% of corrugated and 50-70% of glass). MRF loss rates from Metro's study (of residential loss rates) were applied to residential materials. For commercial materials, which in some cases are sorted separately and believed to be subject to smaller processing losses, a range of MRF loss rates were used, with Metro's rates as an upper bound, and 25% of Metro's loss rates as a lower bound (except for newsprint, which was kept constant at a low 0.16%).

Cost (Savings)? Higher costs to processors (better/different equipment, other operational changes) will be passed on to recycling collectors, and then to ratepayers. Some costs will be offset by lower disposal costs. End-users of the recyclables (e.g., newsprint mills and their customers) will realize significant cost savings.

Cost/Effectiveness? Not evaluated.

Comments: Cross-contamination of recyclables sent to end-markets has been a major concern to domestic end-users of recyclables, especially paper mills. Mills have been forced to spend millions of dollars adding screening equipment and on downtime, premature equipment failure, and disposal costs caused by contamination of recyclable feedstocks resulting from a variety of factors, including inadequate outreach to households, collection system changes (such as commingling and roll carts), and inadequate processing by MRFs. Improving processing at MRFs would have a co-benefit of cleaning up the feedstocks sent to end-users. According to Chris Thomas of SP Recycling, "As an owner of a mill that receives a lot of the material from the Northwest, even small improvements in material quality can have huge effects on the mills' ability to be competitive in the market and for survival. Any combination of . . . (improvements in processing) could have a net effect of a few percentage points on MRF outbound quality. The overall positive effect to the mills would be drastic."

28. Expand product stewardship focusing on end-of-life management to cover additional materials; include life cycle GHG emissions as a primary product selection criteria

Summary: 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. In both cases, industry has primary responsibility for financing and providing for the convenient collection of unwanted product from consumers at end-of-life.

Oregon should continue to bring more products under the umbrella of product stewardship. While Oregon should work on both "upstream" design changes and also reducing "upstream" emissions (under recommendation #5), Oregon should also continue to use product stewardship as a means to improve recovery (recycling) of products. Oregon's product stewardship efforts currently focus on products that contain toxic chemicals and/or are difficult to manage at end-of-life; the State should add greenhouse gas reduction potential to that list of criteria.

Lead: Oregon Legislature, Oregon DEQ, producing industries.

Type of Action: Regulation.

Timing of Impact: Effective in the short-term (1-5 years) but will require longer (10 years) to cover all products that have been identified as having potential.

GHG Savings? Yes. Approximately 0.07 – 0.11 million MTCO2e in 2020.[55, 56] *(Sensitivity analysis: 0.07 – 0.12 MMTCO2e in 2020.)*

[55] The most comprehensive review of potential products for inclusion in product stewardship efforts in North America is the Canada Wide Action Plan for Extended Producer Responsibility, developed by the Canadian Council of Ministers of the Environment in 2009. This Plan identifies products for inclusion in "phase one" and "phase two" of a nationally harmonized program. For the purposes of estimating potential GHG reductions, DEQ reviewed the products in phases one and two, and assumed that Oregon legislation or rules would require stewardship of the following products: mercury-containing lamps (2011), carpet (2013), additional consumer electronics (2015), recyclable film plastic (2016), some household hazardous wastes (2017), and appliances (2018). This list was developed for the purpose of estimating potential GHG reductions only, and in no way implies selection or targeting of materials for potential product stewardship legislation in

Fossil Fuel Savings? Yes; not estimated.

Cost (Savings)? Not estimated. Product stewardship shifts costs from solid waste ratepayers to producers/consumers of covered products.

Cost/Effectiveness? Not evaluated.

29. Expand bottle bill to cover additional materials; increase deposit to ten cents if 80% redemption rate not achieved

Summary: The bottle bill should be expanded to include all beverages except milk. In addition, if an 80% redemption rate is not attained, the deposit should be increased to ten cents, and other steps should be taken as necessary to achieve and maintain an 80% redemption rate.

Lead: Oregon Legislature, OLCC.

Type of Action: Incentive.

Timing of Impact: Short-term (1-5 years).

GHG Savings? Yes. Approximately 0.05 MTCO2e in 2020.[57] *(Sensitivity analysis: 0.05 MMTCO2e in 2020.)*

Fossil Fuel Savings? Yes; not estimated.

Cost (Savings)? Not estimated. Potentially increases costs for retailers; reduces costs for curbside recycling systems.

Cost/Effectiveness? Not evaluated.

30. Increase funding by $1.20 per household-year for recycling outreach

Summary: State law requires local governments to conduct outreach and education to residents and businesses regarding recycling. Some communities invest heavily in outreach, while others do not. An increase in outreach efforts would increase participation in recycling and other waste recovery efforts (such as composting). The State should provide funding for effective recycling outreach.

Lead: DEQ could coordinate development of enhanced outreach materials. Oregon Legislature could create a funding mechanism to help support local outreach efforts. Implementation would primarily be the responsibility of local governments, which often delegate responsibility to their franchised waste collectors.

Type of Action: Education

Oregon. A 2018 cut-off date is used because lead time is required before recovery programs are in place by 2020. Of these materials, recovery of carpet, consumer electronics, recyclable film plastic, and appliances are assumed to result in meaningful GHG reductions. DEQ bumped the recovery rates for these materials from the business-as-usual forecast by 20% for carpet, consumer electronics, and recyclable film plastic, and increased the recovery tonnage for "other mixed metals" by an amount equal to 25% of the recovery tonnage for computers and monitors. Recycling of carpet is one instance where DEQ did not use the emissions factors provided by EPA. EPA's model suggests that recycling one ton of carpet reduces GHG emissions by an amount 180% of the emissions associated with producing the carpet in the first place. Rather, DEQ used the recycling factor for mixed plastics (where recycling reduces GHG emissions by 76% of the emissions associated with producing the product in the first place), and used this as a high estimate of the GHG reduction potential of recycling carpet (relative to production of carpet). Scaling it by 50% (to 38%) provides a lower estimate of per-ton emissions reduction potential, given the mixed materials and challenges associated with recycling carpet.

[56] An additional GHG reduction credit of 0.003 – 0.015 MMTCO2e is added to reflect a reduction in MRF losses due to better management of film plastics. This is based on an assumption that by 2020, stewardship of recyclable film plastics (added 2016) has reduced film plastics mixed with other recyclables by 30-50%, resulting in a reduction in overall MRF losses of 8-25%. See recommendation #27 for additional details on estimating GHG reduction potential associated with reducing MRF losses.

[57] Based on projections by Peter Spendelow (DEQ) for the Oregon Bottle Bill Task Force (2009), updated in 2010. The projections assume that in the absence of bottle bill changes, the recovery rates for targeted materials would fall in 2020 to 74% for aluminum, 69% for glass, and 42% for plastic containers. With the addition of wine, liquor, juice, coffee, and sports drinks, and a ten-cent deposit, the projected recovery rates rise to 86% for aluminum, 88% for glass, and 70% for plastic.

Timing of Impact: Short-term (1-5 years).

GHG Savings? Yes. Approximately 0.04 – 0.12 million MTCO2e in 2020.[58] *(Sensitivity analysis: 0.05 – 0.14 MMTCO2e in 2020.)*

Fossil Fuel Savings? Yes; not evaluated.

Cost (Savings)? Approximately $2.1 million/year in 2020.[59]

Cost/Effectiveness? Not evaluated.

31. Require garbage and recycling service parity (residential curbside)

Summary: Approximately 60% of Oregon households with curbside recycling have their recyclables collected weekly on the same day as garbage. Approximately 40% have their garbage collected weekly, with recycling service offered on the same day, but only every other week.[60] All other things being equal, this lower level of convenience for recycling (relative to garbage) has been shown, on average, to depress recycling participation and reduce the recovery of materials. Although it also saves on fuel and offers the potential for lower collection costs, life cycle analyses of the GHG impacts of recycling and garbage service suggest that less frequent curbside service offers a greenhouse gas benefit approximately 88% that of curbside recycling service on par with garbage collection.

DEQ should impose a temporary moratorium on any program approvals for less frequent service under the opportunity-to-recycle law, so that cities would not be allowed to reduce service convenience for recycling. DEQ should then create an easy-to-use tool that "monetizes" the GHG impacts and benefits of curbside recycling. This tool would be used to evaluate curbside collection systems to provide for a more complete understanding of the costs (and benefits to society). Where the cost of service plus monetized benefits of more frequent curbside (parity with garbage) are found to be lower than the cost of service plus monetized benefits of less frequent service, DEQ should require the provision of more frequent service.

Lead: DEQ

Type of Action: Regulation

Timing of Impact: Effective in the short-term (1-5 years) but may require longer (10 years) to apply statewide.

GHG Savings? Yes. Approximately 0.008 – 0.033 million MTCO2e in 2020.[61] *(Sensitivity analysis: 0.016 – 0.064 MMTCO2e in 2020.)*

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[58] A 2002 report by Skumatz Economic Research Associates, Inc. for the State of Iowa (Evaluating the Impacts of Recycling/Diversion Education Programs – Effective Methods and Optimizing Expenditures) found a correlation between program expenditures on education and waste recovery rates. Specifically, in communities with low educational expenditures (e.g. $0.30 per household per year), adding $1 per household per year – controlling for basic demographic and recycling program differences – adds about 3% in recycling rates. In higher-spending communities ($1.40 per household per year), adding $1 more increases recycling rates by about 1%. To model potential impacts in Oregon, we assume that 80% of Oregon's population is located in "higher-spending" communities and 20% is located in "lower-spending" communities, and that expenditures increase $1 per household (in 2001 dollars) statewide. We increase recovery by ([80% x 1% + 20% x 3%]), representing the absolute increase in the statewide recovery rate. The result is an increase in the state's recovery rate of 0.56%. This is allocated across potentially recoverable materials using the same method described in recommendation #11. The resulting point estimate of GHG reductions is then converted into a range by taking 50% and 150% of the point estimate, representing the high uncertainty associated with this approach.

[59] Adjusting the $1 (in 2001) to 2009 dollars (using the CPI-U; 2010 not available yet) results in $1.21 per household.

[60] This includes residents in 6 of Oregon's 10 largest cities: Eugene, Salem, Hillsboro, Bend, Medford and Springfield. Portland, Gresham, Beaverton, and Corvallis offer recycling and garbage service parity.

[61] Based on a detailed study of curbside recycling options conducted by DEQ for Metro. This study evaluated the life cycle GHG impacts of 7 different curbside recycling service levels for each of 5 different communities in Washington County (4 cities and the unincorporated area). It accounted for fuel use by collection vehicles, MRF losses, the "upstream" impacts and benefits of recyclables actually recycled (post-MRF losses), transport of MRF residue, and marginal changes in garbage collection, transport to landfill, landfill energy recovery, and landfill carbon storage. The range of results represents a lower and upper estimate of potential impacts. The lower estimate assumes that in the

Fossil Fuel Savings? Yes, not currently quantified.

Cost (Savings)? More frequent curbside recycling service is expected to increase service costs, which are borne fully by ratepayers.

Cost/Effectiveness? Yes, by definition.

32. Develop markets for compost products

Summary: Composting – especially composting of food waste – offers the potential for reductions in GHG emissions. Compost also provides other environmental benefits. The viability of the compost industry is dependent upon strong demand for finished compost product.

Oregon should increase demand for compost product. Opportunities include: exploring potential agricultural markets (agriculture is a major user of compost in California, where it has been strongly promoted; Oregon lags far behind and the reasons for this are not well understood); expanded use of compost by ODOT and in other state construction projects; adoption of "low impact development" standards or requirements for new construction by cities and counties; and requirements that landfill covers be managed for higher rates of oxidation (see recommendation #36).

Lead: ODOT, DAS, city and county governments

Type of Action: Standards

Timing of Impact: Short-term (1 – 5 years).

GHG Savings? Yes, but not evaluated.

Fossil Fuel Savings? Yes; not evaluated.

Cost (Savings)? Not evaluated.

Cost/Effectiveness? Not evaluated.

Comments: Other environmental benefits of compost use include more water infiltration (resulting in less run-off and reduced demand for irrigation), improved soil tilth and fertility (resulting in higher yields), a potential for reductions in fertilizer and herbicide applications, and potential for reduced pollutant run-off.

33. Require communities over a certain population to collect for recovery food waste from residences and certain categories of non-residential waste generators

Summary: The State should require communities over a certain size to provide an opportunity to single-family households and certain classes of non-residential waste generators to separate food waste from garbage for the purposes of recovery. Targeted non-residential generators might include, for example, food processors, restaurants, grocery stores, hospitals and schools over a certain size. The requirement would need to include a standard that food waste collection service be offered at rates such that there is no financial penalty to participate.

This is an extension of the current "opportunity-to-recycle" model required of cities with populations greater than 4,000.

Lead: Oregon Legislature, DEQ (policy, regulation); local governments, franchised haulers, and recovery industry (implementation).

Type of Action: Regulation.

Timing of Impact: Short-term (1 – 5 years).

absence of this policy, by 2020 only 40% of households would have curbside/garbage parity, and that this policy would raise that to 60%. The upper estimate assumes that in the absence of this policy, in 2020, no households would have curbside/garbage parity, and that this policy would raise that to 80%.

GHG Savings? Yes. Approximately 0.01 – 0.04 million MTCO2e in 2020.[62] *(Sensitivity analysis: 0.04 – 0.10 MMTCO2e in 2020.)*

Fossil Fuel Savings? Yes, for energy recovery via anaerobic digestion. (AD will capture a higher percentage of methane than landfill gas systems.)

Cost (Savings)? Not evaluated.

Cost/Effectiveness? Not evaluated.

Comments:

34. Implement a feed-in tariff for anaerobic digestion

Summary: In-vessel anaerobic digestion (AD) offers an alternative to composting as a method of recovering value from food waste. AD rapidly decomposes food waste and produces three outputs of value: biogas that can be used to generate electricity, heat, and an undegraded waste remnant that can be further stabilized via composting. Advocates for AD have suggested that feed-in tariffs would help to make AD economically viable in Oregon (and elsewhere). A feed-in tariff guarantees a producer of electricity from renewable sources (such as AD) access to the grid and a guarantee of a long-term price for power produced that covers the difference between the actual cost to produce the electricity and what utilities are otherwise willing to pay for it. The State should provide a feed-in tariff for anaerobic digestion.

According to Dean Foor of Essential Consulting Oregon, 30,000 tons per year is probably a very low threshold for a single AD facility in Oregon.[63] A larger facility will benefit from better economies of scale. Feedstocks may be 80% food waste and 20% manure. At this rate, one small AD facility would need approximately 24,000 TPY of food waste. Limiting our analysis to MSW (and excluding agricultural wastes), commercial and residential food waste collection programs just in Willamette Valley cities might be able to produce 43,000 – 104,000 TPY of food waste (not including food-soiled paper) in 2020. To avoid high transportation costs, the AD facility typically needs to be located no more than ~60 miles of the source of food, although economics improve significantly if transport distances are shorter. This suggests the potential for 1-3 AD facilities serving the entire Willamette Valley, with a combined generating capacity of roughly 1.5 – 3.5 MW.

Oregon already has a pilot scale feed-in tariff, limited to solar photovoltaic systems with capacities of 500 kW or less.

Lead: Oregon Legislature, Oregon Public Utilities Commission

Type of Action: Incentive

Timing of Impact: Short-term (1 – 5 years).

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[62] Based on estimates by the City of Portland, extrapolated statewide using "low" and "high" estimates. The Portland research assumes recovery is 75% food waste and 25% soiled paper. The "low" estimate for residential collection assumes 40% participation and 60% capture rates, for all cities with populations greater than 40,000. The "high" estimate assumes 60% participation and 80% capture rates, for all cities with populations greater than 20,000. The "low estimate" for nonresidential assumes 40% participation and 60% capture rates, for all cities with populations greater than 40,000. The "high" estimate assumes 60% participation and 80% capture rates, for all cities with populations greater than 20,000. The non-residential estimates also assume that 80% of the food and soiled paper currently disposed of from nonresidential sources are from sources that would be eligible to participate in this type of collection service. DEQ assumes recovery is 75% compost and 25% anaerobic digestion. For the sake of modeling, DEQ assumes no significant shift of feedstock currently being recovered from composting facilities to AD facilities. The "low" and "high" estimates also use different emissions factors for landfilling of food waste, as follows: a lower factor for methane emissions using the methane generation algorithm from EPA's WARM model, discounted to account for emissions resulting in years after 2020, and a higher factor for methane emissions in 2020 based on the methodology contained in the Organic Waste Composting Project Protocol, http://www.climateactionreserve.org/wp-content/uploads/2010/07/OWC_Project_Protocol_Version_1.0.pdf.

[63] Thanks to Dean Foor and committee member Ethan Nelson (City of Eugene) for their assistance in evaluating the alternative that formed the basis of this recommendation.

GHG Savings? Yes, assuming that the feedstocks aren't diverted from composting facilities (see comments below). Approximately 0.013 – 0.045 million MTCO2e in 2020.[64] *(Sensitivity analysis: 0.025 – 0.061 MMTCO2e in 2020.)*

Fossil Fuel Savings? Yes.

Cost (Savings)? Electric ratepayers pay for the feed-in tariff. Haulers/waste generators also pay a tip fee at the AD facility to deposit food waste (and other feedstocks), although this fee may be comparable to (or lower than) traditional disposal fees.

Cost/Effectiveness? Not quantified, although a cursory review of literature suggests that feed-in tariffs are often viewed as a cost-effective method of increasing renewable power generation.

Comments: The Materials Management Committee originally evaluated this policy option on the assumption that anaerobic digestion of food wastes would have a greater net GHG reduction than composting of food wastes. A subsequent review of a comparison produced by ICF Consulting for Environment Canada suggests that this might not be the case.[65] However, the comparison is complicated by larger uncertainties in the life cycle GHG impacts, particularly involving soil carbon storage of finished compost.

This alternative focuses on anaerobic digestion because of literature demonstrating that it offers a potential to reduce GHG emissions relative to the alternative (disposal). As research into alternative recovery approaches is completed (see recommendation #9), the State should consider offering a feed-in tariff to additional technologies that demonstrate a meaningful greenhouse gas reduction potential.

Some literature suggests a net job creation potential from feed-in tariffs, generally.

An alternative to dedicated AD facilities is co-digestion of food and other putrescible wastes at wastewater treatment plants. This is viewed as highly feasible at those plants that have excess capacity. This practice has been widely adopted throughout Europe with a high degree of success. Some such development is already underway, including a retrofit of the Pendleton treatment plant to accept food waste from area Wal-Mart stores and the Eastern Oregon Correctional Institution for gas production.

35. Conduct improved research into methane emissions, as well as opportunities to reduce emissions through better surface monitoring

Summary: The State should conduct or support research into two related topics. The first would continue to improve our collective understanding of methane emissions from landfills and the key variables that impact emissions (including the impacts of different waste types, the timing of emissions generation, and the effectiveness of gas collection and oxidation at the landfill surface). This would improve the accuracy of emissions estimates, and improve understanding of how emissions can best be further reduced. This could involve both primary (field) and secondary (literature) research.

The second research project would involve field research (surface monitoring) at Oregon landfills to better understand the prevalence and potential impact of emissions "hot spots." There is concern that potentially large quantities of methane may escape collection where landfill covers develop cracks or tears. While EPA air quality regulations require

[64] Based on residential and nonresidential recovery potential estimates by the City of Portland, extrapolated statewide using "low" and "high" estimates and assuming that 80% of the food and soiled paper currently disposed of from nonresidential sources are from sources that would be eligible to participate in this type of collection service. The Portland research assumes recovery is 75% food waste and 25% soiled paper. The "low" estimate assumes 40% participation and 60% capture rates, for both households and eligible businesses in all Willamette Valley cities with populations greater than 40,000. The "high" estimate assumes 60% participation and 80% capture rates, for both households and eligible businesses in all Willamette Valley cities with populations greater than 20,000. The "low" and "high" estimates also use different emissions factors for landfilling of food waste, as described in recommendation #33. DEQ assumes that all recovery goes to anaerobic digestion facilities.

[65] ICF Consulting, Determination of the Impact of Waste Management Activities on Greenhouse Gas Emissions: 2005 Update, Final Report, submitted to Environment Canada and Natural Resources Canada (2005).

periodic surface monitoring at larger landfills, these requirements may not be sufficient to identify hot spots in a timely manner. California has recently established a higher standard for surface monitoring. Under this research project, more detailed surface monitoring would be conducted at landfills in Oregon on a pilot/research basis, to determine whether or not an improvement is needed to standards.

Lead: Landfill industry, DEQ, Association of State and Territorial Solid Waste Management Officials, and/or US EPA.

Type of Action: Research

Timing of Impact: Short-term (1-5 years).

GHG Savings? Possibly, if the research identifies that "hot spots" are a significant concern and this results in a change in permitting/monitoring/operational requirements.

Fossil Fuel Savings? Not evaluated.

Cost (Savings)? Yes, to conduct and review the research.

Cost/Effectiveness? Not evaluated.

36. Require intermediate covers to be designed as oxidation covers at areas of landfills without active gas collection

Summary: Some landfill cells are partially filled, covered with an "intermediate cover," and then left alone for years while other areas of the landfill are developed. Later, waste may again be placed above this intermediate cover. Only later is a final cover installed. Intermediate covers are expected to be less effective at reducing methane emissions than final covers. In addition, areas under intermediate covers may or may not have gas collection systems installed, and in some cases, it may be years or even decades before this area of the landfill is closed and/or brought under gas collection. DEQ should require such intermediate covers to be designed and maintained to enhance oxidation (microbial conversion of methane to carbon dioxide as gas passes through the cover). This may involve adding more soil and/or blending the cover soil with substances such as compost or sludge, so as to enhance microbial activity.

Lead: DEQ

Type of Action: Regulatory/Permitting. DEQ already has regulatory authority to require this at DEQ's discretion.

Timing of Impact: Short-term (1-5 years).

GHG Savings? Yes. Approximately 0.03 million MTCO2e in 2020.[66]

Fossil Fuel Savings? No, unless the requirement is so expensive that it leads landfills to install active gas collection in order to avoid it, and the collected gas is used for energy.

[66] DEQ has recently updated its model of GHG generation, collection rates, oxidation rates, and emissions for 10 large, open MSW landfills, and an 11th category of "other open MSW landfills" for emissions through 2008. An earlier model (2004) forecast emissions from these landfills to 2025 (including 2020). Using the updated model and emissions in 2008, DEQ identified three landfills that might be impacted by this requirement: Finley Buttes, Wasco, and "other." The other larger, individually-modeled landfills are expected to be exempt due to the presence of active gas collection in all areas under intermediate cover. The gas emissions model for 2008 was adjusted by increasing the oxidation rate from 10% to 30% at these three landfills, adjusted downward to assume that only 20% and 76% of the total surface area would be effected at Finley Buttes and Wasco landfills, respectively (along with the simplifying assumption that emissions are uniformly distributed across the surface area). For the category of "other" landfills, which includes both opened and closed landfills, we assume that 10% of the surface area covering wastes placed prior to 2003, and 50% of the surface area covering wastes placed in 2003 and subsequent years, would be in intermediate cover. Combined, these assumptions result in an estimated reduction of emissions of 0.02 MTCO2e. Results are scaled up to 0.03 MTCO2e for 2020 based on the ratio of projected total MSW landfill emissions in 2020 to estimated total MSW landfill emissions in 2008.

Cost (Savings)? DEQ might need to write an internal management directive. Some landfills will not be impacted by this; others may have to bring in additional soils.

Cost/Effectiveness? TBD.

Comments: Designing intermediate covers as oxidation layers could increase demand for compost product, and so could be viewed as a market development activity for compost.

37. Require installation of gas collection at landfills (horizontal collectors) as waste is placed (reduced installation delay), consistent with current technologies

Summary: Landfill methane production can begin very rapidly after waste placement, then continue for decades, depending on landfill conditions. Large landfills with gas collection systems are not typically required to install gas collection until several (five or longer) years after waste is initially placed. However, some landfills choose to install horizontal collectors throughout the waste mass as it is placed. This increases gas capture and reduces emissions by creating a mechanism to collect early gas generation.

DEQ should require the installation of gas collection systems within 12-18 months of waste placement for landfills that already have an active gas collection system. Landfills without an active gas collection system would not be affected.

Lead: DEQ.

Type of Action: Regulatory/Permitting. DEQ has authority to require this at landfills that recirculate leachate. Additional research is needed to determine if DEQ has authority at other landfills.

Timing of Impact: Short-term (1-5 years).

GHG Savings? Yes. Approximately 0.002 – 0.05 million MTCO2e in 2020.[67]

Fossil Fuel Savings? Yes, as most landfills with active gas collection use the gas for energy recovery.

Cost (Savings)? Additional cost required to install early/horizontal collectors. Additional revenue from increase in energy recovery. Costs not quantified.

Cost/Effectiveness? Not estimated.

38. Require that alternative final covers be designed to reduce GHG emissions

Summary: This builds on what was a "tier one" recommendation of the Governor's Advisory Group on Global Warming (2004), with significant GHG reduction potential. The Advisory Group recommended that DEQ revise its solid waste guidance for landfills subject to EPA New Source Performance Standards for landfill gas so that alternative final covers at landfills would also need to reduce GHG emissions comparable to a conventional geo-

[67] Gas modeling used in 2004 suggests that at wet landfills, 29.7% of gas generation occurs within the first five years of waste placement, and at dry landfills, 1.1% of gas generation occurs within the first five years of waste placement. However, first-order decay models suggest that 90.3% of gas generation occurs within the first five years at wet landfills, and 75.1% occurs within the first five years at dry landfills. To estimate the potential GHG reductions from this recommendation, we use the first set of values (29.7% and 1.1%) as a lower bound, and the mid-points of the two values (60.0% wet and 38.1% dry) as a fairly arbitrary and hypothetical upper bound. These values are applied to the 2008 gas generation/emissions projection referenced in recommendation #36, for the only landfill that this recommendation (#37) is expected to impact: Finley Buttes (a dry landfill). Methane generation in 2008 at Finley Buttes is multiplied by 1.1% and 38.1% as a crude estimate of emissions that occur before gas collection is installed (using a simplifying assumption that disposal in year X is the same in years X-1 through X-4). These "early" emissions are then multiplied by an assumed gas capture rate of 75% as a rough estimate of emissions reduction resulting from this measure. Results are then scaled upward to account for presumed higher gas generation in 2020, using the same scaling factor applied in recommendation #36. The wide range of results suggests that this recommendation would benefit from further evaluation.

membrane cover. Such a change, which DEQ did not implement, would have impacted four large landfills in Central and Eastern Oregon. Since 2004, three of these four landfills have significantly expanded gas collection, significantly reducing the potential benefit of this approach.

DEQ should apply a variation on this requirement to all but the smallest of landfills using alternative final covers. Rather than requiring alternative covers to be "comparable" to a geomembrane, DEQ should require that alternative covers be designed to reduce GHG emissions using best management practices available. This requirement could be met through a variety of practices, including active gas collection and/or improved soil oxidation. The result would be to reduce emissions from several mid-sized landfills in Central and Eastern Oregon.
Lead: Oregon DEQ

Type of Action: Regulation

Timing of Impact: Most impact would occur in the long-term (10+ years).

GHG Savings? Yes. Not evaluated

Fossil Fuel Savings? Probably not.

Cost (Savings)? Yes (cost), but not evaluated.

Cost/Effectiveness? Not evaluated.

APPENDIX D

Background: Overview of Methodology for Evaluating Emissions Reduction Potential

Where possible, DEQ attempted to estimate the emissions reduction potential of individual alternatives/recommendations. These estimates should be understood to be relatively crude in most cases.

A variety of methods were used to evaluate emissions reduction potential. These methods are briefly summarized as follows:

For several alternatives/recommendations with broad, multi-material impacts (1, 4, 14), DEQ drew on estimates of the life cycle GHG emissions of all materials either used in the US or consumed in Oregon, derived from research conducted by the US EPA, research currently underway as part of the development of Oregon's consumption-based GHG emissions inventory, and an input-output GHG estimation tool developed by Carnegie Mellon University (and applied to state purchasing by Good Company).

The baseline model for alternatives/recommendations focusing on food was constructed using USDA data on the types and quantities of food produced and consumed in the US, pro-rated to Oregon. USDA data was also available for the retail and consumer loss rates for each commodity. Using historic caloric rates of increase, an average diet was projected for the year 2020. Greenhouse gas emission factors, courtesy of CleanMetrics, were then identified for 30 different categories of commodities. Average transport was assumed to be 2414km from farm gate to retail. Both refrigeration and freezers during transport were considered. Food packaging, refrigeration at retail, and consumer transport, storage, and cooking was not considered. Finally, emissions from the waste disposed was modeled using Oregon DEQ projected data on the quantity of waste produced in future years and the emissions associated with that waste in 2020.

For alternatives/recommendations involving building materials and practices, a baseline model of building-related GHG emissions was established for all commercial and residential buildings through 2020. The life cycle emissions included: original and replacement material production, construction and maintenance, use, and end-of-life. The model was based on the ODOE GHG inventory for Oregon, which has published data from 1990 through 2005. The average increase in use phase emission over the 15 years of data available was used to estimate the future emissions for commercial and residential buildings. Using an Oregon DEQ-commissioned study on the life cycle GHG emission of an average residential home in Oregon, estimates for materials production, construction, maintenance, and end-of-life were made for both residential and commercial buildings on the state scale. All GHG reduction scenarios were evaluated against this baseline model.

For all other alternatives/recommendations evaluated, a "business as usual" (BAU) projection was made of materials generated as waste, and subsequently recovered (by recycling, composting, anaerobic digestion) or disposed of (via incineration or landfilling) in 2020, assuming that per-capita waste generation remains constant (from 2008) and that the composition and disposition of materials is similarly unchanged. Emissions factors for a variety of materials were then applied to different actions (materials production, represented by waste generation; forest carbon sequestration associated with source reduction; recycling; composting; landfilling; etc.). These emissions factors were largely – but not exclusively – drawn from the documentation behind EPA's WARM tool. The emissions for the BAU scenario were then compared against emissions for a variety of other scenarios involving changes in the quantities of wastes generated, recovered, and/or disposed of. Landfill emissions were derived in part from a DEQ model of Oregon landfills and assumed methane gas capture rates for the state's largest landfills. This landfill submodule was also used to evaluate two alternatives/recommendations specific to landfill practices (37 and 38).

In all cases, the emissions factors used in these models are somewhat imprecise. Compounding this is a dearth of information on the potential impacts of different policies and programs (for example, "how much would an undefined incentive for carbon labeling result in changes by producers and consumers, and in what ways?"). While DEQ has attempted in some cases to reflect this uncertainty through the use of ranges of estimates as opposed to point estimates, readers are cautioned to understand the moderate to high uncertainty associated with many of these estimates.

Timing of Emissions Reductions

DEQ was charged with estimating the emissions reductions potential in the year 2020. The use of this accounting frame requires that two additional considerations be explained.

First, emissions associated with materials management only change when producers and consumers change how materials are managed. Many of the recommendations are designed to drive such change, through education, incentives, and/or regulation. There is a delay between when programs are implemented and when producers and consumers respond with changes in how they use materials. The extent to which change occurs depends somewhat on the timing of when such education, incentives, and/or regulations begin. DEQ has generally assumed, for the purposes of modeling, that implementation of most recommendations would begin around 2015, which allows some time for resulting change to occur. This assumption is made for the purpose of standardizing evaluation, and does not necessarily reflect political or economic conditions that may result in some recommendations being delayed. In any case, many of the policies and programs evaluated here have the potential for a delay in when they result in actual changes in materials management.

While this first consideration is true for all of the committees of the 2020 Vision project (energy/utilities, industry, forestry, transportation/land use, agriculture, materials management), materials management has a second consideration related to timing. Even if consumers or producers change how they manage materials in 2020, not all of the resulting changes in emissions occur in that year. (This is unlike, say, consuming less electricity in 2020, where emissions reductions are instantaneous). Specific to materials management, some emissions or emissions reductions can be delayed by years or even decades. These include: methane generation at landfills (or reduced generation, in the case of waste diversion); increased carbon uptake and storage in forests associated with the source reduction and recycling of wood and paper; and increased carbon storage in soils treated with compost.

To accommodate the need to evaluate all emissions reductions relative to actual emissions in the year 2020, DEQ adjusted the landfill methane and forest/soil carbon storage emissions factors provided by EPA to reflect the fact that only some of the emissions associated with how materials are managed in the period 2015-2020 will occur in 2020.[68] So as to not unfairly bias alternatives in favor of landfilling, DEQ made an equivalent adjustment to the landfill carbon storage emissions factors. Regardless, the result is to generally downplay or underestimate the potential carbon benefit, relative to other practices, of practices that recycle, reuse, or reduce use of wood and paper, produce compost, and divert putrescible wastes from landfills. To illustrate the potential impact of these adjustments, DEQ also conducted a sensitivity analysis for some alternatives/recommendations wherein all consequential GHG reductions associated with a materials management practice in 2020 are assigned to the year 2020 (even though some of the reductions are delayed). This provides an alternative picture of the GHG reduction potential of these actions. Results of the sensitivity analysis are presented alongside other results in Appendix C.

[68] Note that this only applies to recommendations evaluated using the emissions factors provided by EPA. These are primarily recommendations related to waste prevention (including food), recycling, and composting.

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