Summary Report

Consumption-Based Greenhouse Gas Emissions Inventory for Oregon - 2005

State of Oregon
Department of Environmental Quality

Summary Report

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Local Consumption, Global Impact

Greenhouse Gas Emissions from Consumption in Oregon

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Introduction

In 2011, the U.S. economy is climbing out of the deepest recession in seven decades. Under new financial strain, millions of Americans are reconsidering their habits of spending and saving. The U.S. savings rate – defined as the percent of disposable income not spent – has reached its highest level in 15 years. Long accustomed to living beyond their means, many Americans have adapted to the recession by consuming less.

As the Oregon economy recovers, households, businesses and government have a unique opportunity to consider the sustainability of future consumption patterns. Just as growing consumption levels have recently proven to be financially challenging, they also pose a fundamental threat to resource and ecological sustainability. In addition to driving water scarcity, forest loss and other human and ecological pressures in regions of the world, the increasing energy and other resource demands of producing goods and services are increasing the concentration of heat-trapping greenhouse gases in the atmosphere to levels that could dangerously disrupt the global climate system. A landmark study by 13 U.S. government agencies predicts that rising greenhouse gas emissions will result in the average U.S. temperature rising by between 4 and 11°F by the end of this century. For the Northwest, the study predicts, among other impacts, strained water supplies, increased insect outbreaks and wildfires, declining salmon runs and rising sea levels.[1]

The convergence of financial and natural calamities has led some to wonder whether the same root cause – overconsumption – underlies both. In the words of *New York Times* columnist Thomas Friedman, "What if the crisis ... represents something much more fundamental than a deep recession? What if it's telling us that the whole growth model we created over the last 50 years is simply unsustainable economically and ecologically and that 2008 was when we hit the wall?"[2]

Even if such questions cannot be readily answered, the combined financial and ecological challenges do suggest the importance of examining the climate (emissions) implications of current consumption patterns. A better understanding of the links between the consumption of specific goods and services and greenhouse gas emissions is fundamental to informed purchasing decisions by Oregonians as well as to designing government policies that yield lasting global emission reductions.

Momentum is underway for an attempt at addressing ecological and financial struggles jointly. For example, the Obama administration directed a significant fraction of the federal economic stimulus funds towards cleaner energy technologies. And locally, Oregon is leading the country in "green jobs" according to the Pew Charitable Trust[3] and has been ranked the second "greenest" state in the nation by *Forbes*.[4] These and other developments signal growing interest in both greener, low-emission products on the consumer side and a shift towards new industrial technologies and processes on the production side.

While a few studies have examined the relationship between consumption and greenhouse gas emissions at the national and

[1] Karl, Melillo and Peterson (2009)
[2] Friedman (2009)
[3] Pew Charitable Trusts (2009)
[4] Wingfield and Marcus (2007)

international levels, this report provides the first such assessment for all consumption within a U.S. state. Based on the Stockholm Environment Institute's modeling analysis, we present estimates of the greenhouse gas emissions released to make, transport, use and dispose of the goods and services Oregonians enjoy. This analysis helps clarify the role of Oregon's consumption in global greenhouse gas emissions, as well as to identify the specific contribution of different product types, ranging from food and beverages to clothing and appliances, to Oregon's overall emissions footprint. By improving the understanding of relationships between consumption and global greenhouse gas (GHG) emissions, this report can assist Oregon households, businesses and policymakers to chart a path to more sustainable consumption patterns.[5]

Roadmap of this Report

We begin the report with a brief discussion of our study methods, including some background information on methods of accounting for greenhouse gas emissions.[6] We then present key results, such as types of consumption that contribute most to greenhouse gas emissions. Finally, we close with recommendations on how policymakers and the public might use information provided by consumption-based greenhouse gas accounting to help reduce Oregon's global emissions impacts.

Background and Methodology

Methods to estimate greenhouse gas emissions originating within a community are well-established, as are methods for assessing the "life-cycle" environmental impacts of household consumption (e.g., the "carbon footprint" or "ecological footprint").[7] What's been less clear, however, is how to combine the two approaches to quantify the greenhouse gas emissions associated with all consumption activities of a state or region.[8] This report presents results of our efforts to develop such a method for Oregon and provides a new view of the link between greenhouse gas emissions and consumption.

A Brief Review of State Greenhouse Gas Accounting

Over the past two decades, a relatively standard method has evolved to account for GHG emissions by entity or geographic scale. Widely referred to as the production-based method, it involves quantifying the emissions produced within an entity or regional/state boundary. Emission sources within that boundary are identified, e.g. power plants, vehicles, or ruminant animals (e.g., cattle, sheep) in Oregon, and methods are applied to estimate their annual emissions of the most important greenhouse gases, carbon dioxide and several trace gases.

Most production-based emission estimates draw from methods first set forth in 1994 by the Intergovernmental Panel on Climate Change for use by nations in compiling their official greenhouse gas emissions inventories.[9] These methods serve as the official methods for nations to submit inventories and track progress towards emission-reduction goals, such as those established in the United Nations Framework Convention on Climate Change and the Kyoto Protocol.

The U.S. Environmental Protection Agency has also adapted these methods for use by U.S. States. For over a decade, the Oregon Department of Energy (ODOE), with assistance from DEQ and other agencies, has used EPA's

[5] Consumption was identified by the Oregon Climate Change Research Institute (2010) as one of the primary drivers of greenhouse gas emissions.
[6] For a much fuller discussion of our methodology, please see the companion technical report by Stanton et al (2011).
[7] Methods are summarized in Scott (2009) and generally rely either on economic input-output analysis (the method employed in this paper), process life-cycle assessments (LCAs), or a hybrid of the two.
[8] Among other pioneers, Carnegie Mellon University has been a leader in the field of consumption-based inventory analysis, particularly for the U.S. as a nation, although their method has also been applied at the state level, e.g., in Morris, Matthews, Ackerman, Morris and Hlavka (2007) and at the community level at http://coolclimate.berkeley.edu.
[9] And subsequently revised as IPCC (1996).

methodology as the basis for official state inventories of greenhouse gas emissions. These inventories count emissions from sources such as power plants, cars and trucks, industry, building heating systems, and other sources. In calendar year 2005, Oregon's emissions totaled 68 million metric tons of carbon dioxide equivalents (MMT CO_2e).[10] ODOE-produced greenhouse gas inventories serve as the basis for tracking progress towards achievement of the state's emission reduction goals of 10 percent less than 1990 levels by 2020 and 75 percent less than 1990 levels by 2050.[11] The inventory has also provided guidance in targeting major emissions sources, and in designing the actions called for in former Oregon Governor Ted Kulongoski's legislative priorities for climate change[12], and the *Oregon Strategy for Greenhouse Gas Reductions*, *Framework for Addressing Rapid Climate Change*, and *Interim Roadmap to 2020*.[13]

As with all standard "production-based" inventories, the Oregon inventory considers emissions occurring within the state's boundaries. However, the Oregon inventory departs from the standard production-based methodology with respect to electricity emissions. Oregon was one of the first states to account for emissions associated with the electricity used within the state, an approach which has become increasingly common practice for accounting for electricity emissions at the state and local level. Under this practice, electricity emissions are estimated based on the electricity generation sources that are used to meet the state's electricity demands (in this case, Oregon), regardless of whether the electricity is generated within or outside the state. For example, some utilities in Oregon rely on emissions-intensive coal plants in Wyoming to serve their Oregon customers, while some Oregon power plants, in turn, deliver power to consumers in other states.

Oregon's official greenhouse gas inventory therefore includes all emissions that occur within the state's boundaries, with the exception of electricity emissions, for which the inventory reflects the emissions released at the facilities that produce the electricity used in Oregon.

Oregon's method for treating electricity emissions is sometimes referred to as a "consumption-based" approach. Using this method helps to better align the state's inventory with actions it can take to reduce emissions, such as promoting efficiency in electricity use or sourcing electricity from renewable energy sources, and as such, provides important insights on how to design emission reduction strategies.

Our analysis provides a consumption-based methodology for all products and services, not just electricity. This methodology counts the emissions generated to produce all products (including electricity) and services consumed in Oregon, regardless of whether they are produced locally, nationally or internationally. On the one hand, Oregon produces paper, plywood and strawberries for consumption outside the state. On the other hand, Oregon buys cars, appliances and clothing made in other states or countries. A production-based accounting for Oregon emissions includes emissions from producing paper, plywood and strawberries for export, but not emissions from producing imported cars, appliances and clothing. A consumption-based approach to the state's emissions includes imported cars, appliances and clothing but not exported paper, plywood and strawberries.[14]

Just as the consumption-based approach provides a useful framework for designing

[10] Oregon Global Warming Commission (2011). Carbon dioxide equivalent is the standard metric used to compute and compare emissions from carbon dioxide, methane, and other greenhouse gases.
[11] As called for in Oregon House Bill 3543: Global Warming Actions (2007).
[12] Kulongoski (2008)
[13] Governor's Advisory Group on Global Warming (2004), Governor's Climate Change Integration Group (2008), and the Oregon Global Warming Commission (2010).
[14] Using this definition. Oregon's treatment of electricity is not purely consumption-based, since it includes the electricity used to make the state's exports to the rest of the world. Furthermore, unlike the approach taken in this report, Oregon's treatment of electricity does not include the life-cycle emissions associated with producing fuels and other equipment used to produce electricity.

emission reduction strategies in the electricity sector, our hope is that a full economy consumption framework can do the same for the broader Oregon economy.

Our Consumption-Based Approach

A consumption-based approach to greenhouse gas accounting can capture emissions throughout successive stages of product manufacture, transport, use and disposal. By looking at these stages, often referred to as the product "life cycle," analysts can identify where in the supply chain the emissions for a particular product may be concentrated. Such types of analysis are becoming increasingly common in both government and industry. For example, PepsiCo found that 60 percent of the greenhouse emissions associated with its liquid Tropicana orange juice were associated with producing (not transporting, selling or packaging) the juice, and that most of these production emissions were from fertilizer manufacture and application.[15]

Advances in economic data allow such consumption-based approaches to be applied to entire segments of the economy. In particular, organization of economic data into input-output tables allows for expenditures in one sector of the economy to be tracked to all other sectors. For example, by using input-output analysis, it is possible to estimate what fraction of the cost of an average automobile is retained by the manufacturer, what fraction the manufacturer spends on steel, and what fraction the steel mill spends on iron ore versus electricity and other inputs.[16] If the emissions intensity (as measured on a per-dollar basis) of each of these industries is known, the entire greenhouse gas emissions released to produce the car can be estimated by totaling the emissions associated with each individual unit of activity in the product chain. Furthermore, since the U.S. government assembles extraordinarily detailed economic data for the entire country (and, to some degree, for U.S. states), similar assessments for entire economies (not just cars or orange juice) can be feasibly conducted.

Our analysis for Oregon takes just such an approach. First, we start with a widely used input-output model based on data from the U.S. Commerce Department's Bureau of Economic Analysis, the U.S. Bureau of Labor Statistics, the U.S. Census Bureau, and other sources.[17] Second, for each sector of the economy, we use existing greenhouse gas inventories for the U.S. and the State of Oregon to estimate industry-specific emissions, and from those, develop industry-specific emissions intensities (greenhouse gas emissions per dollar of economic activity). Third, since an increasing fraction of goods and materials consumed in Oregon are produced internationally, we include international emissions intensities based on a global input-output model developed at the Center for International Climate and Environmental Research in Norway and based on the Global Trade and Analysis Project of Purdue University.[18] Our end product is an integrated model of the greenhouse gas impacts of Oregon's consumption: the Consumption-Based Emissions Inventory (CBEI) model, which relates consumption (in dollar terms) to greenhouse gas emissions (in terms of tons of carbon dioxide equivalent, CO_2e).[19]

Summary of Production- Versus Consumption-Based Inventories

A production-based inventory documents emissions that physically arise from within an entity or region, regardless of where any resulting

[15] See Martin, Andrew, 2009. "How Green is My Orange?" *New York Times*. January 21, 2009.

[16] Data are not available for individual products or manufacturers, just in aggregate for many detailed sectors of the economy.

[17] Our source for these data is the IMPLAN software from the Minnesota Implan Group (www.implan.com), a leading economic software product used widely in Oregon and nationally for economic impact studies.

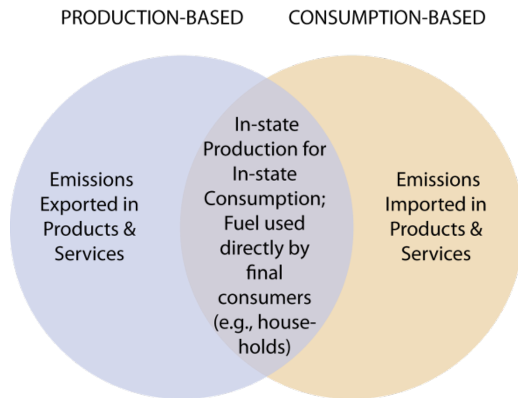
[18] Peters and Hertwich (2008). We extend great thanks to Glen Peters for sharing his model results with us.

[19] Consumption is measured by what economists refer to as "final demand" and includes both personal and government spending as well as capital investments by businesses. For more details on the study's methodology, please see the technical report, Stanton, Bueno, Ackerman, Erickson and Hammerschlag (2011).

products and services are consumed. In contrast, a consumption-based inventory documents emissions released to produce all the goods and services consumed within that entity, regardless of where produced.

For the entire globe, production- and consumption-based inventories would be identical, as all worldwide emissions are generated in response to demand for consumption by the world's residents and (presumably) no one else. For any given region or entity, however, the production-based and consumption-based inventories are likely to differ. A consumption-based inventory counts all emissions "embodied" in the products and services consumed in the state and excludes any emissions released to make products or services exported from the state. A production-based inventory does the reverse: it counts all emissions released to make products and services produced within the state, but excludes emissions embodied in products or services imported into the state. Both approaches include emissions released for Oregon-made, Oregon-consumed products, as well as fuels used within the state to support Oregon consumption (such as driving cars or heating homes). Figure 1 depicts how production- and consumption-based inventories share some, but not all, sources of emissions.[20] Specifically, Oregon's consumption-based emissions inventory does not include all emissions associated with in-state production. Only when in-state producers are satisfying consumption in Oregon are those emissions included.

Figure 1. Comparison of Production- and Consumption-Based Inventory Approaches



Understanding the Results

The following section presents results of our consumption-based inventory for Oregon. We state results in million metric tons carbon dioxide equivalent (MMT CO_2e) for the year 2005. Emissions intensities and consumption patterns can change over time, and so the results should not necessarily be extrapolated to other years.[21]

Like any model, consumption-based inventory methods, CBEI included, have limitations. For example, CBEI depends on estimates of consumer, government and business spending and trade relationships based on national data scaled to Oregon. As a result, CBEI may not reflect significant deviations in local behaviors relative to national averages. These limitations, among others, make consumption-based inventories inherently less accurate than elements of production-based inventories that are based on direct measurement of fuel use (e.g., building energy use) or production (e.g. cement process emissions).

[20] Because production- and consumption-based inventories both count some of the same sources of emissions, they should not be simply added together.

[21] For example, EPA reports that the energy (and therefore emissions) intensity of several sectors of the economy (e.g., cement, aluminum) has steadily declined over time (EPA 2007). Similarly, Capper, Cady and Bauman (2009) have shown that the GHG emissions per kilogram of milk produced in the US in 2007 were significantly lower than production in 1944. On the other hand, research in Europe suggests that efficiency gains in domestic industries can be offset by a trend toward increasing imports from more emissions-intensive countries (Baiocchi and Minx, 2010).

Accordingly, all figures presented in this report should be regarded as estimates subject to uncertainty. In general, uncertainty is greater at the level of individual product or service categories than it is for total statewide emissions.[22]

Study Findings

In this section, we present our estimates of the global emissions impact of Oregon consumption.

Our principal finding is that **the emissions "footprint" of Oregon's consumption is significantly greater than the emissions released within state boundaries.**

Emissions associated with Oregon's consumption are roughly 47 percent greater than the emissions released within state boundaries.[23]

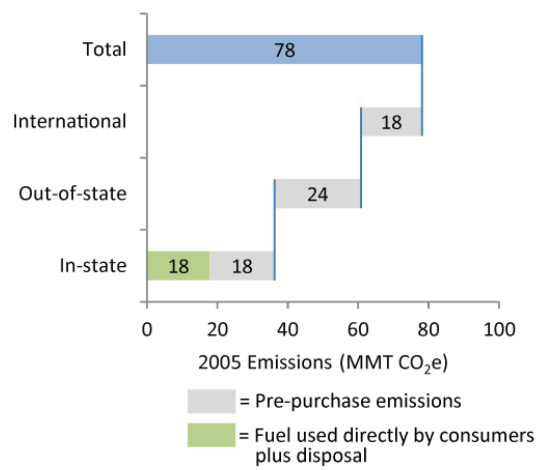
Some of the electricity imported for use in Oregon is produced from the burning of coal and other fossil fuels. Consumption-based emissions are higher in part because of Oregon's reliance on this higher-emission electricity from other Western states, a phenomenon already accounted for in the state's official inventory. As a result, the consumption-based emissions are only 15 percent greater than emissions reflected in the official inventory for 2005. This difference is explained by our finding that emissions associated with products and services imported into Oregon significantly exceed emissions associated with products and services exported.

In the discussion that follows, we elaborate on this primary finding and discuss the contribution of individual product and service categories to these results.

Oregon's Emissions "Footprint"

We estimate that 78 million metric tons carbon dioxide equivalent were associated with the consumption of goods and services in Oregon in 2005.[24] Of these 78 million metric tons CO_2e, a little more than half (42 million, or 54%) were released outside of Oregon. Of the remainder (36 million, or 46%) released within Oregon, 17 million metric tons CO_2e were associated with fuels used directly by consumers (e.g., driving personal vehicles, heating homes), 18 million metric tons CO_2e came from the production of goods and services (including electricity) consumed within the state, and disposal of post-consumer wastes contributed about 1 million metric tons.[25] Figure 2 shows the consumption-based greenhouse gas inventory according to geography of release.

Figure 2. Consumption-Based GHG Emissions by Geography of Release



[22] A full quantitative assessment of uncertainty (e.g., "error bars") was not possible.

[23] Based on Oregon's estimate of in-state emissions (including production-based inventory for electricity) of 53.2, as cited in Oregon Global Warming Commission's report (2011).

[24] All estimates of emissions associated with consumption in Oregon in this report exclude any emissions associated with land-use change (e.g., clearing of forest to allow for planting of crops) due to data and modeling limitations. As a result, emissions associated with some products (e.g., soy, beef, or palm oil grown in the tropics on recently cleared forestland) may be underestimated.

[25] The estimated split of emissions by geography is dependent on assumptions in our underlying data, from IMPLAN, regarding the share of goods imported into Oregon by economic sector. IMPLAN staff advise that lag times exist between availability of trade data (as well as uncertainty in their application at the state level). As a result, our estimates of the geographic split of emission sources inherit these same uncertainties and would be a natural candidate for further work.

The distribution of emissions far beyond Oregon's boundaries reflects the complex international supply chains for many products.

For example, an Oregonian's purchase of a car assembled in Tennessee would be associated with some emissions in the U.S. at the assembly plant. In addition, emissions might occur at factories in other countries where component parts are fabricated, materials such as steel are produced, or raw materials such as iron are extracted. Similarly, a computer purchased and assembled in Oregon might be associated with emissions from lighting and space conditioning the assembly plant, as well as emissions for producing the various components, such as semiconductors produced in Oregon and disk drives produced in Asia. Emissions from producing materials and components such as these – as well as finished products – are each described in our analysis according to the geography in which they were released.

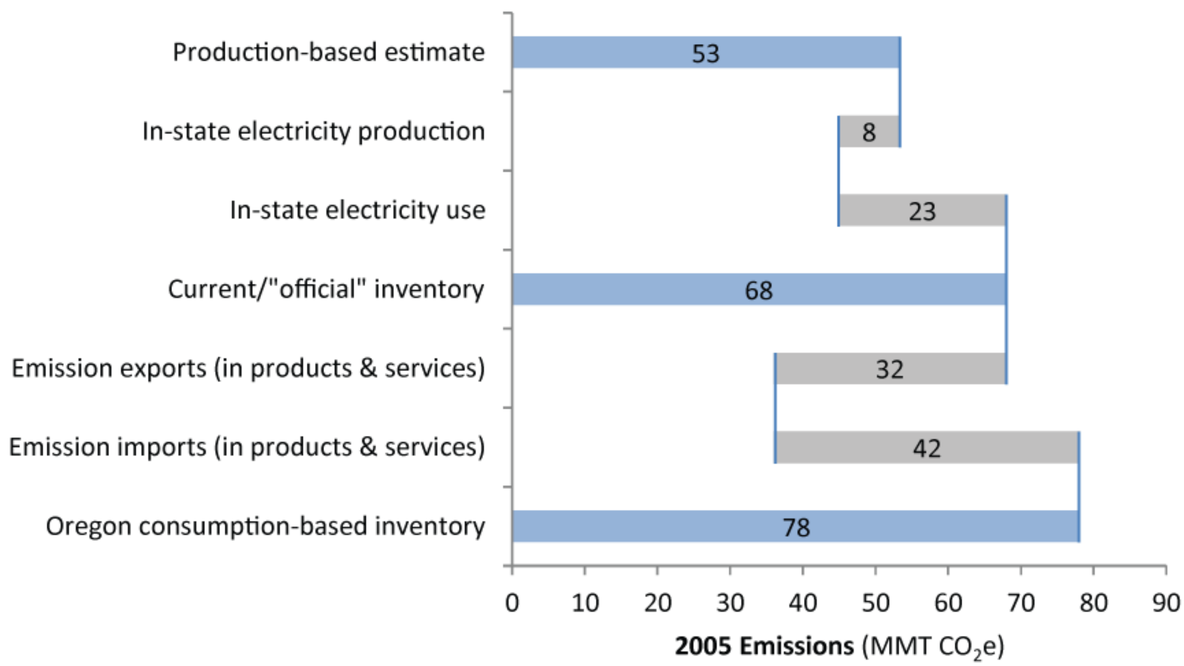
Our analysis suggests that emissions associated with Oregon consumption (78 MMT CO_2e) represents 0.17 percent of global emissions, a contribution greater than implied by Oregon's official greenhouse gas inventory, 68 MMT CO_2e (0.15 percent of global emissions) or than the emissions released within the state, 53 MMT CO_2e (0.12 percent).[26] In short, because Oregon imports more goods and services (particularly emissions-intensive products, such as vehicles) than it exports, its share of global greenhouse gas emissions is greater than the emissions released within the state.

For a more-detailed look at how this 78 MMT CO_2e estimate compares to Oregon's official inventory, see Box 1.

[26] Oregon's official inventory and the estimate of emission released within the state are both found in Oregon Global Warming Commission (2011).

Box 1. Comparison of Oregon Greenhouse Gas Inventories

In conducting the inventory of Oregon's greenhouse gas emissions over the years, the Oregon Department of Energy, preparing inventories for use by the Governor's Advisory Group on Global Warming (2004), Climate Change Integration Group (2008) and Oregon Global Warming Commission (2011), has used standard methods created by the U.S. Environmental Protection Agency for conducting state inventories, with one major exception. ODOE relied on an emerging consensus for how to treat electricity emissions wherein the agency accounted for emissions from electricity used (not generated) within the state. So, whereas ODOE and the Global Warming Commission have reported that a traditional, geographic-based greenhouse gas inventory would count 53 million metric tons CO_2e in Oregon for 2005, the official inventory contains a higher emissions estimate of 68 MMT CO_2e, to account for emissions associated with the use of electricity within the state. Our consumption-based inventory for Oregon goes a step further and counts emissions associated with producing all the products and services imported into Oregon (less all the products and services made in Oregon and exported). We estimate that 32 MMT CO_2e are released in Oregon to make products and services exported outside the state, whereas 42 MMT CO_2e are released outside Oregon to make products and services consumed in the state. The figure below presents a step-by-step transition from a production-based inventory to Oregon's official inventory to our consumption-based inventory, accounting for all the imports and exports. (Note that this is a conceptual diagram; steps to construct the respective inventories do not necessarily occur in the order presented.)



Provision of Goods and Materials

In addition to assessing overall levels of emissions associated with consumption, our model also allows for a look at the life cycle of goods and services consumed in Oregon's economy. In particular, the model allows for calculation of emissions associated with the production, transportation, sale, use and disposal of goods and services consumed in Oregon. Each of these phases is defined as follows.

- **Producer:** manufacturing, growing, raising, or otherwise producing a good, material or service, including any supplies or materials needed;
- **Pre-purchase transportation:** transporting supplies or materials to a manufacturer or other producer, transporting a good from producer through wholesaler to retailer;[27]
- **Retail/Wholesale:** operating wholesale and retail establishments;
- **Use:** using a good, such as a personal vehicle or home heating system; and
- **Post-consumer disposal:** disposing of post-consumer wastes in landfills or incinerators.

Table 1, below, shows results of our consumption-based greenhouse gas inventory for Oregon according to these five phases.

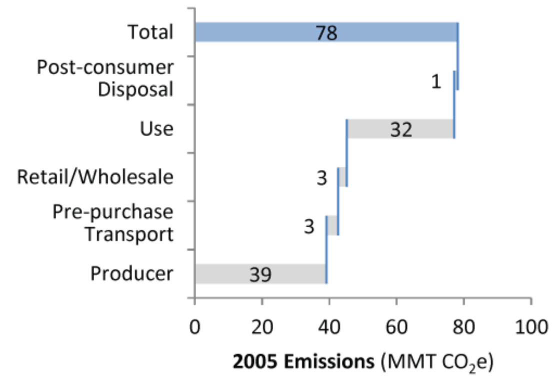
Table 1. Emissions by Life-cycle Phase

Life-cycle Phase	2005 Emissions (MMT CO_2e)
Producer	39.0
Pre-purchase Transport	3.4
Wholesale/Retail	2.9
Use	32.0
Post-consumer Disposal	0.8
Total	**78.1**

Figure 3 displays these results graphically.

[27] To the extent producers undertake their own transportation instead of purchasing transportation services, these emissions are included in the *producer* phase. Due to the nature of input-output analysis, the *pre-purchase transportation* phase includes only purchased / contracted transportation.

Figure 3. Emissions by Life-cycle Phase



As seen in the table and chart, producing all goods and services consumed in Oregon (i.e., the *producer* phase) releases slightly more greenhouse gases than using them (i.e., the *use* phase). By contrast, transportation involved in goods and services represents a relatively minor share: about 4 percent.[28] Furthermore, emissions at retail/wholesale establishments and disposing post-consumer goods are also small shares: about 4 and 1 percent, respectively.

The broad conclusion that producing and using goods is a significant contributor to greenhouse gas emissions in Oregon underscores the importance of consumption habits on emissions. Simply by buying products, Oregonians contribute to climate change through the emissions released to make these products. Using the products (especially vehicles and home heating equipment) also releases significant emissions. Efforts to practice or promote "sustainable consumption" would therefore need to look at what products and services are particularly emissions-intensive to produce in addition to which are particularly intensive to use, so that consumers can focus on decisions that are likely to have the greatest benefit. The

[28] As described in footnote 27, some transportation (say, of raw materials) may be included in the producer phase (or, potentially also the retail/wholesale phases if those establishments operate their own transport fleets). Accordingly, transport of materials and goods could occupy a somewhat greater fraction than our model indicates. Yet even on a national basis, direct emissions from freight comprise only about 7% of U.S. greenhouse gas emissions (U.S. EPA 2011) and would likely still occupy less than 10% if one included (as we do here) the precombustion emissions from the fuels used (Facanha and Horvath 2006), suggesting that transportation is indeed a relatively small component.

following section of this report addresses the results of our analysis by broad product and service category.

Emissions by Product and Service Category

Unsurprisingly, different types of products and services require varying quantities of energy and greenhouse gas emissions to produce. Some products, such as vehicles, which have both complex supply chains and use large quantities of metal, require large quantities of energy, which, when based on fossil-fuels, releases correspondingly high quantities of greenhouse gas emissions. Other products, such as food, require both significant amounts of energy and also release emissions when fertilizers are applied to soil or when animals (particularly cows) digest their feed. Table 2 presents emissions by product category and consolidated life-cycle phase.[29] Emissions in this table are allocated to each category based on the life-cycle of activities and emissions needed to make the product or service, including component parts, electricity use and other inputs.

Table 2. Emissions by Life-Cycle Phase and Product Category (Million Metric Tons CO_2e in 2005)[29]

	Total	Pre-purchase	Use	Post-consumer Disposal
Vehicles and parts	**18.9**	2.6	16.3	<0.1
Appliances	**11.7**	0.3	11.4	<0.1
Food and beverages	**9.1**	8.9	*	0.3
Services	**5.6**	5.5	*	0.1
Construction	**5.2**	5.1	*	0.1
Other manufactured goods	**5.4**	5.4	*	<0.1
Healthcare	**4.0**	4.0	*	<0.1
Electronics	**3.5**	2.1	1.4	<0.1
Transportation services	**3.4**	3.4	*	<0.1
Lighting and fixtures	**2.9**	0.0	2.9	<0.1
Furnishings and supplies	**2.9**	2.6	*	0.3
Retailers	**2.1**	2.1	*	0.0
Clothing	**1.8**	1.8	*	<0.1
Wholesale	**0.8**	0.8	*	0.0
Water and wastewater	**0.3**	0.3	*	<0.1
Other	**0.4**	0.4	*	<0.1
Total	**78.1**	**45.3**	**32.0**	**0.8**

***Use** phase emissions for these product categories are zero, though in some cases emissions may be associated with the use of products in these categories but are assigned to another category. For example, emissions associated with washing clothing (e.g., use of a washing machine) are included under the *use* phase of appliances, as are emissions associated with home heating (e.g., the furnace, a type of appliance) and food preparation (e.g., a refrigerator, range oven, microwave, or blender). Emissions associated with the "use" of an airplane are included under *transportation services* ("pre-purchase" phase) since the consumer is purchasing the service of the airplane, not the airplane itself or the jet fuel.

[29] In this table, emissions associated with transporting and selling products through wholesale and retail channels are counted under the *Transportation services, Retailers* or *Wholesale* categories and not within the respective "pre-purchase" figure for each individual product or service category. For example, emissions associated with *Transportation services* are those resulting from actual final demand for transportation as a service (e.g., passenger air travel) as well as the transportation needed to move final products to warehouses and stores. Product categories in this table have been altered somewhat from those in the companion *Technical Report* (Stanton et al, 2011) for clarity. Specifically, the category here called *Other manufactured goods* includes the following from the *Technical Report* and accompanying CBEI model: *Manufactures* (a category dominated by machinery and other heavy equipment)*; Foundries, metal processing;* and select items from the *Other* category, including cigarettes, power hand tools, sporting goods, and musical instruments. *Fuel and utilities* has been renamed *Water and wastewater* here (since all emissions from other fuel and utilities, namely energy and waste, have been reassigned to the *use* and *disposal* phases, respectively). *Lighting and fixtures* has been split out of *Media and furnishings*¸ a category that is renamed *Furnishings and supplies* here. Lastly, *Other* here now includes *mining, oil, and gas,* which was its own category in the *Technical Report*.

Immediately apparent from these results are the significant emissions from use of personal vehicles (16.3 MMT CO_2e) and appliances (11.4 MMT CO_2e), a category that includes home heating and cooling equipment, such as furnaces. These emissions include both direct emissions from burning fossil fuels, indirect emission associated with extracting, refining and delivering those fuels, and emissions released to produce electricity used to power electric appliances.

After vehicles and appliances, the biggest category of emissions is food, where total life-cycle emissions are 9.1 MMT CO_2e and pre-purchase emissions are estimated at 8.9 MMT CO_2e. Table 3, below, presents additional detail on the sub-categories of food considered in our analysis.

Table 3. Detail on Pre-purchase Emissions in "Food and Beverages" [30]

Food Sub-category	2005 Pre-purchase Emissions (MMT CO_2e)
Beverages	0.8
Condiments, oils and sweeteners	0.2
Dairy and eggs	1.2
Frozen food	0.2
Fruit, nuts and vegetables	0.8
Grains, baked goods, cereals	0.8
Pet food	0.1
Poultry	0.5
Red meat	1.7
Seafood	0.1
Other animal products	0.1
Other food and agriculture	0.2
Subtotal household food	*6.8*
Restaurants	2.1
Total	**8.9**

Comparing the overall amount of pre-sale emissions per product category helps shed light on what types of consumption contribute large shares of greenhouse gas emissions.[31]

As indicated in Table 3, our analysis indicates that *red meat* (a category that here includes beef, pork, lamb, and meat from other ruminant animals) and *dairy and eggs* are the two largest categories of emissions from household (non-restaurant) food consumption.[32] Several other studies have arrived at similar conclusions.[33] Emissions associated with red meat and dairy products, in particular, are high (on average) due to the emissions associated with the extensive feed requirements of cattle as well as the particular composition and functioning of the ruminant digestive tract, which produces methane, a potent greenhouse gas.

Food is also important because significant amounts of food are wasted. 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.[34] According to our analysis, the "upstream" greenhouse gas emissions associated with food consumed in Oregon are roughly 30 times higher than the emissions associated with disposal of uneaten food by consumers. In other words, reducing the wasting of food – both by consumers and also upstream in the supply chain – can significantly reduce life-cycle greenhouse gas emissions, so long as waste is reduced at the source (by reducing excess production and/or

[30] As in Table 2, pre-purchase estimates for individual types of food do not include emissions associated with transporting food to wholesale/retail establishments or those associated with operating those establishments.

[31] CBEI reports sector-wide (average) emissions intensities and does not distinguish qualitative differences within a product category (e.g., the durability of furniture or the growing practices of food). Significant differences between particular products (i.e., brands) or producers may exist.

[32] The "restaurant" sub-category is not directly comparable to the other food sub-categories shown in Table 3, because it includes not only emissions associated with food production, but also emissions associated with energy and other materials purchased by restaurants. By contrast, emissions from energy used for cooking at home as well as other kitchen supplies purchased directly by consumers are assigned in CBEI not to "food" but to other, non-food categories such as "appliances" and "furnishings".

[33] Stehfest, Bouwman, Vuuren, Elzen, Bas Eickhout and Kabat (2009), Weber and Matthews (2008), Tukker and Jansen (2006).

[34] Hall, Guo, Dore and Chow (2009).

purchasing). Managing wastes after they're produced (composting, for example), offers a much smaller potential for greenhouse gas reductions.[35]

Another way to look at the emissions by product category is to look at emissions intensity, as normalized to volume of consumption. Since our model is based on consumption in dollars, normalizing the emissions intensities to dollars of "final demand" expenditures is a clear approach.

Table 4. Pre-sale Emissions Intensity by Product Category[30,36]

Product Category	2005 Pre-purchase Emissions Per $ of Final Demand (kg CO_2e/$)
Transportation services	1.6
Clothing	1.1
Food and beverages	0.9
Lighting and fixtures	0.7
Water and wastewater	0.7
Appliances	0.7
Other manufactured goods	0.6
Electronics	0.6
Vehicles and parts	0.5
Furnishings and supplies	0.5
Construction	0.4
Healthcare	0.2
Services	0.2
Retailers	0.2
Wholesale	0.1
Other	<0.1
Total (all consumption) emissions intensity	**0.36**

Looking at emissions on a per-dollar basis can be difficult to translate into meaningful comparisons, since most goods are not purchased in dollar-value (or even similar) increments. However, the emissions intensity of the different categories does give indication of the emission impacts of a given unit of spending. When Oregonians make choices about how to spend their limited discretionary income, the results in Table 4 could help support decisions that minimize climate impact. For example, emissions associated with an average *electronics* purchase (e.g. $1,000 for a new computer) are less than an average purchase of *transportation services* (e.g. a cross-country airline trip costing $1,000).[37]

Local Production, Lower Emissions?

One benefit often cited for eating or buying "local" is to reduce greenhouse gas emissions associated with transporting products long distances. However, our findings do not necessarily support this generalization.

As indicated in Figure 3, transportation of goods and services represents about 3 MMT CO_2e, or about 4 percent, of emissions associated with consumption in Oregon. This finding suggests that transportation of goods and services is a relatively minor contributor to Oregon's consumption-based emissions.[38]

Other analysts have researched the contribution of transportation to individual product categories. For example, for food, a product category where the "locavore" movement has gained particular traction with consumers, a study by Carnegie Mellon University found that transportation represents 11 percent of life-cycle emissions of food consumed in the U.S., and fewer than half of those emissions were associated with transportation from the final producer to the retailer.[39] Locally-produced foods may have

[35] Oregon Global Warming Commission (2010).
[36] Emissions intensities have been adjusted from the *Technical Report* (Stanton et al. 2011) to exclude spending on categories of emissions that are considered part of the *use* or *disposal* phases (fuels, electricity, waste disposal) as well as spending on government salaries that, though considered part of "final demand", are not associated with any emissions in CBEI.

[37] Strictly speaking, such an analysis should occur at a more detailed level than using either of these broad categories, which also include subcategories not directly related to either computers or air travel, respectively. Furthermore, the figures in this table are based on the "producer dollars" of final demand without taking into account the markups (margins) applied by wholesale and retail establishments. Nevertheless, this coarse method employed here can help provide rough, order-of-magnitude results.
[38] A significant exception to this finding would likely be shipping by air, where freight emissions can be many times greater than if shipped by road or, especially, rail. For more information see: Facanha and Horvath (2006) or Pirog, Pelt, Enshayan and Cook (2001).
[39] Weber and Matthews (2008)

lower transportation emissions than foods shipped long distances, but this advantage is often quite small. If the local method of production leads to higher production-related emissions, the overall GHG footprint of the local food could easily be higher. Conversely, local food will likely have a lower carbon footprint than distant food if the local production methods release fewer emissions.

The contribution of transportation to different product categories likely varies from our finding of a 4 percent average contribution. Assessment of transportation's role in any given product's life cycle is an important next step in developing the CBEI model. At present, CBEI cannot accurately parse emissions associated with transportation of goods and services to individual product or service categories. Instead, emissions associated with transporting materials and goods are included as *transportation services.*[40]

Nevertheless, our results indicate that on an economy-wide basis, transportation is a minor share of the greenhouse gas emissions of products.[41] Are there instead other emissions-related reasons to shop for local products? Our model is able to identify some product categories where emissions associated with producing the good or material (per dollar) are lower in Oregon than in other areas of the world. For example, the per-dollar emissions intensity of Oregon-made *furnishings and supplies* are about half what would be expected in the countries that import to Oregon.

As an illustration of the potential magnitude of differences in emissions associated with geography of product origins, consider clothing, an industry that relies heavily on imports. Our analysis indicates that the emissions intensities of clothing production can vary substantially between countries, from 0.4 kg CO_2e/dollar in Mexico to approximately 2 kg CO_2e/$ in India and China, as compared with the average (1 kg CO_2e/dollar) reported in Table 4.[42]

However, caution should be exercised in interpreting these findings, as they do not necessarily reflect real underlying differences in production practices. Higher emissions intensities in one country versus another do not necessarily imply higher emission products. For example, suppose a shirt produced in China and in another country have similar production emissions. If the shirt from China cost half as much to produce, the emissions intensity (per dollar) would be twice that of the other country. In such a case, the difference in emissions intensities would reflect a difference in production *costs*, not in actual production practices or emissions.[43]

Furthermore, these findings reflect differences in *average* rather than *marginal* emissions intensities. A key reason that current *average* emissions intensity of Oregon production is lower for some product categories is the relatively low carbon-intensity of the electricity used in Oregon, thanks in large part to the regional hydropower resource from Bonneville Power Administration and other regional facilities. This resource however, is largely tapped – small hydro additions and increases in turbine efficiency are possible, but large new dams are unlikely. Therefore, if and as production of goods and services in Oregon grows, the *marginal* sources of electricity used to support this growth could be significantly more carbon intensive, for example, requiring new investments in natural gas combustion.[44]

[40] Similarly, CBEI cannot parse emissions associated with retail and wholesale operations to individual product or service categories, and so these emissions are included as their own categories.
[41] For some individual products, particularly those with low producer-phase emissions and/or transported long distances using high-impact methods, transport could be significant, but these will represent exceptions, not the norm.
[42] Peters and Hertwich (2008)
[43] In fact, the average value of a boy or men's knit cotton shirt imported to the U.S. in 2005 was $3.33 from China, $5.02 from Mexico, $6.48 from Canada, and $4.91 averaged over all importing countries (UN Statistics Division 2011). This suggests that price differences may be a significant reason for the differences in emissions intensities between China and other regions.
[44] NPCC (2008). That study addresses the marginal source of electricity during any given hour, which is usually a natural gas-fired combined-cycle plant. The marginal type of

As a result, without further analysis, one cannot simply suggest that increasing the purchase of Oregon-made goods would result in a net, global emissions benefit without considering the relative cost of goods and the marginal sources of power in both Oregon and the competing region. Similarly, the CBEI results are not sufficient, alone, to suggest that increasing the purchase of one category of goods or services (e.g., furnishings and supplies) at the expense of another (e.g. clothing) would, by necessity, reduce global emissions. Better estimates of the emissions consequences of shifting consumption patterns (among product categories and origins of production) would benefit from further research, and in particular, a deeper understanding of and accounting for marginal sources of energy and production for specific product types.

For example, the following table displays the average and marginal electricity emission factors for Oregon and three foreign countries that make goods consumed in Oregon.

generation plant built could, though not necessarily, also be more emissions-intensive than the average.

Table 5. Average and Marginal Emissions Associated with Electricity Use (2005) for Oregon and Select Countries

Geography	Average (kg CO_2e/kwh)	Marginal (kg CO_2e/kwh)
Oregon[45]	0.5	0.4
China[46]	0.8	0.9
India[46]	0.9	1.0
Mexico[46]	0.5	0.6

The relatively small differences between average and marginal emissions for these three countries suggests that, at least for the fraction of emissions associated with electricity production, CBEI results are a reasonable proxy for assessing shifts in the sources of production of goods and services.[47]

Discussion of Results

Looking at greenhouse gas emissions from a consumption-based approach offers some potential new insights. For example, our consumption-based method has allowed for a much more complete picture of how consumption in Oregon contributes to global greenhouse gas emissions, as well as increased detail on emissions (particularly the pre-sale emissions) associated with specific categories of consumption.

In other cases, a consumption-based approach reinforces lessons from traditional approaches. Both approaches, for example, suggest strongly that the manufacturing of goods, use of vehicles, and home heating and appliances contribute strongly to greenhouse gas emissions.

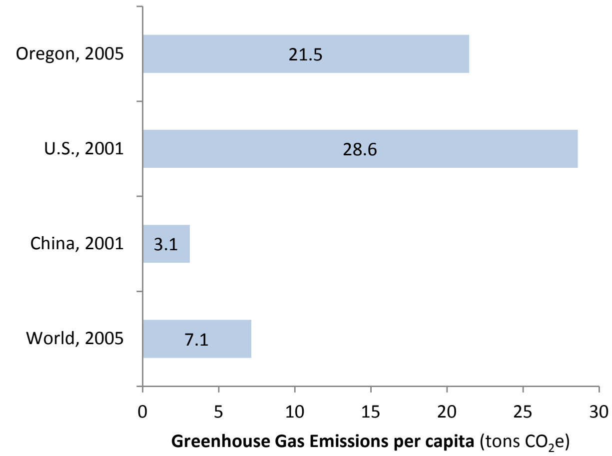
[45] Average: Oregon Global Warming Commission (2011). Marginal: NPCC (2008) forecast of 0.8 lb CO_2/kwh.
[46] Average: IEA (2010). Marginal: Amatayakul and Fenhann (2009)
[47] In life-cycle analysis terminology, this means that the *attributional* results from CBEI could be a reasonable proxy for assessing *consequential* effects, at least for emissions associated with electricity. For other categories of emissions, additional research would help to illustrate the potential impact of other differences between regions of production, such as differences in agricultural or other production practices.

The primary difference between the two approaches – and the key to gathering and applying potential lessons – lies in the basic definition of the consumption inventory. It represents emissions associated with products and services people in Oregon buy, use, and dispose, not emissions that arise within the state as a production-based method would do.[48]

This distinction is discussed in international climate policy negotiations as nations debate the relative responsibility for global greenhouse gas emissions. Our analysis suggests that the debate is also relevant to Oregon. For example, Oregon could reduce the emissions in its existing inventory, as it plans to do, with only a moderate impact on the emissions released to produce the goods consumed in the state. Why? Because about two-thirds of the emissions released to produce goods and services consumed in Oregon are released outside Oregon. Addressing global climate change will no doubt require that Oregon reduce its own emissions, but every world region that makes goods (whether for ultimate consumption in Oregon or elsewhere) will also need to reduce emissions. The consumption-based inventory for Oregon helps provide an indication of how Oregon consumers – and policymakers – might contribute to these reductions outside of Oregon and will be the subject of the final section ("Recommendations") of this report.

As context for this question of global emissions, consider that worldwide emissions in 2005 were 46,000 MMT CO_2e, or 7.1 tons CO_2e per person.[49] Oregon's consumption-based inventory suggests that Oregon's share of these emissions is 0.17 percent, or 21.5 tons CO_2e per person. Figure 4, below, compares consumption-based greenhouse gas inventories for Oregon, the U.S., China and world.

Figure 4. Comparison of Consumption-Based GHG Emissions Per-capita[50]



This comparison suggests that Oregon is responsible, on a per-person basis, for a much higher share of global greenhouse gas emissions than either the world average or China, now the current world leader in total greenhouse gas emissions. The average contribution of an Oregon resident appears to be somewhat lower than the average U.S. resident, a difference due in part to the serendipity of Oregon's location in a region that can rely more heavily on low-emission hydroelectricity than the national average.

Impacts of Changes in Consumption

As discussed in this report's introduction, the current convergence of financial and ecological challenges provides an opportunity to consider what "sustainable consumption" might look like. While we cannot claim to offer assessments of what level of consumption would truly be financially or ecologically sustainable, our analysis can help address the possible impacts of alternative modes of consumption on Oregon's contribution to global greenhouse gas emissions.

[48] As discussed elsewhere, Oregon's official greenhouse gas inventory already takes a hybrid approach and includes some out-of-state emissions associated with the in-state use of electricity.
[49] McKinsey & Company (2009)

[50] Sources: Oregon, this study; U.S. and China: Hertwich and Peters (2009); A consumption-based GHG inventory for the world is no different than on a production basis. In 2008, global emissions were about 46,000 $MtCO_2e$, with a population of about 6.5 billion, or 7.1 tCO_2e per person (McKinsey & Company 2009).

For example, our results can help assess opportunities to switch from high-carbon to low-carbon goods and services.

Our model cannot distinguish between individual products within a given commodity (e.g., organic vs. conventionally grown produce), but it can help identify opportunities to shift from one type of good to another and put them in context relative to other more commonly cited strategies for reducing emissions. For example, each of the following would result in a reduction of about 2 MMT CO_2e in Oregon's consumption-based greenhouse gas emissions:

- **Increasing the efficiency of personal vehicles by 15 percent,** comparable to a shift from a standard sedan car (such as a Toyota Camry) to a highly efficient hybrid (such as the Toyota Prius) for about a quarter of the cars on the road in Oregon. Such a shift would reduce the *use* phase emissions of vehicles as described in Table 2.[51]
- **Increasing the efficiency of home appliances (including heating) by 25 percent in almost all Oregon's households**. Such a reduction, averaged over 90 percent of Oregon households, would reduce the *use* phase emissions of "heating and cooling appliances" in Table 2.[52]
- **Doubling the useful life of home furnishings and clothing.** Extending the useful life of just these two product categories could lead, through reduced need for new products, to an avoidance of emissions associated with manufacturing of at least 2 MMT CO_2e.[53]

Even greater reductions would likely be possible, since the lifetimes of many other types of products could also be extended. Emissions savings due to efficiency gains in certain new products (e.g., vehicles and appliances) could, however, easily outweigh the embodied emissions in their manufacture. In general, extending the useful life of products that don't directly consume energy, like clothing or furnishings, can yield life-cycle emissions benefits. However, for products with major *use* phase emissions impacts, specifically energy-consuming products like cars or appliances or construction materials such as windows and doors that indirectly affect energy consumption, the merits of life extension need to be carefully considered. In such cases, in fact, early retirement (life "shortening") might yield energy and emissions benefits. Such a notion in part informed the design of the federal government's 2009 "cash for clunkers" program aimed at providing both an economic stimulus to households and automakers as well as greenhouse gas emission reductions through increased efficiency.

In addition, many more specific opportunities exist to shift consumption from high-carbon goods to lower-carbon goods. However, when comparing different consumption options, we recognize that emissions are not the only factor to consider in purchasing decisions. For example, dietary shifts (for example from red meat and dairy products to grains and legumes) might reduce greenhouse gas emissions but could also have nutritional, health and cost effects, as well as other social and environmental implications that are beyond the scope of this study.

[51] A 15 percent improvement in efficiency would lead to a fuel use reduction of 1- 1/(1+0.15) , or 13 percent, of the present. Applied to the 16.3 MMT CO_2e of personal vehicle emissions yields a reduction in emissions of 2.1 MMT CO_2e.

[52] A 25 percent improvement in efficiency would lead to a fuel use reduction of 1-1/(1+0.25), or 20%. Applied to 90 percent of Oregon households, would lead to a 18 percent reduction in energy use, which, applied to the 11.4 MMT CO_2e of home appliance "use" emissions yield an emission reduction of 2.1 MMT CO_2e. In fact, because these efficiency measures would also reduce electricity consumption, savings could be greater since the marginal electricity supply in Oregon is fossil-fuel-based.

[53] For example, the combined pre-purchase emissions from *clothing* and *furnishings and supplies* as displayed in Table 2 are 4.4 MMT CO_2e. A reduction could be realized by doubling the life of these products, assuming manufacturing of more durable items did not release significantly larger quantities of emissions and that consumers reduced purchase of new items accordingly (i.e., by half).

In addition to shifts in consumption between various commodities, emissions may also change as overall consumption increases or decreases. For every $1 million change in overall spending in Oregon, results of our model suggest that greenhouse gas emissions would rise or decline (respectively) by approximately 540 tons of CO_2e. If this relationship were to hold, consider what might happen if the historic personal savings rate, which for the last 50 years has averaged about 7 percent nationally, returned as the norm from its 2005 level (the year for which our analysis was conducted) of about 1 percent. The approximate impact on final demand would be a decline of approximately 4 percent.[54] This decline would lead, assuming a direct relationship between economic activity and emissions described, to a reduction in Oregon's consumption-based greenhouse gas emissions of approximately 3.2 MMT CO_2e.[55] Of course, if those savings enabled increased consumption in future years or mobilized capital that enabled present-year consumption by others, then the net emissions reduction could be less.[56]

In the next sections, we discuss how the results of our analyses might be interpreted by policymakers and public interested in addressing climate change and reducing greenhouse gas emissions.

Potential Applications of Consumption-based Greenhouse Inventories

Our results suggest a number of opportunities to address climate change through policies and programs that engage public education, government purchasing, and business action. In particular, we suggest that this study's results may be particularly relevant for the following efforts:

- **Waste prevention and sustainable consumption.** Oregon's current waste prevention efforts place strong focus on reduced and shifted consumption[57] as a means of preventing waste and conserving resources. Our analysis indicates that the pre-purchase or "embodied" greenhouse gas emissions associated with consumption in Oregon occur primarily out-of-state and represent more global greenhouse gas emissions than using and disposing all products consumed in the state. These findings, as well as the more detailed results presented in this report, can help inform education or market-based efforts on waste prevention and "sustainable consumption" implemented by the Department of Environmental Quality or other state and local government agencies in Oregon. In addition, planners may find our results useful for efforts focused on extended producer responsibility or "product stewardship" that work with manufacturers to "reduce environmental and health impacts across the entire life cycle of the product."[58] Results presented in this report could serve as a "screening tool" to identify product or service categories that are good candidates for

[54] Calculated using a simplified macroeconomic relationship between the personal savings rate and final demand as (1-0.07)/(1-0.01) multiplied by 68 percent, the share of household final demand in total final demand, per IMPLAN's final demand data for Oregon. Note the 1 percent and 7 percent figures are from national data from the Bureau of Economic Analysis and are assumed for this example to apply to Oregon.

[55] Calculated as 4.1 percent of 78.1 million tons CO_2e.

[56] Assessing the full implications of increasing the savings rate or reducing the dollar-value of consumption is a topic that would benefit from further research.

[57] Per Oregon DEQ (2007), waste prevention means "reducing consumption (and wasting) of goods outright without substitution; extending the life of products already in use (and by extension, delaying purchase of replacement items); shifting purchases from disposable or single use products to products that are more durable, repairable, or reusable; purchasing used products in lieu of new products; shifting purchases from material intensive products to products that are less material intensive (dematerialization); shifting consumption from goods to services so that needs and wants are satisfied in a different manner."

[58] Oregon DEQ (2007)

further research, partnerships, and/or emissions-reduction assistance.

- **Government procurement.** Public agencies, including the State of Oregon, often use government purchasing policies to "lead by example" and drive market change towards products with improved environmental characteristics. This study could help such agencies develop priorities for product or service categories worthy of particular attention in efforts to reduce the overall greenhouse gas impacts of government spending.[59]
- **Greenhouse gas analyses and actions in business and industry.** In addition to shifts in *consumer* behavior, actions by *producers* (whether in Oregon or not) can also affect Oregon's consumption-based emissions. Results of this report may help inform enterprise-level GHG inventories of business and industry "supply chain" emissions. Furthermore, when coupled with Oregon's official GHG inventory (Oregon Global Warming Commission, 2011), this report may help identify industries (including those with a significant presence in Oregon) for which actions to shift technology, energy sources, or suppliers may yield significant reductions in Oregon's consumption and/or production-based GHG emissions.

Some members of the public may wish to use results of this study to help inform day-to-day purchasing decisions. It is therefore essential to understand the limitations of our analysis. First, our analysis only considers greenhouse gas impacts, and not the myriad other factors (financial, environmental, social, health, etc.) that consumers also consider when making purchasing decisions. Second, our analysis is based on commodity averages and so cannot help consumers choose between competing brands of any given product. Similarly, our analysis cannot help consumers choose between similar products made using different production methods (such as shade-grown vs. conventionally-grown coffee, or paper made from recycled vs. virgin pulp feedstock) or between similar products made of different materials (such as cotton vs. synthetic clothing).

However, our analysis can help assess what *categories of decisions* matter most in terms of reducing greenhouse gas emissions and addressing climate change. In particular, as was indicated in Table 2, the categories of consumption associated with the greatest greenhouse gas emissions are:

1. Personal vehicles, responsible for 18.9 million metric tons CO_2e;
2. Appliances, responsible for 11.7 million metric tons CO_2e; and
3. Food and beverages, responsible for 9.1 million metric tons CO_2e.

Together, these three categories account for half of all the greenhouse gas impacts of Oregon's consumption. All three are categories where clear opportunities exist for reducing greenhouse gas emissions, as discussed in this report. In addition to these three categories, this report identifies extending the useful life of personal and household goods as a significant opportunity to reduce greenhouse gases. Buying items – such as clothing and furniture – that last longer, or delaying purchase of new items by reusing items already in use can, in aggregate, have an impact on Oregon's consumption-based greenhouse gas emissions of at least 2 million metric tons of CO_2e. Furthermore, pursuing other changes in consumption can also yield significant benefits, and the results of this report can help support consumer choices, in a relatively broad sense, about how to spend limited discretionary income. For example, spending in the *services* category (e.g., haircuts, concerts or massages) is much less emissions-intensive than in the *transportation services* category (e.g.,air travel).

We encourage readers to explore the results of our analysis in Table 2 (on page 10) and

[59] In particular, our CBEI model includes results particular to state/local government spending that, although not presented specifically in this report, could be used by planners to gain even more specific insight into government demand as distinct from household demand.

throughout this report, as well as other research, to learn more about the links between consumption, greenhouse gases, and climate change.

Researcher Recommendations

Consumption-based approaches such as that used in our analysis can offer new insights into opportunities to mitigate global greenhouse gas emissions.

Calculating consumption-based greenhouse gas inventories is highly complex, however, and presents some disadvantages for fully integrating them into state (or national) climate policy. For one, the complex modeling calculations depend on less certain national and international data sources, making them inherently less reliable than relatively straight-forward production-based inventories that can be calculated based largely on direct fuel-use data within each state. Even more critical, however, are the political implications of taking responsibility for greenhouse gas emissions outside the jurisdictional boundary of a state or nation.[60]

Our view is that states and local governments should adopt methods of counting greenhouse gas emissions that allow them to assess the emissions implications of consumption-related decisions over which they have influence. By including imported electricity emissions in its official inventory, for example, Oregon has recognized that it has large influence over emissions through activities that affect electricity consumption, such as energy efficiency programs, which are often the most cost-effective means of reducing greenhouse gas emissions.[61] We suggest that Oregon, a national leader in waste prevention and other efforts to promote sustainable consumption, also has influence over product, material and service choices of its government practices as well as opportunities to create policy and outreach programs that support climate-friendly decisions by individual residents and businesses. Our analysis, as presented in this report and our companion *Technical Report,* helps quantify these potential benefits and makes the case for why looking at greenhouse gases from a consumption-based perspective can open up new opportunities for engaging consumers and producers in reducing global greenhouse gas emissions.

In particular, we recommend the following actions:

- **Conduct a full consumption-based inventory on a regular basis.** Most states rely on production-based or modified production-based methods (e.g., Oregon's treatment of electricity) to conduct their regular greenhouse gas inventories. These methods generally align well with states' efforts to reduce emissions through vehicle emissions standards, transportation planning, renewable portfolio standards for electricity, energy efficiency, and work with local manufacturers. Our analysis here suggests that a full consumption-based method would count a greater share of global emissions and open up new options for reducing these emissions. We therefore recommend that Oregon and other states conduct full consumption-based greenhouse gas inventories on a regular basis, to track progress in reducing consumption-based emissions. Consumption-based greenhouse gas inventories could also support policy or other actions at the community/local government level.
- **Adopt a consumption-based emissions-reduction target.** States often use their greenhouse gas inventories as a basis for setting greenhouse gas reduction targets and tracking progress towards their achievement. Oregon's target, as stated in House Bill 3543: Global Warming Actions (2007), is a 10 percent reduction by 2020 and a 75 percent

[60] For a summary of the challenges and opportunities in consumption-based greenhouse gas inventories at the national level (as well as some suggested remedies), see Peters (2008).
[61] For a summary of reduction opportunities in the U.S. and their costs, see McKinsey & Company (2007).

reduction by 2050 (as compared to 1990 levels). We recommend that Oregon also set a goal for reducing its consumption-based emissions. In addition to addressing the global emissions responsibility associated with Oregon consumption, adopting a consumption-based target would help encourage emission-reduction strategies that maximize global, not just local, reductions. Progress against any consumption-based goal should be measured using consumption-based accounting, just as progress against the state's existing goal is measured using Oregon's existing inventory approach.

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