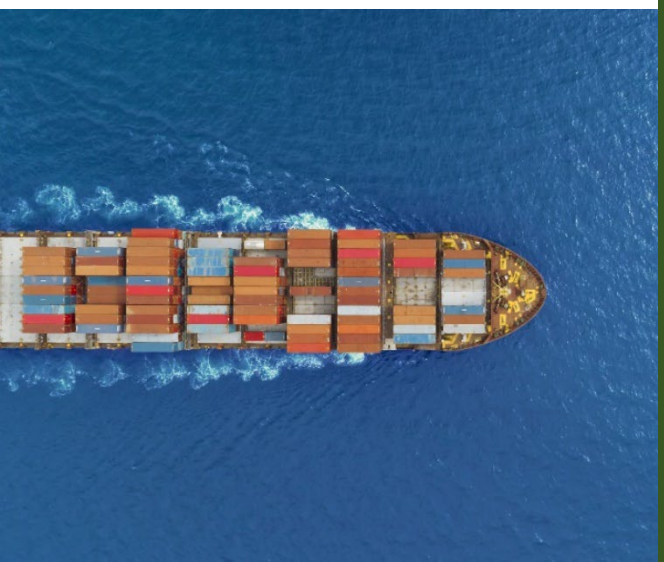

Opportunities to Reduce Greenhouse Gas Emissions Caused by Oregon's Consumption

Prepared for the Oregon Legislature in accordance with HB 3409 (2023)

September 12, 2024

DEQ

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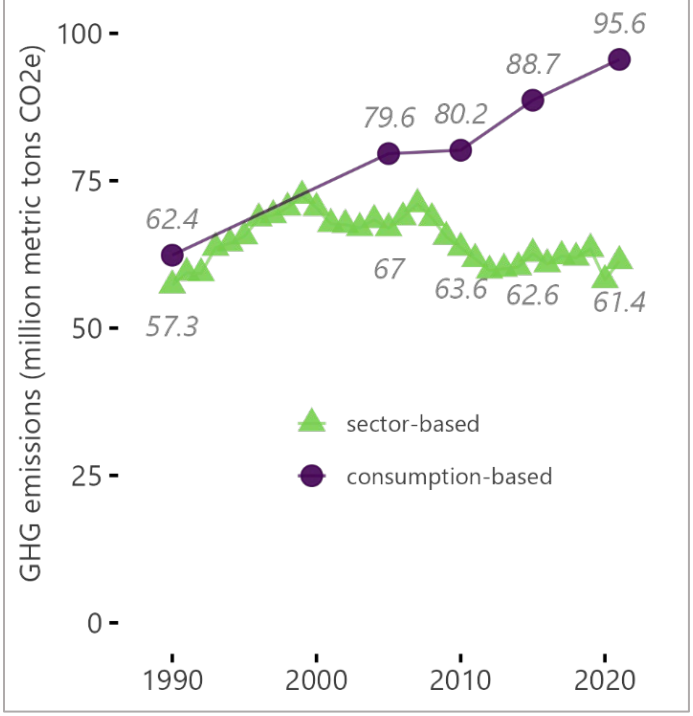
Executive Summary

Opportunities to Reduce Greenhouse Gas Emissions Caused by Oregon's Consumption

Figure ES-1. Oregon's consumption- and sector-based emissions, 1990-2021



Oregon's response to the crisis of global warming shows two starkly different trends from 1990-2021, depending on the method used to account for greenhouse gas emissions.

The State has made notable progress on its **sector-based emissions,** which are the emissions arising *within the state's borders* plus those linked to imported electricity. In 2021, these emissions were down 15% from their peak in 1999.

At the same time, the *global* emissions that Oregonians caused via their consumption of materials, energy and services rose dramatically, overwhelming the reductions in sector-based emissions. In 2021, these **consumption-based emissions** were up 53% from their 1990 values.

Comparing the two measurements shows that Oregon has not reduced its emissions overall – our global carbon footprint has grown much faster than reductions in in-state emissions.

Potential Solutions

While consumption-based accounting reveals that Oregon contributes to emissions occurring around the world, it also uncovers new opportunities to reduce emissions. Because greenhouse gases ignore borders, **the people of Oregon will benefit from reductions in emissions no matter where those reductions occur.**

This report quantifies Oregon's consumption-based emissions and estimates the potential of diverse actions for reducing those emissions. It finds significant opportunities to reduce consumption-based emissions in:

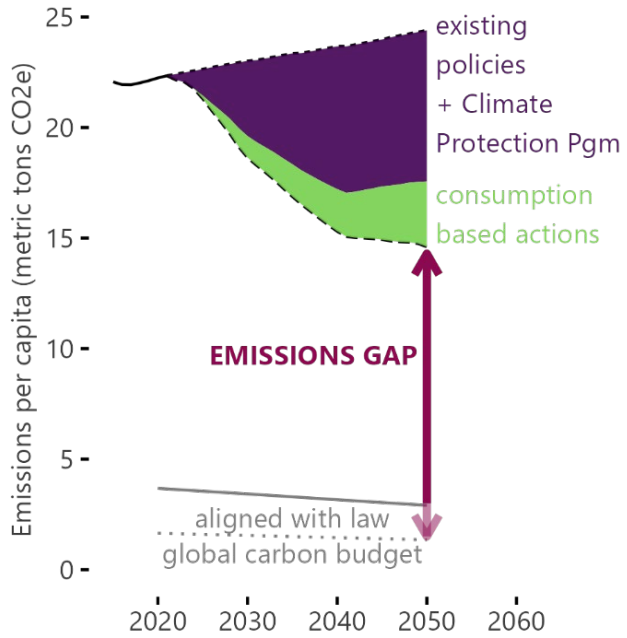
- Existing state and federal policies focused on transportation and electrical generation.
- Enhanced "smart growth" policies encouraging walkable and accessible communities.
- Improved standards and methods in construction materials for buildings and infrastructure.
- Consumption of sustainably produced, lower-carbon foods; and
- Product stewardship approaches that engage producers, bolster competitiveness of Oregon businesses, and remove existing barriers to low-carbon consumption options.

This Report Finds that:

- Many actions that reduce consumption-based emissions also save money for Oregon consumers and businesses.
- Reductions in consumption-based emissions can also lead to additional environmental and social benefits. Lower-carbon diets and walkable communities improve health outcomes. Walkable neighborhoods, which align with smart growth strategies, reduce emissions and are broadly viewed as desirable places to live.
- Consumption-based GHG policies can reduce emissions while benefitting those most vulnerable to climate change.

Figure ES-2. Oregon's projected consumption-based emissions to 2050

with possible target zones



Looking Ahead: 2050 and the Emissions Gap

- Even with numerous new actions in effect, projected 2050 emissions remain well above levels necessary to avoid extreme climate impacts.
- The range between projected 2050 values and possible target values is Oregon's "emissions gap."
- Closing the emissions gap will require systemic changes beyond the scope of this report – and may further improve quality of everyday life of those living in Oregon.

Recommendations

Consumption-based emissions are a large part of Oregon's contribution to the crisis of climate change. To reduce these emissions Oregon should:

- Adopt a consumption-based emissions goal
- Update the State's consumption-based emissions inventory on a more regular basis
- Take targeted actions to reduce consumption-based emissions.

Contents

Companion Documents and Citations

This report to Oregon's legislature is required by Section 52 of House Bill 3409 (2023). It draws significantly on two companion technical reports.

DEQ's Inventory Report

Oregon's Consumption-Based Greenhouse Gas Emissions: 1990-2021, authored by DEQ, provides detailed results and methods from Oregon's consumption-based emissions inventory for 2021. For short, this will be referenced as "**DEQ's inventory report**."

SEI's Technical Report

Technical report on opportunities to reduce greenhouse gas emissions caused by Oregon's consumption, authored by Stockholm Environment Institute (under contract to DEQ), provides information on opportunities to reduce Oregon's consumption-based greenhouse gas emissions, including:

- An emissions forecast and wedge analysis
- A qualitative assessment of outcomes and policy options
- A simplified marginal abatement cost curve
- Several short papers discussing potential goals and opportunities to achieve deeper reductions in emissions

For short, this will be referenced as "**SEI's technical report**."

Citations

To improve readability, this report follows a convention for citations and endnotes. No citation or endnote is usually provided if the fact, finding, or claim has been drawn from the companion reports. Interested readers can find sources in those documents. This report does provide endnotes with citations for additional sources of information.

Introduction

Contents of this Report

This report evaluates Oregon's greenhouse gas emissions using a method that recognizes the interdependence between consumers and producers, including:

- Summarizing results from Oregon's "consumption-based emissions inventory" (CBEI), which calculates the greenhouse gas emissions linked to Oregon's consumption, no matter where in the world the emissions arise. Projecting those consumption-based emissions out into the future.
- Evaluating the potential of diverse actions for reducing those emissions.
- Recommending foundational actions the State of Oregon could take to make sustained and meaningful progress at reducing these emissions.

Consumption-based accounting methods bring with them the potential for greater opportunities to reduce GHG emissions, while contributing positive co-benefits to the lives of the people of Oregon. In Oregon, this approach uncovers numerous actionable opportunities for reducing emissions.

Emissions in a Connected World

In today's globalized world, the human need for material consumption threads us together in a complex web of social, economic, cultural, and environmental interdependencies. Every day, the people of Oregon engage with this network, using products sourced from a variety of states and countries—cars, phones, foods, and houses—all made from ingredients that span the globe. At the same time, Oregon is exporting to the rest of the world – wood products, computer chips, cheese, grass seed, fruit, and airplane parts, to name just a few things. This flow of goods and money often goes unnoticed until a disruption of this network brings it to the forefront of our attention. Yet, every transaction has far-reaching impacts – affecting lives, economies, and communities – near and far.

Consider the simple act of making a homemade apple pie. To create a truly delicious pie, one needs high-quality ingredients from the homemade apple pie supply chain: perhaps apples from an orchard near Hood River, butter from a dairy near Milton-Freewater, and flour from a farm in Washington. The pie also requires energy for baking, supplied by a local utility, and tools like an oven from Mexico and a pie pan from Brazil.

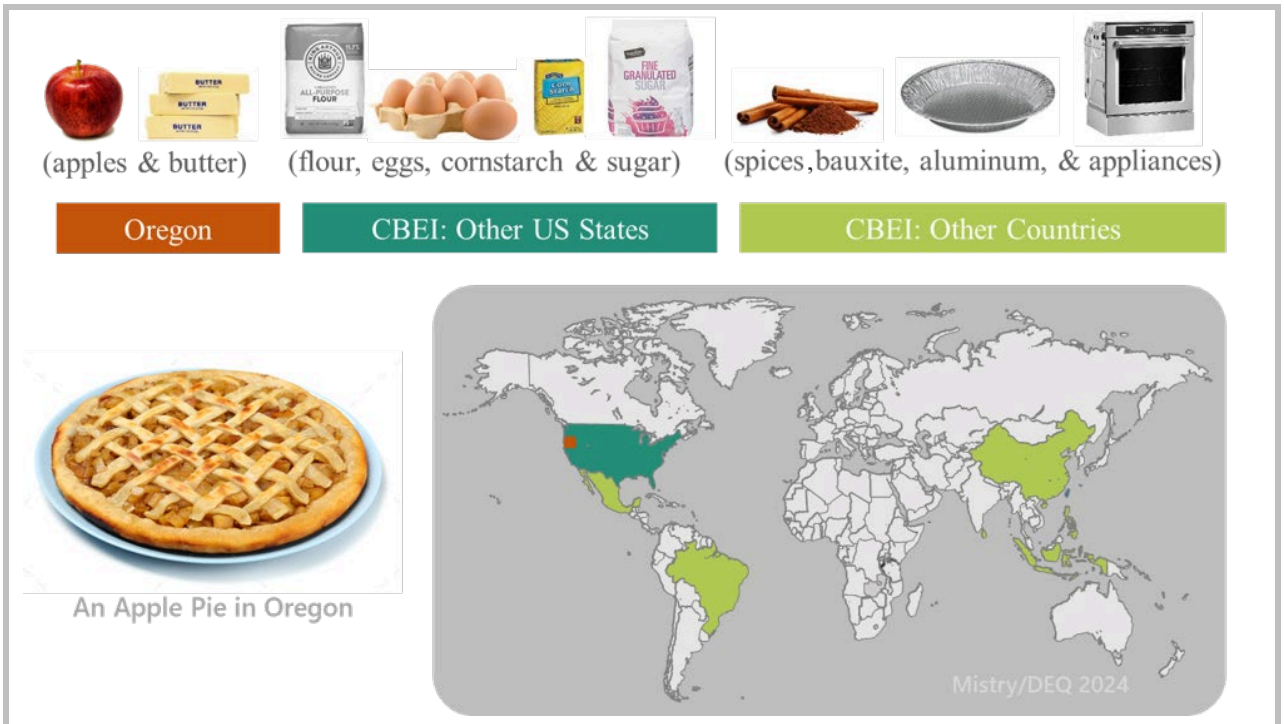


Figure 1. *A few of the emissions sources linked to a homemade, locally sourced apple pie. Some emissions originate in Oregon – such as operating the oven and driving trucks to get Oregon apples to market – but even a local pie creates out-of-state emissions from supply chain activities such as producing sugar, spices, the oven, and the pie tin.*

Money flows from consumers to those industries—farmers, utilities, appliance manufacturers, but it doesn't stop there. Those industries have their own networks of suppliers. Farmers purchase tractors and crates, and appliance factories invest in heavy tools and electricity – and those suppliers, in turn, have their own suppliers.

As we navigate these economic chains, we see how they shape critical aspects of human life—impacting public health, critical infrastructure, and sustainable food systems. Our daily choices are intricately tied to the well-being of distant communities, families, and individuals.

This sophisticated web of transactions complicates our accounting for environmental impacts, such as greenhouse gas (GHG) emissions. Initially, it may seem straightforward to tally-up the emissions from baking an apple pie. Gas burned in an oven generates emissions in the home, and machinery on farms generates emissions in Oregon and Washington. But it gets complicated when we acknowledge that not all the ingredients are from the Pacific Northwest – the sugar and spices and pie pan have their own supply chain impacts, which occur in places as distant as Brazil and Africa.

Oregon is partly responsible for emissions in places like Washington State and Brazil. Conversely, people around the world who buy Oregon's products—whether it's wood, computer

chips, cheese, grass seed, or airplane parts—also share the responsibility for the emissions generated in Oregon.

These relationships are important because GHGs do not recognize borders. Excessive emissions, whether they arise in Salem or Senegal, result in harm to the people of Oregon. This harm is expressed through various environmental events like extended droughts for farmers and ranchers, or heat domes for city dwellers. Similarly, when emissions are reduced, the people of Oregon will benefit regardless of where the reduction originates.

Why Oregon Needs Two Greenhouse Gas Inventories

To create comprehensive greenhouse gas policy, Oregon needs a full picture of our emissions, as well as a robust list of emissions reductions opportunities.

Oregon has two key greenhouse gas inventories that can accommodate a fuller picture of emissions: the **sector-based** and **consumption-based** inventories. Both are essential and complement each other, offering valuable insights. However, using them separately provides an incomplete view of the state's role in global emissions and the actions needed to address them effectively. A dual approach provides Oregon with a more complete assessment of our greenhouse gas emissions, and a more comprehensive set of options for reducing them.

Sector-Based and Consumption-Based Inventories Compared

The sector-based inventory (SBI) is an accounting of emissions sources within Oregon's borders, plus emissions associated with imported electricity. Much of its data comes from direct reporting about quantities of fossil fuels combusted in vehicles, industrial operations, and power generation, though other sources, such as agricultural and industrial process emissions, are included as well. Accordingly, the emissions reductions opportunities it reveals are largely local ones, for example, tailpipe emissions from cars driven in Oregon.

The SBI documents many specific sources of emissions over which Oregon government has some direct influence. It has informed many important policies and programs, focusing on energy sold into the state, transportation fuels, and other sources of in-state emissions.

However, the SBI:

- **Does not adjust for trade.** The SBI assigns Oregon industries responsibility for emissions associated with exported products and could reward "leakage," where producers relocate their operations out of state, reducing Oregon's sector-based emissions but shedding jobs and leaving global emissions undiminished.
- **May create a false sense of progress** if reductions in sector-based emissions are offset by larger increases in consumption-based emissions
- **Does not reveal all possible opportunities** to reduce emissions.

The consumption-based emissions inventory (CBEI) quantifies the emissions generated around the world that result from Oregon's consumption of energy, material goods and services. Its method is less direct than the one used for the SBI. The CBEI works by combining information from sector-based inventories and economic tables describing spending (consumption) and trade.

The CBEI is:

- A **more comprehensive accounting for imports**, assigning emission responsibilities to the final consumer. In the CBEI model, Oregon producers are not held accountable for emissions linked to their exports, whereas Oregon consumers are held responsible for the emissions related to their imported goods.
- A **more complete accounting of the emissions linked to supply chains**, no matter how deep and complex.[1]
- A **tool that can reveal additional important opportunities to reduce Oregon's emissions** – both in-state and elsewhere. Many such emissions reductions opportunities are described and quantified in chapters of this report.

The CBEI methodology has its limitations. CBEI isn't designed to provide a level of detail that distinguishes emissions from individual facilities and vendors. Instead, it estimates emissions for various consumption categories using averages from around 500 economic sectors. This means it isn't intended to compare emissions from different choices within the same sector. For example, all spending on imported "wood office furniture" is given the same environmental impact per dollar, even though some pieces of wood furniture are likely more eco-friendly than others.[2] While CBEI is a statewide, subnational inventory, it is important to note that a one-size-fits-all approach won't effectively reduce CBEs across Oregon. The state's diverse population, regional differences, and cultural contexts require tailored, location-specific solutions that are crucial to consider.

A Dual Approach

This report shows that CBEI and the SBI are complementary sets of information for policymakers and members of the public. The CBEI provides a relevant, panoramic assessment of Oregon's global emissions and uncovers critical and diverse opportunities to reduce the state's emissions footprint – opportunities that we can implement here in Oregon, and which would significantly expand the impact of Oregon's climate protection efforts.

Key Results from the 2021 CBEI

Top-line summary results from Oregon's CBEI for 2021 can be found below. A more detailed set of results, including methodology and data sources, is available in DEQ's inventory report for 2021, formally titled *Oregon's Consumption-Based Greenhouse Gas Emissions 1990 – 2021*. Those detailed 2021 results served as key inputs for Stockholm Environment Institute's technical report formally titled, *Technical report on opportunities to reduce greenhouse gas emissions caused by Oregon's consumption*. This document contains an extensive analysis of opportunities to reduce emissions.

Emissions are Moving Out of State

Figure 2 illustrates how the state's consumption-based and sector-based emissions have changed – and diverged – between 1990 and 2021.

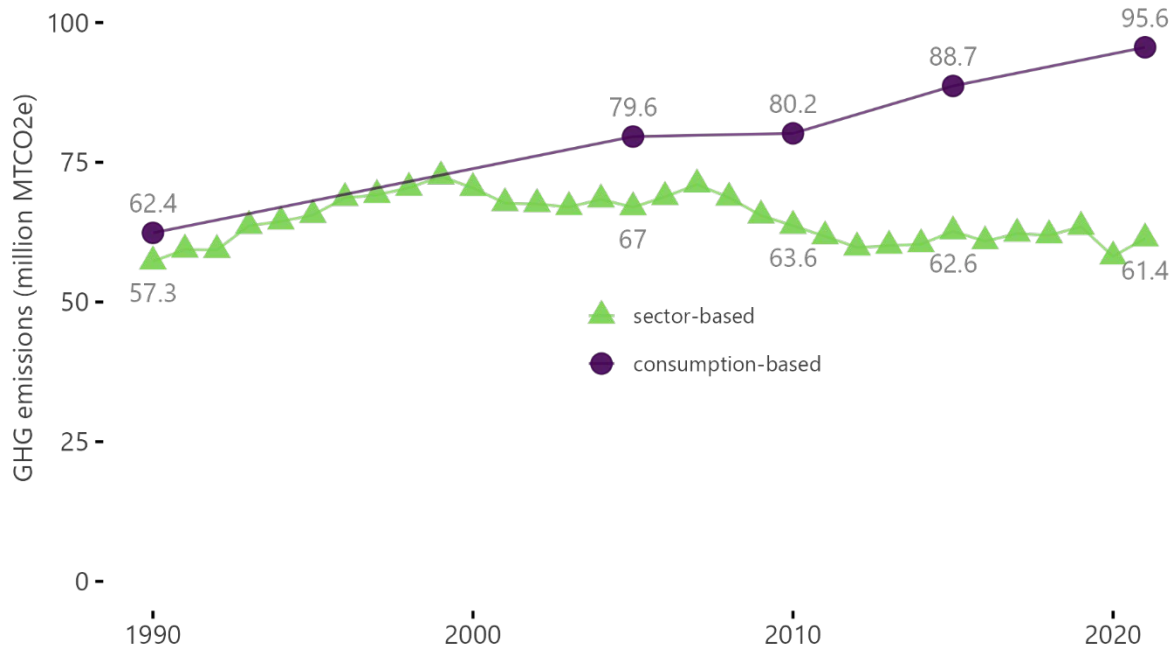


Figure 2. *Trends in Oregon's consumption- and sector-based emissions, 1990-2021.*

The state's sector-based emissions peaked in 1999 at around 72.5 MTCO2e (metric tons CO2 equivalents). By 2021 they were 15% lower at 61.4 million MTCO2e. [3] In contrast, Oregon's consumption-based emissions have risen steadily over time.

Importantly, the gap between the two inventories has grown nearly seven times larger in size between 1990 and 2021:

Year	**Consumption-Based** (Emissions in million MTCO2e)	**Sector-Based** (Emissions in million MTCO2e)	**Difference between CBEI & SBI** (Emissions in million MTCO2e)
1990	62.4	57.3	5 million
2005	79.6	67.0	13 million
2010	80.2	63.6	17 million
2015	88.7	62.6	26 million
2021	95.6	61.4	34 million

This widening gap might be explained by several concurrent factors, the most significant being rising consumption in Oregon. Other factors could include increased reliance on imports (from outside of Oregon), offshoring of domestic (and in-state) production, and Oregon decarbonizing its sector-based emissions at a faster rate than states and nations that produce items consumed by Oregon.

Oregon's Total Emissions are Strongly Affected by Imports *and* Exports

The magnitude of the effect of trade on Oregon's emissions is demonstrated in **Figure 3**, which provides a graphic representation of the overlap and differences between the consumption- and sector-based inventories for year 2021.

In 2021, Oregon's sector-based greenhouse gas emissions (the overlapping circle on the left) were estimated to total 61.4 million MTCO2e (preliminary). This is compared against the State's consumption-based greenhouse gas inventory (the overlapping circle on the right), with an estimate of 95.6 million MTCO2e.

The two inventories share approximately 37 million MTCO2e. This shared total includes direct emissions from vehicles and appliances used by households and governments, emissions from electricity generation used by these groups, and other in-state emissions from commercial and industrial activities as part of the supply chain that satisfies Oregon's consumption.

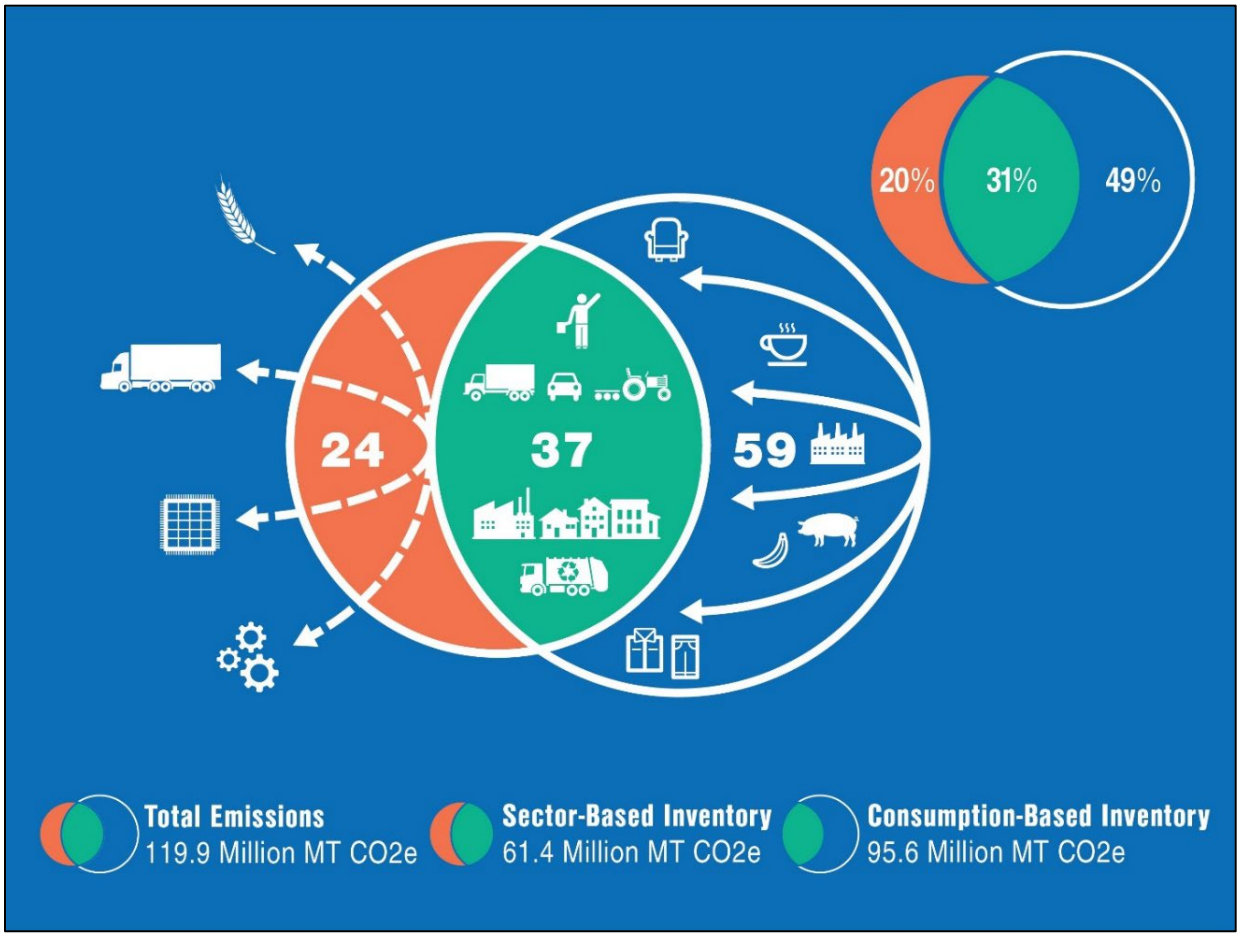


Figure 3. Comparison of Oregon's 2021 sector- and consumption-based inventories.

The crescent in the left side of **Figure 3** are emissions that are unique to Oregon's sector-based inventory. In 2021, these emissions were estimated at 24 million MTCO2e. These include emissions from in-state businesses producing goods and services consumed by, or as part of the supply chain of goods and services consumed by, households and governments not based in Oregon.

The crescent on the right side of **Figure 3** are emissions that are unique to Oregon's consumption-based inventory. In 2021, these emissions were estimated at 59 million MTCO2e. These include emissions in other states and nations associated with satisfying consumption by Oregon households, governments and businesses. Many of these emissions are associated with the consumption of imported materials. Significantly, these imported emissions (**59 million MTCO2e**) are almost as large as Oregon's entire sector-based inventory (**61 million MTCO2e**).

The Majority of Emissions Occur Before Purchase and Use

Figure 4 summarizes Oregon's 2021 consumption-based greenhouse gas emissions, by category of consumption and life cycle stage.

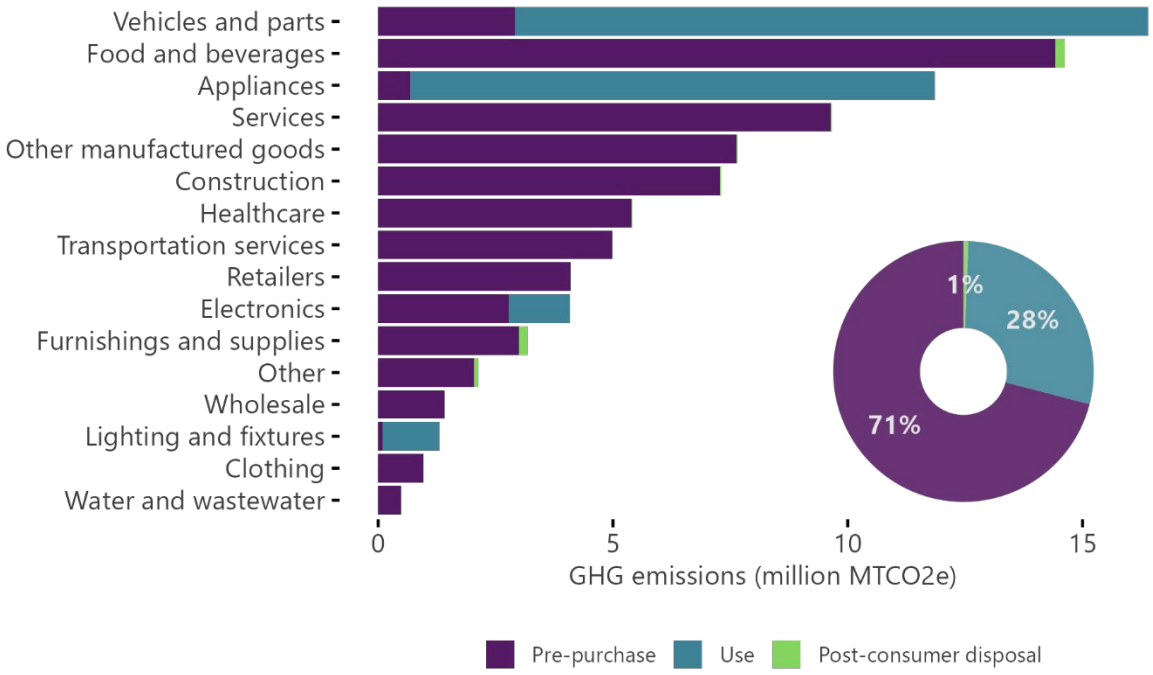


Figure 4. *Oregon's 2021 consumption-based emissions, by spending category and life cycle stage*

The breakdown by life cycle stage is notable. The great majority of impacts associated with consumption occur before the final consumer has even purchased the product. Consumer-facing media coverage of climate emissions often focus on the impacts of driving cars or heating homes, but **Figure 4** shows such "use-phase" impacts are only 28% of Oregon's total. Only 1% of consumption-based emissions are related to post-consumer disposal.

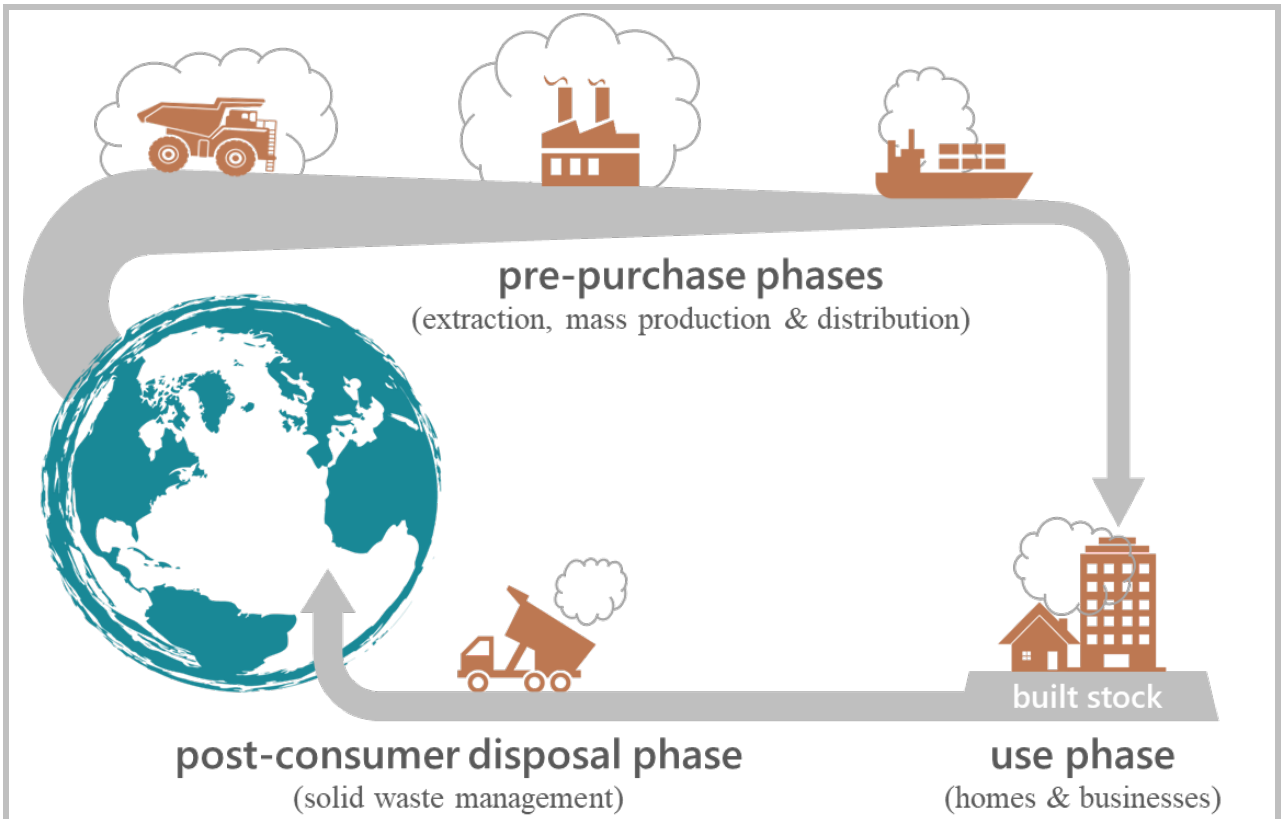


Figure 5. *Schematic of emissions across life cycle stages*

Three categories of consumption contribute 44% of all CBEs:

1. "Vehicles and parts" contribute the most; while these emissions are dominated by fuel use, the pre-purchase emissions associated with producing vehicles contributes more to total emissions than lighting, clothing, and wastewater treatment combined.
2. A close second in terms of magnitude are "food and beverages" – these emissions are dominated by production, both on-farm and in factories and supply chains.
3. "Appliances," dominated by use-phase emissions, are the third largest contributor, followed by services, other manufactured goods, and construction.

Higher Income Households are Responsible for More Emissions

Oregon's CBEI measures the global emissions linked to what economists call "final demand" – which includes all of the goods and services bought by households and governments. The CBEI also includes business investments in capital and inventory, in line with national economic accounting standards. In 2021**, households were responsible for 73%** of Oregon's consumption-based emissions, **governments for 11%,** and **business capital investment for 16%**.

Different households contribute to emissions in very different degrees. One highly predictive factor is household income, as illustrated in **Figure 6.**

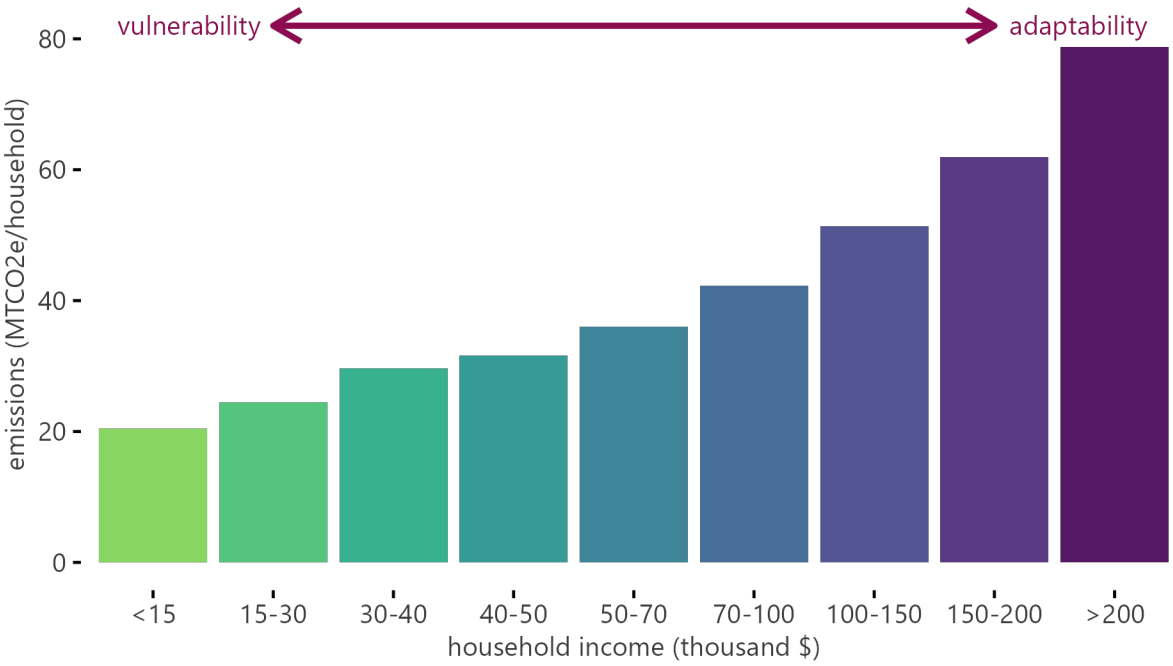


Figure 6. *Average per-household consumption-based emissions in 2021 for Oregon income groups*

Households with annual incomes of $15,000 or less represent 9% of all Oregon households and contribute less than 5% of household consumption-based emissions. In contrast, about 7% of Oregon households have incomes in excess of $200,000, but they contribute 14% of household consumption-based emissions. Households that contribute relatively more to the problem of climate change have more opportunities—and more ability—to reduce their emissions. In contrast, households that contribute relatively less have fewer opportunities and less ability to make change, in addition to generally being more directly vulnerable to a changing climate.[4]

What Can Oregon Do? Opportunities to Reduce Consumption-Based Emissions

There are many opportunities to reduce consumption-based emissions through policies and programs that Oregon could consider.

Figure 7 graphically represents a forecast of Oregon's consumption-based greenhouse gas emissions out to 2050. The dotted line at the top of the wedge shape shows emissions under a "no action" scenario if no policies were implemented.[5] The first wedge below the dotted line illustrates the potential benefits of existing policies related to transportation, land use, efficiency and decarbonization of energy sources such as electricity and natural gas. Also included with the existing policy wedge is a draft proposed replacement for the State's Climate Protection Program.[6]

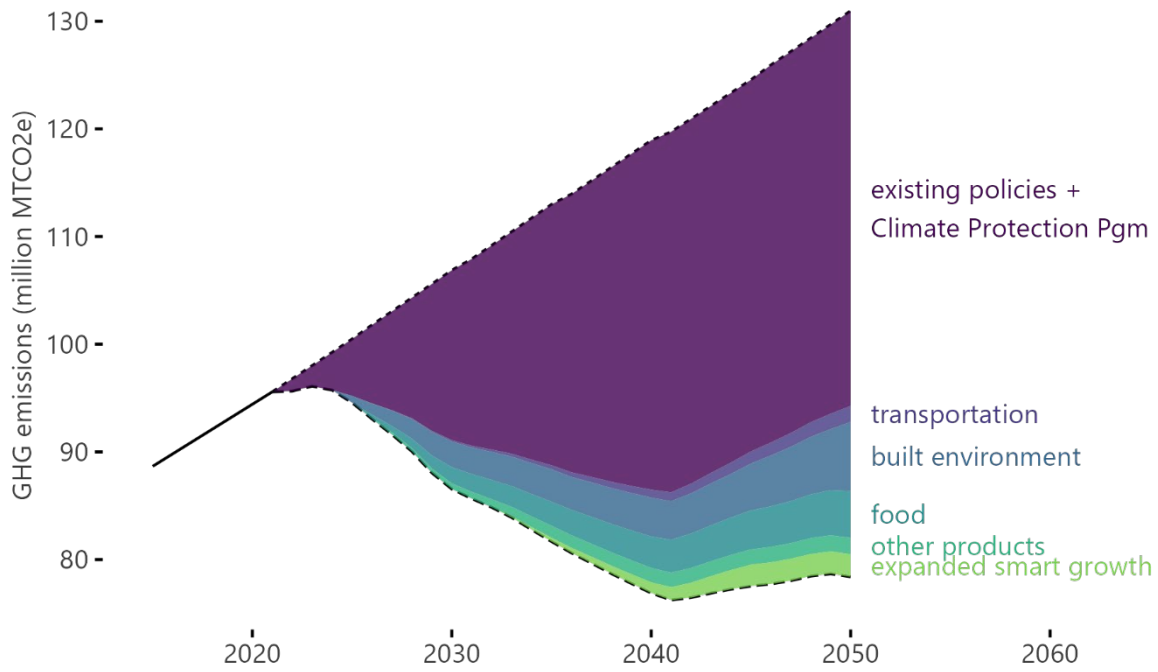


Figure 7. *Summary of SEI's wedge analysis, showing Oregon's projected consumption-based emissions, with and without major action areas.*

Opportunities to Reduce Consumption-Based Emissions

This report aims to uncover new ways to reduce CBEs by exploring policies beyond those already in place. It highlights areas within the CBEI that haven't been given much attention in policy discussions. For years, emissions from vehicles and building energy use have dominated

state and federal climate policies. However, to lay the groundwork for future action, DEQ has turned its attention to less-explored topics, such as the carbon impact of the built environment and the emissions linked to the entire life cycle of food.[7]

This approach has uncovered opportunities for state-led climate benefits, illustrated by the brightly colored wedges at the bottom of the emissions forecast in **Figure 7**. As presented in the following pages, they involve additional opportunities to reduce emissions associated with:

- Air travel and vehicle life cycle emissions.
- Oregon's built environment, including embodied carbon.
- The life cycle of foods consumed by Oregon.
- Other products, such as electronics, clothing, appliances and furnishings.
- "Smart growth," which can reduce emissions associated with transportation, building energy use, embodied carbon, and general household consumption.

The Importance of Policy Solutions

A common assumption is that the way to address consumption-based emissions is to persuade individual consumers to change their behavior. A growing body of evidence, however, suggests that these kinds of approaches – while effective in some contexts – have limited lasting effectiveness.

Consumption is shaped not only by individual actions but also larger economic and social systems, such as income, education, cultural factors and societal norms. Decisions by governments and businesses to invest in specific products, services, infrastructure, and technologies also impact the consumption choices available to individuals. Additionally, the failure to consider negative externalities in the pricing of goods and services masks the social and environmental costs of consumption behaviors, including upon low income and marginalized communities.

The most effective approach to reducing consumption-based emissions will combine policies that target consumer behavior with those that address the structural factors driving consumption across multiple scales and actors. Rather than expecting individuals to make decisions that may be expensive, difficult, and/or inconvenient, policies can change the options available to make lower-carbon consumption choices affordable and easy.

The Business Case for Addressing Consumption-Based Emissions

Viewing the challenge of climate change through the lens of consumption-based emissions presents at least three potential opportunities to enhance the connection between emissions reduction and Oregon businesses.

First, since the consumption-based inventory is agnostic with regards to where production occurs, it doesn't penalize Oregon for being home to businesses that sell products to consumers across the globe.

Second, a consumption-based approach introduces new policy options that offer potential **benefits to Oregon businesses**. The consumption framework points towards an approach where businesses could be regulated on the basis of what is *consumed* in Oregon, regardless of where those goods are produced. Several precedents already exist for this type of "product stewardship" policy[8], which offers to Oregon producers a more level-playing field because they are obligated only on the basis of what they sell into Oregon (and not what they sell elsewhere), and their out-of-state competitors are similarly obligated and held to the same standard.

Finally, a consumption-based policy framework can offer benefits to those businesses that can more quickly adapt to lower-carbon production processes. By signaling a preference for lower-carbon goods through state procurement and other policies, Oregon can help its businesses transition to, and profit from, an economic future where lower greenhouse gas emissions will be the norm, as opposed to the exception.

Potential Economic, Social and Environmental Co-Benefits

Reducing consumption-based emissions, can provide significant economic, social and environmental co-benefits. SEI evaluated potential **economic benefits** by preparing a limited marginal abatement cost curve that evaluated the costs to achieve six different consumption-based outcomes.

Four of the six options evaluated reduced emissions for consumers and organizations while simultaneously providing economic benefits, in that total economic savings exceeded total costs. These options would be economically positive even *without* climate benefits. The other two options, for which total costs exceeded savings, would still yield an economic benefit if the societal benefits of avoiding greenhouse gas emissions were considered.

Addressing consumption-based emissions creates potential for broader **social benefits** such as:

- Improving the competitiveness of Oregon businesses (see Business Case text box above).
- Improved health outcomes, which are associated with lower-carbon diets and nonmotorized transportation options.
- Helping more Oregon residents meet basic needs and improve well-being by considering how policies distribute burdens and benefits across different socio-economic groups. For example, some Oregon households are not meeting basic needs of housing, even as the average size of newly constructed housing is near record highs. Similarly, 1 in 8 Oregon households are food insecure, even as **38% of food sold into Oregon goes uneaten due to waste.**

Reducing consumption-based greenhouse gas emissions also offers potential additional **environmental benefits**. The production of foods, construction materials, and consumer goods all impose significant burdens on natural systems, through land and water use and emissions of pollutants to both air and water. Reducing consumption can reduce not only greenhouse gases but also many other environmental impacts. Other decarbonization efforts, such as assessment and disclosure of life cycle carbon emissions, are easily expanded to include additional types of impacts.

The following pages address opportunities to reduce consumption-based greenhouse gas emissions associated with transportation, the built environment, food, and other products, as well as through enhanced smart growth policies and additional approaches that could achieve even deeper decarbonization. Information presented below is high-level and summary in nature; additional details, including additional opportunities, can be found in SEI's technical report.

Transportation

Transportation is often seen as a simple matter of getting from one place to another, but the global transportation network has climate impacts visible in both of Oregon's greenhouse gas inventories. In Oregon's sector-based inventory, transportation is the largest sector, contributing over 35% of all emissions in 2021.[9]

In Oregon's consumption-based inventory, transportation is at least 25% of total emissions. The purchase and use of vehicles and parts account for 16%. Another 4% of emissions come from the supply chains for consumer goods and services, such as the transport of food from farms to factories. Transportation services, which include the transport of finished goods from final producers to retailers, and the transport of consumers themselves, for example with airplane trips, adds another 5%.

Transportation is an area where there is much overlap in the emissions of the sector- and consumption-based inventories. Oregon has a broad ongoing strategy to reduce sector-based transport emissions, including expanding transportation options, reducing carbon emitted by fuels, changing vehicle technologies, managing road growth and congestion, using pricing incentives, and impacting emissions through land use changes.[10]

Consumption-based approaches to transport emissions have received less attention to date, but the text below describes two: reducing the weight (and size) of passenger vehicles and reducing emissions from air travel. A sidebar explores why "buying local," while often promoted as a means to reduce GHG emissions, may not have the GHG benefits that are often assumed. Other transportation-related approaches to consumption-based emissions are explored in the chapters on built environment and smart growth.

Opportunities to Reduce Emissions

In this and all subsequent chapters of this report, additional details regarding opportunities to reduce emissions are provided in SEI's technical report.

Lighter Weight Vehicles

While most emissions from vehicle use stem from the combustion of fuels during use, the emissions from vehicle *production* are non-trivial, contributing more to emissions (2.7 million MTCO2e in 2021). One strategy for reducing transportation related CBEs is to shift consumption to lighter weight cars. Vehicles that weigh less require less raw material and energy to produce, cause less wear on roadways and consume less fuel, which results in overall fewer emissions. Educating consumers about the benefits of lighter vehicles can influence purchasing decisions.

Financial incentives, such as tax rebates for purchasing lighter-weight cars, can further encourage this transition.

Reducing Air Travel Emissions

Approximately 11% of Oregon's consumption-based transport sector emissions are from air passenger travel, and these emissions are growing over time. Oregon can reduce air travel emissions by prioritizing virtual meetings, investing in regional to national high-speed rail, or even empowering local economies through incentivizing "staycations."

What about Reducing Freight Emissions by Buying Local?

The idea that consumers can reduce greenhouse gas emission by buying local is widely promoted. A closer examination reveals the climate benefits of buying local may not be as large or consistent as commonly believed.

Freight contributes surprisingly little to life cycle greenhouse gas emissions. Instead, emissions tend to be dominated by supply chain and manufacturing activities that are less visible to consumers.[11] For example, **the distribution of finished foods contributes less than 4% of the greenhouse gas emissions of foods** consumed in the United States, on average.[12] In contrast, production phase emissions are quite large and variable. A classic study from the UK found that local tomatoes grown in heated greenhouses result in higher overall GHG emissions than field-grown tomatoes shipped from Spain, despite their higher transportation requirements. This and other examples can be viewed in a separate literature review available on DEQ's website.[13]

Additionally, manufactured goods can have supply chains that span the globe, making "local" difficult to define. If a reusable shopping bag is made from polypropylene produced in Saudia Arabia and woven in India, then sewn into a bag in Vietnam and shipped to Oregon, the carbon footprint isn't necessarily much different than a "local" bag made of the same woven polypropylene but assembled locally in Eugene.

There are cases in which local consumption is preferable through a climate lens. **The mode of shipping is often more impactful than distance**. Local seafood, for example, carries a lower carbon footprint than fresh-caught seafood flown across the continent – or the world. For heavy products with relatively low carbon impacts – such as bottled water – transport can add significantly to overall carbon footprints.[14]

There are other, non-climate benefits to promoting localism, including greater regional resilience and keeping more consumer dollars circulating in local economies. However, buying local is not a consistently reliable means of reducing GHG emissions, and should not be advocated as such.

Program and Policy Options

Policies and programs that Oregon could consider reducing transportation-related consumption-based emissions include the following:

Consumer Education and Financial Incentives. Consumer education and financial incentives are critical components of any comprehensive strategy to combat GHG emissions from transportation. Information disclosure, such as labeling vehicles with their life cycle emissions ratings (including production), can empower consumers to make informed choices. Financial incentives, including subsidies for lighter and smaller vehicles, can make these options more accessible to a broader audience. Conversely, financial disincentives, such as higher taxes on high-emission vehicles, can discourage the purchase and use of less efficient cars. Similarly, Oregon could consider charging flight levies, adjusting airport passenger facility charges to price short-haul travel higher, implement carbon emissions-based pricing of flights, or set new aviation fuel taxes. By leveraging these tools, policymakers could influence consumer behavior and drive the market toward more sustainable options.

Government Investment and Procurement Standards. Oregon could invest in infrastructure for lower-carbon forms of long-distance travel, such as rail improvements, cyclist-friendly infrastructure, and high-speed internet to support virtual meetings. Government procurement standards and requirements could set an example for the private sector, while actively reducing CBEs. For example, the State could prohibit flights by State employees in the Eugene – Vancouver corridor and use its purchasing power to prioritize smaller and lighter-weight vehicles, paying attention to full life cycle impacts, not only emissions from fuel use. These standards can also extend to other aspects of transportation, such as contracting with airlines that demonstrate a commitment to reducing their carbon emissions.

Zoning and Land Use Policies are considered in later chapters on Built Environment and Smart Growth.

Overview of Economic, Social and Environmental Considerations

Economic: Reducing air travel will reduce economic activity in some sectors while increasing it in others. Most policies that would reduce vehicle size or weight could reduce public expenditures on road maintenance, but otherwise are not expected to have significant economic impacts in Oregon.

Social: Larger and heavier vehicles lead to increased rates of harm to pedestrians and smaller vehicles.[15] The adoption of lighter-weight and smaller vehicles could result in fewer traffic

fatalities and other injuries. Reducing air travel may also bring health benefits to households located near airports that currently experience air and noise pollution.

Air travel is predominantly used by higher-income households, and implementing financial penalties, such as taxes, will further limit the ability of lower income individuals to use air travel. This can be an issue when there is a need to care for family or attend special events, especially for lower-income individuals who may also be immigrants, refugees or have family members living abroad. Targeting financial penalties towards frequent fliers or private jet users can reduce this inequity, as would redistributing revenue generated.

Environmental: Both air travel and vehicle manufacturing create significant environmental impacts in addition to greenhouse gas emissions. Reducing air travel and reducing materials used in vehicles, while maintaining high fuel economy and reducing wear and tear on roadways, will result in additional environmental benefits such as reduced pollution to soil and water.[16]

SEI's technical report contains additional approaches to reduce transportation-related emissions, as well as additional considerations of the equity impacts of transportation policies.



Built Environment

The built environment includes residential and commercial buildings, public spaces, and the interiors of these structures, including finishes, furnishings, and equipment. It also encompasses the infrastructure that supports us: utilities, roadways, power, water, sewer services, and connectivity. Vast and varied, the built environment is a major contributor to Oregon's emissions, accounting for 29% of consumption-based emissions and 34% of sector-based emissions. Emissions associated with materials used in buildings and infrastructure are typically referred to as **embodied carbon**, and the State of Oregon has committed to leading edge efforts that reduce embodied carbon.[17]

The emissions from the built environment are measured differently in sector-based and consumption-based inventories.

Sector-Based Inventory includes emissions associated with the energy used to operate residential, commercial and industrial buildings and homes. It has made strides in reducing GHGs through increasing building energy efficiency and decarbonization of the energy supply.
Consumption-Based Inventory expands the sector-based framework, breaking down the built environment into dozens of categories such as construction, appliances, furnishings, and lighting. It considers emissions throughout the life cycle of materials and products—from production to use to disposal.

The two inventories overlap regarding emissions from energy used by residential and governmental buildings. This report focuses on a major *additional* source of emissions that features prominently in the consumption-based inventory: "embodied carbon" – a large quantity of emissions associated with the materials used to construct and maintain buildings and infrastructure (see text box).

Embodied Carbon: A Deeper Dive

Embodied carbon includes emissions pollution from resource extraction, manufacturing, transportation, installation, maintenance, and disposal or recovery of materials. The **emissions from construction materials account for 14.4% of Oregon's consumption-based emissions.** Importantly, 91% of those emissions occur early in the life cycle—during extraction, manufacturing, and transportation—well before buildings are occupied or roads are used.

From now until 2050, if new construction is built to high-performance standards, emissions from the building sector will be roughly split between operational (44%) and embodied carbon (56%).[18] Projections indicate that between now and 2030, **embodied carbon will account for 67% of emissions in the building sector**. Considering the urgent need for housing, this could lead to massive embodied carbon emissions depending on how this demand is met – new construction or renovation, housing size, and embodied carbon of selected materials will all influence the potential emissions that arise.

Expanding and maintaining public infrastructure, including roads, streets, and Oregon's iconic bridges, also significantly contributes to these embodied emissions. In 2021, nearly 25% of all government consumption-based emissions came from non-residential construction and maintenance. A study of ODOT's greenhouse gas emissions found that approximately half of ODOT's total GHG emissions in FY 2016-2019 were from the concrete, asphalt, and steel used in construction (91,400 MT CO2e).[19]

The State has historically set emissions reduction goals for buildings and transportation through sector-based inventory accounting. This scope could be more robust and expansive with the inclusion of embodied carbon emissions that are only fully accounted for in the consumption-based emissions inventory.

Opportunities to Reduce Emissions

Oregon is already a national leader in assessing and reducing embodied carbon. However, there is rich potential to make deeper and more substantial reductions.

Reducing Embodied Carbon of Building and Construction Materials

Since 91% of embodied carbon emissions occur before materials reach the construction site, a product stewardship approach could present a substantial approach for reducing embodied carbon in building materials. One structural barrier to individuals being able to make carbon-friendly material choices is lack of transparency about the carbon intensity of building materials. Product stewardship that supports the implementation of product-specific Environmental

Product Declarations[20] for construction materials sold into Oregon is an example of such an approach.

This product stewardship approach could be extended in several directions. Over time, producers could be required to reduce the carbon intensity of high-impact building materials, using EPDs to demonstrate carbon reductions. Producer responsibility could also be applied at the scale of whole buildings, such as by requiring Whole-Building Life Cycle Assessment during the design stage of new buildings and setting embodied carbon targets as part of zoning or permitting requirements.

Space-Efficient House Sizes

The size of our homes plays a crucial role in energy use and consumption-based emissions, significantly impacting the environment.[21] Larger homes use more energy and have a bigger impact on the environment, including more embodied carbon. Building bigger houses means more construction materials are needed, and having more space often leads families to buy more stuff. Until recently, the average size of new homes in the U.S. was increasing, even though the number of people in each household stayed the same or has slowly been declining. As of 2019 in Oregon, the average square footage of newly constructed homes has started decreasing. However, there is still room to continue this trend. A DEQ study[22] found that the environmental impact of an "extra-small" home (1149 square feet) is reduced 20-40% from that of a "medium" home (2262 square feet) across all impact categories.

Enhance the Utilization of Existing Buildings

Enhancing the utilization of already existing buildings would result in a reduced need for new construction, leading to a reduction of emissions from production of new building materials. Oregon has a substantial amount of vacant building stock, with a 29.7% vacancy rate[23] for office buildings in Portland, and a 47% vacancy rate in upper stories of downtown retail buildings in "main street communities" across Oregon.[24] Converting these otherwise empty spaces into residential and/or alternative uses when housing is not a viable option could both reduce the need for building materials while also addressing an ongoing need for greater housing availability in walkable, economic centers. A similar approach could be the conversion of large single-family homes into multi-family unit homes by adding internal accessory dwelling units, or converting to duplexes.[25] Additionally, given the rise of hybrid and remote work, there are opportunities to be more efficient with commercial office space. Tenants could reduce the footprint of their lease or share a space with another tenant.

Program and Policy Options

Information Disclosure. Oregon could take substantial steps by assisting, incentivizing, and/or mandating manufacturers to provide item-specific Environmental Product Declarations for

construction materials.[26] Projects could also be required to complete a Life Cycle Analysis as a condition of permitting. These approaches could drive transparency and promote sustainable practices in the construction industry. Evidence suggests that providing such information could influence both consumer decisions and producer behavior. Producers may be inclined to take proactive measures to minimize impacts before disclosing the information.

Product Regulation and Standards. As stated earlier in this chapter, 91% of CBEs associated with built environment are generated before the construction materials are placed into use. Product regulation and standards may offer the greatest potential to reduce consumption-based emissions, as they would address CBEs of construction materials at the source.

Financial Incentives. The State and local governments could offer financial assistance by providing tax rebates, permitting waivers, or density bonuses that incentivize the development of new buildings that meet or exceed carbon benchmarks, as well as incentives for the reutilization of existing buildings, where appropriate. The State could also incentivize the development of smaller housing by lowering taxes or development fees for homes that meet defined standards. The State could also incentivize hybrid and remote work policies that allow for better utilization of existing commercial office space.

Zoning and Land Use Policies. Zoning and land use policies have significant potential. Oregon could continue to expand HB 2001 (2019) to additional jurisdictions in order to provide zoning for more multi-unit dwellings. Additional zoning considerations such as easing minimum housing size restrictions; setting maximum house size limits; easing allowable densities, height, and mix; and easing parking mandates could also contribute meaningful, structural support for reducing CBEs in the built environment.

Overview of Economic, Social and Environment Considerations

Economic: Increases of space-efficient housing could lead to an increase in volume of livable housing, which could help alleviate the overwhelming need for additional affordable and workforce housing in Oregon. By using existing infrastructure, we can cut down on the need for new construction, which in turn lowers new infrastructure costs for local governments. Requiring Environmental Product Declarations for building and construction materials sold in the state levels the playing field for local producers with producers who import products, while also allowing Oregon producers to be more competitive in markets outside of the state where there is an increasing demand for lower carbon materials.

Social: The social impacts of sustainable, vibrant communities are far reaching. From the ethical sourcing of sustainable construction materials, to increased access to affordable, space-efficient housing, the implications of an improved quality of life extend tangibly to those living in Oregon. Additionally, while people living in Oregon could benefit from increased housing

availability, the impacts of ethically sourced materials could also improve the quality of lives within the state's borders and beyond.[27] Disclosure of supply chain labor practices could be included with embodied carbon disclosures.

Environmental: Materials used in construction have environmental impacts that extend well beyond climate change. For impact categories such as ecotoxicity and respiratory pollution, production of construction materials contributes *more* to total impacts than greenhouse gas emissions.[28] Reducing materials use will reduce greenhouse gases and a host of other environmental impacts. Impact disclosure and decarbonization of materials (by producers) and buildings (by developers) can be expanded to include other environmental considerations.

Co-Benefits of Embodied Carbon Reductions

The built environment industry is increasingly focused on ***ethical decarbonization***, addressing the broader impacts on air quality, public health—especially in vulnerable communities—and labor conditions. These practices and policies offer additional benefits, such as:

Concrete: The production of cement, a primary component in conventional concrete, is a carbon intensive process, and according to the EPA, the cement sector is the third largest industrial source of pollution. Low carbon concrete mixes with less cement are widely available in Oregon at little to no cost difference. Recent studies[29,30] found that emissions reductions are possible with no or low-cost premiums.

Steel is another material that carries a substantial embodied carbon intensity. One of the easiest ways to select lower carbon steel is to Buy American/Buy Local because the carbon intensity of US-made steel is lower than that coming from many other countries.[31] American-made, lower carbon steel also supports livable-wage American jobs.

Timber: While wood products tend to be lower in embodied carbon than other structural materials, timber is also one of the building materials most at risk for forced labor in the supply chain.[32] Human trafficking within the timber industry is also a concern in some countries. Fortunately, wood products from sustainably managed forests in the region are widely available in Oregon. Using Pacific Northwest-grown and processed wood products can reduce embodied carbon emissions, while support good-paying American jobs, and reduce the risk of forced labor.

Reusing existing buildings has the potential to reduce embodied carbon emissions between **50 and 75%.**[33] **Building more space-efficient housing** also has the potential to reduce emissions by **20 to 40%.** These strategies also offer additional advantages, including retaining historic structures and a sense of place in Oregon towns and cities, supporting small businesses and building community by locating people in downtowns and main street areas, providing walkable lifestyles and more affordable housing options through smaller footprints.

Food Systems

The movement of food from farm to table creates GHG emissions at numerous stages. Agriculture involves practices that emit GHGs from a variety of sources such as equipment to work the land, methane from livestock and nitrous oxide from fertilizers. As food passes through distribution centers and retail outlets, energy-intensive refrigeration systems add to emissions. At the consumer level, food waste creates environmental impacts. When food is discarded, the resources that are invested in its production and distribution – water, energy, land, material, and labor – are wasted as well.

While long-distance transportation of food plays a role in the generation of CBEs, this role is often perceived as larger than it really is. Similarly, the materials used for packaging, often essential for protecting and preserving food, add to these emissions, but the actual impact and emissions intensity of freight and food packaging are typically overshadowed by the GHGs generated via the production of carbon-intensive foods, such as meat, dairy, and others.

Opportunities to Reduce Emissions

There are three main pathways available to reduce Oregon's consumption-based emissions from food: decarbonization of foods sold into Oregon, food waste prevention, and reduced consumption of meat and dairy products.

Decarbonizing Foods Sold into Oregon

As awareness of climate change and environmental sustainability grows, there is an increasing demand for **low-carbon foods**, which involve low emissions per dollar value. Changes in agricultural and production processes can decrease the carbon emissions associated with specific products. For example, modifying feed for cattle, rotational grazing, and improved manure management can reduce the emissions of meat and dairy production.

Consumers may be prepared to act on these differences as they are becoming more conscientious about the impacts of their dietary choices. However, transitioning to lower-carbon practices could come at a cost to producers, and it can be difficult to monetize consumer demand to pay those costs. Oregon at present lacks a comprehensive strategy to support markets for low-carbon products. The State could do more to provide all interested parties, particularly those in high-impact sectors, the support needed to adapt to changing market demands and environmental standards.

Reduce Wasting of Food

A large portion of food-related emissions comes from food that is produced but never eaten. An estimated **38% of all food produced in or imported into the U.S. is never eaten**.[34] Both the federal government and the State of Oregon have committed to cutting food waste in half by 2030.

Food waste reduction can be accomplished in many ways. Waste recovery and disposal avoidance strategies, such as composting and anaerobic digestion, are widely understood. However, their GHG reduction potential is relatively small because they only reduce landfill emissions. The emissions associated with *producing* foods are many times higher, so strategies that reduce food loss at the source, such as waste avoidance and packaging improvements, offer far greater potential for emissions reduction and economic benefit. Source reduction of food waste has 6 to 7 times the GHG reduction potential of keeping food waste out of landfills, according to EPA's Waste Reduction Model (WARM). There are also co-benefits in related reductions in chemical pesticides, fertilizers, water and land use.

Food waste can be subdivided into the location at which the waste occurs: household, manufacturing, food service, and retail. **About 60% of food waste occurs at the household level**, which is why Oregon has committed resources to better understand household behaviors.[35] Nonetheless **manufacturers, food retailers and food service providers play key roles in the generation of food waste** – not only in their own operations, but in their influence on households. Food marketing practices, like packaging that prevents consumers from purchasing amounts of food appropriate for their households, or buy one-get one free sales, can contribute to food waste associated with over-purchasing. Changing such practices could be a resource-effective approach to achieve CBE reductions at multiple levels of scale.

Climate-Friendly Diets: Reducing Meat and Dairy Consumption

In SEI's wedge analysis, the largest potential for reducing the CBEs of food comes from shifting meat and dairy consumption to less emissions-intensive foods, such as fruits, vegetables, legumes, and more. The production of meat and dairy involves substantial agricultural inputs, including feed crops, which contribute to emissions through deforestation, fertilizer use, as well as methane emissions from livestock. In 2021, meat and dairy consumption accounted for **5.6% of Oregon's total consumption-based emissions** and approximately **39% of emissions within the category of food** alone.

For the purpose of mitigating consumption-based emissions, reducing the consumption of meat and dairy products is a pivotal challenge. However, the challenge may be eased by existing consumer trends. Research indicates that beef consumption is declining in younger age groups[36], and fluid milk consumption[37] has been declining over a scale of decades.

Oregon could ensure that the transition to a low-carbon food system is fair and inclusive by incorporating a framework that encourages **Just Transition**[38] – providing adequate resources and support to those most affected by the changes. This could include financial assistance for farmers adopting new practices, retraining programs for workers in traditional meat and dairy industries, and investments in community-based food systems. Such changes could help mitigate the economic disruptions already resulting from the trends away from beef and dairy consumption.

Program and Policy Options

Information Disclosure. By adopting or approving specific standards for assessment and disclosure of environmental impacts, Oregon could ensure that consumers are better equipped to make decisions about the food they consume. This approach can help shift both consumer and producer behavior towards more sustainable options, as evidence suggests that producers that evaluate and disclose impacts are also more likely to reduce them. Additionally, this approach could deepen the understanding of low-carbon food items for an increasing population of consumers. A growing pool of evidence suggests that including carbon footprint information on restaurant menus, for example, can meaningfully shift consumer behaviors.[39] A simple way to help reduce household and retail level food waste would be requiring standardized food date labeling on food products.

Financial Incentives. Oregon could offer financial assistance to food producers for decarbonization efforts. This support could be direct, through grants or tax credits for Oregon farmers to improve emissions-intensive practices, or indirect, such as vouchers for lower-income households to access carbon-friendly diet choices. As some evidence suggests that lack of adequate refrigeration contributes to food waste in lower-income households, another approach could be to subsidize the purchase of effective and efficient refrigeration.

Public Procurement Standards and Requirements. Government procurement standards can influence food purchasing for institutions such as public school, hospitals, and provision of meals at government-led events such as meetings, workshops and public occasions. Oregon could experience similar success to New York City's public hospitals, which cut GHG emissions of government-purchased foods by 36% by making plant-rich entrees the default choice for patients.[40] Some traditionally carbon-intensive foods can be produced in lower-emitting ways, such as low carbon milk. If these carry a higher price tag, Oregon could provide funds to school districts and other public institutions to enable them to buy the lower-carbon options.

Product Standards and Regulations. Establishing product standards for foods sold into Oregon could play a major role in reducing food-related CBEs. Some pathways to facilitate this

change could include requiring meat and dairy products sold in Oregon to meet GHG-intensity benchmarks, or requiring comparable, plant-based products to be offered alongside high-emission foods. Also, setting standards for food marketing—package sizes more appropriate to smaller households and changing "buy one, get one free" approaches, for example—could reduce household food waste.

Overview of Economic, Social, and Environmental Considerations

Economic: Food production is a major contributor to Oregon's economy, and food purchases are a major item in household budgets. Reducing the wasting of food offers significant savings potential for households and businesses.[41] In addition, helping Oregon producers transition to lower-carbon methods of production can help industries gain competitive advantage in a carbon-constrained future. Shifts in diet will cause some economic dislocation (losses in some sectors and gains in others), and special attention would be needed to ensure a just transition.

Social: Food is a fundamental need for every person, making it a highly sensitive and crucial category in the discussion of CBEs. Any strategy to reduce food-related CBEs should first center and account for the 186,000 households—or 463,000 individuals—who experience food insecurity in Oregon. This presents a unique challenge: while it is important to reduce overall emissions across the life cycle of food, it is equally necessary to ensure vulnerable populations in Oregon have increased access to adequate nutrition. There are demonstrated health co-benefits of reducing dairy and meat consumption,[42] as long as protein and nutritional needs are met. Some research suggests that people are more likely to pick plant-based meal options when those meals are presented prominently as appetizing, nutritionally comparable, and satisfying.

Environmental: Because food production impacts the environment in so many ways, transforming food systems to reduce CBEs presents both daunting environmental challenges and promising opportunities. The potential environmental benefits of reform are substantial, including reduced deforestation, conservation of water resources, and enhanced carbon sequestration in natural lands. Yet, such comprehensive reforms must be carefully planned to avoid unintended consequences such as changes in land use patterns or disruptions to local ecosystems. Thus, achieving meaningful reductions in emissions while ensuring environmental integrity is needed for the long-term sustainability of Oregon's food systems.

Additional information about opportunities to reduce consumption-based greenhouse gas emissions associated with food systems is included in SEI's technical report.

Other Products and Goods

Oregon's CBEI for 2021 illustrates that 48% of Oregon's consumption-based emissions stem from the purchase of products and goods. The *production* of appliances, electronic devices, clothing, and furnishings and supplies consumed by Oregon contributed 7.4 million metric tons of CO2e in 2021, or 7.8% of Oregon's total consumption-based emissions.[43] Almost all of these emissions occur in other states or nations.[44]

There are numerous opportunities to reduce these emissions. For businesses, decarbonizing supply chains offers potential emissions savings. For consumers, and products that are intended to be used multiple times, such as cell phones, appliances, and clothing, reducing consumption by extending product lifespans can reduce both climate and other pollution. Lifespans may be extended via more durable material choices and facilitating maintenance and repair.

However, it can be difficult for consumers to choose these options on their own. Systemic barriers to personal action include:

- The expense and difficulty of repair, which is often the result of design decisions, such as embedded batteries that are difficult to replace.
- Lack of free time. For example, re-hemming pants or replacing buttons can extend the lifetime of clothes, but many households lack the time, knowledge or means to engage in sewing.
- Planned obsolescence and lack of long-term warranties, which encourage the rapid replacement of products.
- The fact that product prices fail to include "externalities," such as the cost of pollution. This creates a false price signal that can make new goods appear "cheap" and undermine the motivation for consumers to repair, maintain or upgrade products.

These kinds of structural barriers impose significant limits on how much individual consumers can reasonably be expected to do to reduce consumption-based emissions. Achieving deeper reductions in emissions will require systemic changes including greater producer responsibility.

The Role of Packaging

Like other products, packaging can be linked to GHG emissions – and other types of environmental impacts. But this report does not identify opportunities to reduce GHG emissions through packaging policy, and the reasons for this include:

Packaging performs a role in protecting products from damage and spoiling, and the GHG impacts of the products *inside* the packaging are often many times higher than the impact of the packaging itself. A narrow focus on packaging alone risks creating "solutions" that reduce packaging waste but increase product loss, thereby increasing total GHG emissions.[45]

When policy aims to influence packaging design, it often focuses on advancing packaging ***attributes*** such as recyclability or bio-based content – but these attributes don't consistently lead to reductions in GHG emissions, as research by Oregon DEQ has demonstrated.[46] Climate impacts are dependent on *which* materials are used, and *how* they are produced. There can also be trade-offs between climate impacts and other forms of pollution. Reducing the impact of packaging is not easily achieved through most existing frameworks.[47]

Lastly, the waste-related impacts of packaging are already being addressed through SB 582 (2021), Oregon's Plastic Pollution and Recycling Modernization Act. While focused primarily on improving recycling of packaging, the law also includes several "upstream" elements that, over time, could help reduce the life cycle greenhouse gas impacts of packaging in a more effective way than by using attributes like "recyclability" or "bio-based."

A **product stewardship** approach could offer a significant opportunity to reduce systemic barriers and reduce emissions. Product stewardship could take several forms, such as requirements to assess, disclose, and/or reduce environmental impacts; mandatory standards for performance or durability; extended warranties; coordinated investment in industry decarbonization; and infrastructure to support repair and upgrades (or some combination of all of the above).[48] Regardless, such an approach – which would regulate impacts on the basis of products *sold into Oregon* as opposed to regulating emissions that physically originate in Oregon – offers two significant benefits.

First, an expanded product stewardship strategy could enable Oregon to achieve much greater reductions in these emissions than a conventional approach would, by itself. Many of these emissions occur outside of Oregon's borders and are not subject to traditional regulatory approaches that focus on controlling in-state sources of pollution.

A second major benefit of product stewardship is its potential to maintain a more level playing field between in-state and out-of-state producers. Under product stewardship, in-state producers are only subject to financial obligations based on what they *sell* into Oregon; their

out-of-state competitors are held to a similar standard. This is in contrast to conventional regulatory approaches, such as permitting industrial sources of pollution, where achieving deep reductions in emissions might require Oregon to hold in-state producers to a different standard than their out-of-state competition.

Opportunities to Reduce Emissions

Methods to reduce emissions associated with the consumption of appliances, electronics, and clothing include actions by individuals, such as maintaining and repairing items, extending product lifespans through upgrades, leasing, renting or sharing goods (such as tools or lawn mowers) with others, buying used and refurbished goods, and reducing extra purchases. For clothing, emissions could be further reduced via laundry practices that both use less energy and increase longevity of clothes, such as washing full loads only, washing in cold water, turning clothes inside out, washing clothes less often and air-drying clothes.

However, greater potential rests with producers, both to create and enhance opportunities for consumer behaviors such as repair, upgrades and renting, and also to improve durability and reduce pre-purchase impacts so that all consumer choices can be lower-impact options.

Program and Policy Options

Outreach and Education. The State could provide more information to consumers about environmental impacts and opportunities to reduce them, or it could require producers to perform that function.

Information Disclosure. Oregon could require greater disclosure of information to consumers, in accordance with standards that the State could adopt or approve. For example, major appliances and electronics could include a "repairability index" indicating how repairable items are based on availability of spare parts, technical documents, and ease of disassembly. Textiles could be marketed with eco-labels that disclose supply chain information. There is some evidence that such information could shift both consumer choices and producer actions, with producers more likely to take proactive steps to reduce impacts prior to disclosure.

Financial Incentives. The State could offer financial assistance to support businesses providing services that extend the lifespan of products, such as appliance and electronic repair. Financial assistance could be direct, such as grants or tax credits to businesses, or indirect, such as, vouchers to help lower-income households access appliance repair, or financial incentives to build careers in repair.

Product Regulation and Standards. Product regulation and standards may offer the greatest potential to reduce consumption-based emissions. Consistent with the "product stewardship" approach discussed previously, Oregon could:

- Establish binding requirements for products, such as standards related to lifespan or repairability.
- Require high-cost durable goods to be sold with extended warranties, as is now required in the European Union.
- Require evaluation and disclosure of life cycle impacts (including climate change) in accordance with standards established or approved by the State.
- Require producers to join a producer responsibility organization that could deliver services, such as a centralized repair hotline and reduced-cost repair services, with priority for lower-income residents.
- Evaluate the recently adopted Right to Repair law, SB 542 (2023) and consider future improvements or modifications as warranted.

Specific to clothing, Oregon could borrow additional ideas from recent legislative initiatives in other states. New York's proposed Fashion Sustainability and Social Accountability Act would require large apparel and footwear companies to track and reduce environmental impacts across their supply chains.

Public Investments. The State could invest in lending libraries for tools, lawn, and office equipment, as well as similar products that individual households use only infrequently. More broadly, investments in cultural, recreational and educational facilities and programs may reduce use of electronic goods by providing residents with other forms of activities.

Public Procurement Standards and Requirements. The State could lead by example in State procurement practices by supporting reuse, repair and durability considerations, as well as requiring or incenting disclosure and reduction of life cycle impacts.

Overview of Economic, Social and Environmental Considerations

Economic: Broadly speaking, a shift away from more frequent sales and purchases of appliances, electronics, clothing and other items, accompanied by increases in repair and reuse activity, may decrease employment and business activity in the manufacturing and retail sectors, and increase employment and business activity in skilled trades such as repair and refurbishment. To the extent that most goods sold in Oregon are not manufactured here, but service is inherently a local profession, the result could be a net increase in Oregon employment and business activity.

Social: Improving the durability and repairability of goods may result in financial savings to the buyers of those goods. Because of their lower retail price, used goods are already more likely to

be purchased by lower-income households. Used goods may not last as long and ensuring that they work and delivery costs are affordable, particularly for large appliances, is important. If producers were required to internalize environmental and social costs, the result could be higher product prices – and while that would incentivize reuse and other lifespan extension activities, impacts could be regressive. Some product stewardship options could be designed to address equity concerns, such as requiring enhanced services or subsidized access (affordability) for lower-income households. For example, repair services can be costly and inconvenient, but financial incentives such as vouchers, which could be provided by the State or a producer responsibility organization, could make them more cost-effective for lower-income households. Finally, to the extent that the manufacturing and supply chains of these items are resource-intensive and often create pollution burdens, especially in the global South, reducing consumption could lead to reduced emissions and improved health outcomes.

Environmental: Climate change is not the only environmental impact of producing appliances, electronics, and clothing. The supply chains for those products also deplete natural resources and generate chemical pollution. In many cases, these environmental impacts affect places, people and habitats far removed from Oregon. Reducing consumption through extending product lifespans has potential to reduce multiple types of resource pollution and environmental injustice impacts.

Can Recycling Reduce Climate Pollution?

Oregon's CBEI results already incorporate the climate benefits of *existing* recycling operations. The emissions reductions from recycling are part of "pre-purchase" impact totals.

This report does not focus on the potential benefits of *additional* recycling for several reasons. First and most importantly, Oregon's recycling policy was recently updated, via passage of the Recycling Modernization Act in 2021. The law is set up to protect against backsliding and to create modest additional climate benefits.[49]

In addition, this report aims to present *new* solutions to the challenge of climate change. The topic of recycling has been extensively studied and debated, and much like energy conservation and renewable electricity targets, can be considered a fairly mature and well-developed field. Consistent with Oregon's *2050 Vision for Materials Management*, DEQ recognizes that recycling, while often beneficial, is also insufficient to reach the State's climate and environmental goals. SEI's wedge analysis reveals significant additional emissions reduction potential through solutions other than recycling.

Smart Growth

"Smart growth" is an umbrella term for the creation of walkable, connected communities, where most daily activities – going to school, shopping, working, and to parks – are accessible without driving.

A series of surveys from the National Association of Realtors,[50] most recently updated in April 2023, contains a remarkable set of findings. When considering a new place to live:

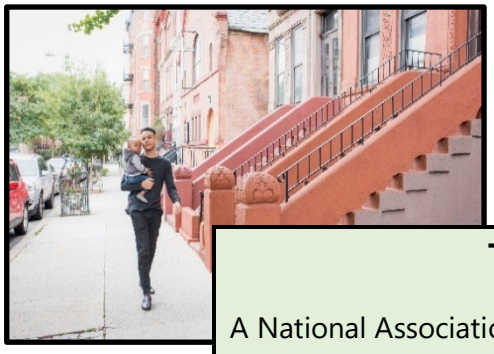
- Respondents list walkability to shops and restaurants as the *most highly desired quality* of neighborhoods, after the universally prioritized quality of low crime.
- Strong majorities (at least in 6 in 10) of respondents say they would be *willing to pay more* to live within walking distance of parks, shops, and restaurants.
- A growing majority prefers housing with small yards and walkability to housing with large yards and more driving.

These preferences are more pronounced among younger age classes, especially Gen Z and Millennials, who may be motivated by the many quality of life benefits associated with smart growth. The infrastructure improvements discussed within this chapter – and related quality of life benefits – should extend to both highly urbanized areas and rural communities. For example, the need for accessible mobility infrastructure is not limited to urban centers; it extends to rural communities, where reliable transportation is essential for job stability, particularly for low-income families.[51]

Meanwhile, there is a strong relationship between land use and development patterns and consumption-based emissions.

In a landmark study published in 2014,[52] University of California researchers investigated the reasons American zip codes varied in consumption-based emissions. Household income strongly influenced household emissions (see Figure 6 in this report). But land-use-related factors such as the number of vehicles per household and population density were often strong enough to overwhelm the effect of income. High-income areas such as lower Manhattan could have lower per-household impacts than moderate-income suburbs in nearby New Jersey.

Together these findings suggest consumption-based emissions could be reduced substantially by creating more walkable neighborhoods.



The Many Benefits of Walkable Communities

A National Association of Realtors survey[53] finds that:

"Living in a walkable community is correlated with higher quality of life, with half of those who live in a highly walkable community saying they are very satisfied with their quality of life."

That quality of life has dozens of identifiable aspects, according to *Cities Alive: Towards a Walking World* by the consulting group Arup.[54] Compared to other types of development, walkable communities can be associated with improved mental and physical health, reduced infrastructure spending per capita, strengthened community identity, increased tourism, reduced health care needs, reduced air and noise pollution, and more.

Personal health directly affects quality of life and represents considerable government expenditure. There is strong evidence that walkable, lower-traffic living environments improve health outcomes by reducing traffic fatalities and increasing exercise. For example: A study of hundreds of American counties found a dramatic relationship between neighborhood compactness and traffic deaths, with the most compact communities having a death rate of one-third or one-quarter of the most sprawling ones.[55]

A systematic review of dozens of papers found that "urban attributes such as street connectivity, residential density, recreational facilities and availability of traffic devices improves neighborhood walkability… which, consequently, lowers the incidence of [cardiovascular disease]."[56]

Opportunities to Reduce Emissions

Walkable communities are inherently more compact than suburban-tract type development, but the research suggests that residential density on its own is only a weak influence on consumption-based emissions. Emissions savings, and co-benefits listed in the text box above, arise when everyday resources – such as schools, shops, and parks – are close and easy enough to reach that many or most can be accessed without driving.

The wedge in SEI's technical report illustrates some impacts smart-growth policies are associated with:

- Decreased mileage traveled in private vehicles, which decreases emissions from direct burning of fuel.

- A reduced need for private cars, which means household can own fewer vehicles, reducing the emissions associated with producing vehicles. Currently Oregon averages 2.1 vehicles per household, according to Census sources, but under smart growth it is possible for that number to decline.
- A possible decline in impacts related to the purchase of goods, because smaller dwellings are able to hold fewer material items.

The combined effects of these factors can be remarkable. In a California study of household consumption-based emissions, researchers found that it was due largely to these geographic factors that household emissions of different census block groups could vary by as much as 100% (or 33 to 66 tons per household per year), when holding typical income steady at $100,000).[57]

Program and Policy Options

Since walkable communities can take on many different forms, a diverse set of program and policy options can contribute to their creation. In general, these programs and policies work to: a) *concentrate* new development, whether greenfield or infill, in areas which already have developed resources such as schools, shopping, and transit; and b) *encourage connection* between both new and existing resources via planning principles, infrastructure, and transportation.

Existing Policies. Oregon has at least two significant existing statewide policies promoting these principles. First is Oregon's decades-old policy of "urban growth boundaries" which requires that expansion of cities occur within designated boundaries, thereby protecting forests, farms, and rangeland.

Second is the newer "Climate-Friendly and Equitable Communities" (CFEC) program coordinated by Oregon's Department of Land Conservation and Development. Rules designed to implement the CFEC apply to eight metropolitan areas of the state, where they require:

- Updated land use and transportation planning, following certain guidelines.
- Lightened or eliminated parking requirements.
- Local governments to allow certain types of buildings and developments.
- Explicit planning for walkability and connection.

Though CFEC rules provide strong direction, its impacts on the state's consumption-based emissions totals are likely to be modest in the next few decades, according to SEI's wedge analysis. This finding is due to several factors. CFEC is limited to eight metropolitan areas, mostly affects new development, and communities change slowly.

Possible Future Policies and Programs. Zoning and land use policies like CFEC's could be strengthened, according to SEI's technical report, by several additional kinds of actions.

Financial Incentives could be used to increase development compatible with smart growth and walkability. Such incentives could take varied forms, for example, density bonuses, split-rate property taxes, congestion pricing on transportation, and lower development fees. For example, Portland's move to eliminate systems development charges for new accessory dwelling units spurred a spike in development

Public Investments in infrastructure and services could create the connections necessary for a walkable community. Such investments include choice of location for government offices, schools, and public housing; increased transit service; and improved infrastructure for non-motorized transportation, such as bike lanes and pedestrian crossings.

Outlook for Consumption-Based Emissions, 2021-2050

Figure 8 provides SEI's forecast of Oregon's consumption-based greenhouse gas emissions, and a projection of how those emissions might change as various policies and programs are implemented.

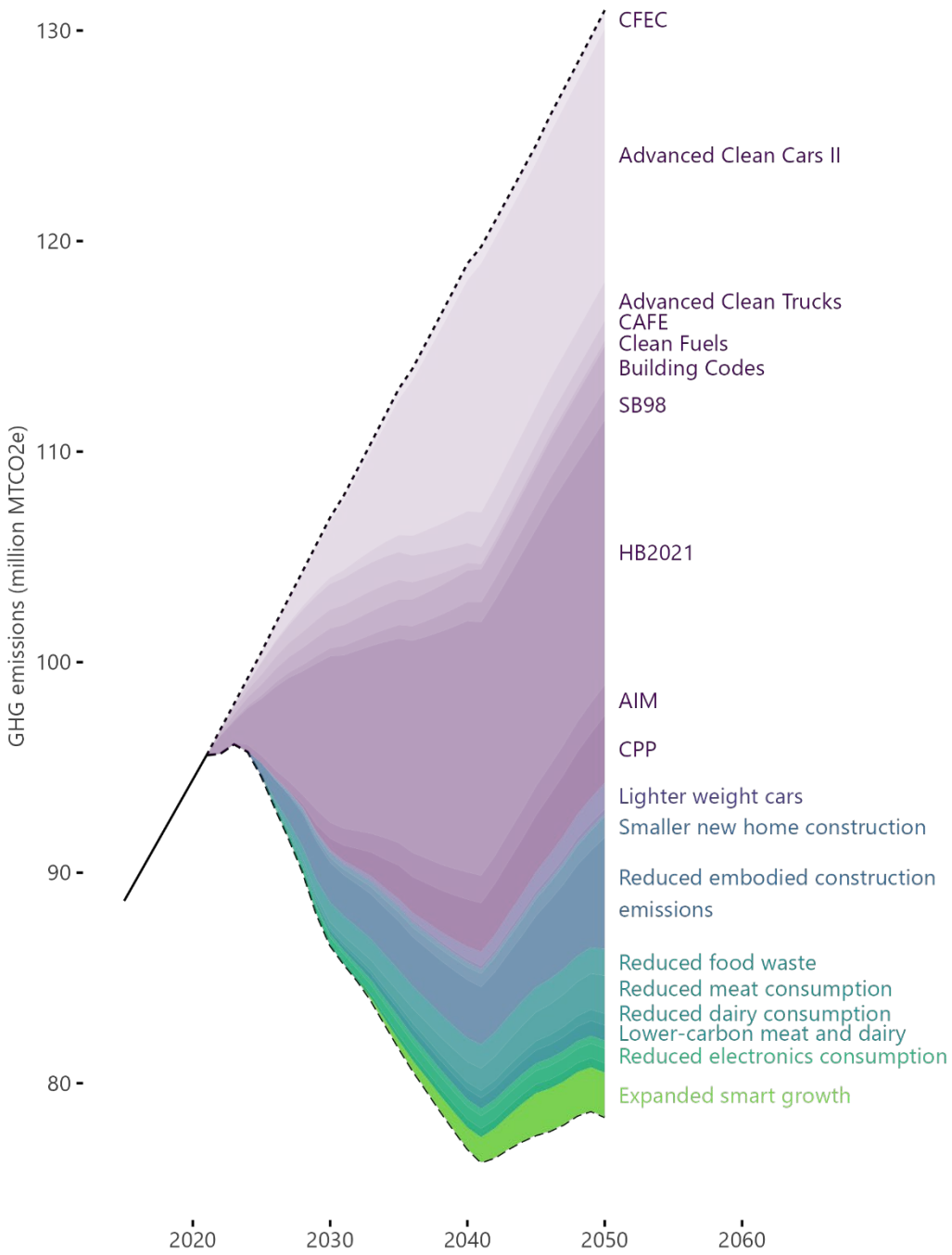


Figure 8. *SEI's forecast and wedge analysis for Oregon's consumption-based GHG emissions.*

The solid black line at the left of **Figure 8** illustrates Oregon's consumption-based GHG emissions from 2005 to 2021. The dotted black line which extends up and to the right projects those emissions out to 2050 under a "no action" scenario where emissions intensities and relative expenditures across consumption categories remain fixed, even as population and real (inflation-adjusted) incomes continue to grow.

A detailed discussion of these projections can be found in SEI's technical report.

Oregon and the US have already adopted a number of policies that, if fully implemented, should reduce Oregon's consumption-based emissions.[58] The GHG reductions resulting from full implementation of those existing state and federal policies are visually represented by the wedges labeled "CFEC" through "AIM" at the top of **Figure 8**. Also included is the draft proposed replacement for the State's Climate Protection Program which, for the purposes of this report, is assumed to achieve greenhouse gas reductions at a scale similar to that of the original CPP.[59] Full implementation of these existing (and, in the case of the Climate Protection Program, under development) policies are estimated to reduce annual consumption-based emissions in 2050 by 36.7 million MT CO2e – a 28% reduction from "no action." The full GHG reduction potential of these measures is larger than shown in **Figure 8** for several reasons,[60] including that **Figure 8** is limited in scope to consider only emissions in Oregon's consumption-based inventory.[61]

The additional wedges in **Figure 8** (below the large top wedges of existing policies and the proposed Climate Protection Program) represent emissions reduction potential that might be realized through ambitious implementation of the types of additional policies described in this report. Wedges addressing similar types of emissions are shown in different shades of the same color.

Figure 9 demonstrates the potential emissions reductions of different wedges.

Abatement Wedge	2050 Abatement Potential (million MTCO2e) [62]	% of "No Action" forecast (2050)
Lighter weight cars	1.2	0.9%
Reduced air travel	0.3	0.2%
Transportation subtotal	*1.5*	*1.1%*
Enhanced building utilization*	0.1	0.1%
Smaller new home construction	1.0	0.7%

Reduced embodied construction emissions	5.3	4.1%
Built environment (embodied carbon) subtotal	*6.4*	*4.9%*
Reduced food waste (household and retail)	1.3	1.0%
Reduced meat consumption	1.8	1.4%
Reduced dairy consumption	0.6	0.4%
Lower-carbon meat and dairy	0.7	0.6%
Food subtotal	*4.3*	*3.3%*
Reduced clothing consumption	0.4	0.3%
Reduced electronics consumption	0.7	0.5%
Reduced appliances and furnishings consumption	0.5	0.3%
Other products and goods subtotal	*1.5*	*1.2%*
Expanded smart growth policies	2.1	1.6%
Additional cross-cutting measures subtotal	*2.1*	*1.6%*
Total, additional measures	**15.9**	**12.1%**

Figure 9, *Estimated GHG reduction potential for abatement wedges, 2050*
Rows may not total exactly due to rounding.

*The GHG reduction potential of this wedge peaks around 2035-2038 and is higher than shown for 2050, because the capacity for enhanced utilization declines over time as available vacant space gets "used up" for other purposes.

In total, new policies and programs as profiled in this report, if robustly implemented, have potential to reduce Oregon's annual consumption-based GHG emissions in 2050 by at least **15.9 million metric tons of CO2e – a 12.1% reduction below the "no action" projection**, when implemented together with existing and planned policies.[63]

Closing the Emissions Gap

SEI's wedge analysis estimates that, by taking a set of actions beyond its current GHG policy, Oregon could reduce its consumption-based emissions by 15.9 million metric tons of CO2e annually by 2050 (see **Figure 8**). Besides providing significant benefits to the climate, these measures could create co-benefits to human health, well-being and community, including prospects for job creation and economic development.

However, a change of this magnitude may not reduce Oregon's global carbon footprint to a sustainable or equitable level.

The Emissions Gap

Various researchers have attempted to define meaningful targets for consumption-based GHG emissions. SEI describes these attempts and the scientific and value considerations that contributed to them in their technical report, in a chapter titled "Setting consumption-based emission reduction goals."

The literature reviewed by SEI suggests several possible target zones for consumption-based emissions worth considering.

- One target zone is aligned with a current legislative goal. Oregon law calls for a 75% reduction in the state's GHG emissions, compared to 1990 values, by 2050. While often this goal has been discussed in the context of sector-based emissions, the law does not specify that accounting framework. If 1990's consumption-based emissions are used as the basis for the calculation, 2050 target values under this standard would be **2.9 metric tons CO2e/capita**, after adjusting for the state's likely population growth.
- A more ambitious target zone is aligned with global carbon budgets. Given a goal of climate stabilization at 1.5 degrees Celsius higher than the historic average – a level thought to be consistent with preventing extreme ecological changes – literature cited by SEI provides a world total maximum emissions of 13 gigatons CO2e. After adjusting for projected changes in world population, this total is equivalent to **1.35 metric tons CO2e/capita** in 2050.

Figure 10 compares Oregon's outlook for consumption-based emissions to these target zones. It uses the same source data as **Figure 8** but transforms the results to per-capita values.

It shows that implementing existing state and federal policies will reduce Oregon's consumption-based emissions per capita meaningfully, and additional consumption-based measures described in this report would further reduce them. Whereas the "no action" scenario

leads to emissions of 24.4 metric tons per capita, the collected actions result in emissions 9.8 metric tons per capita lower.

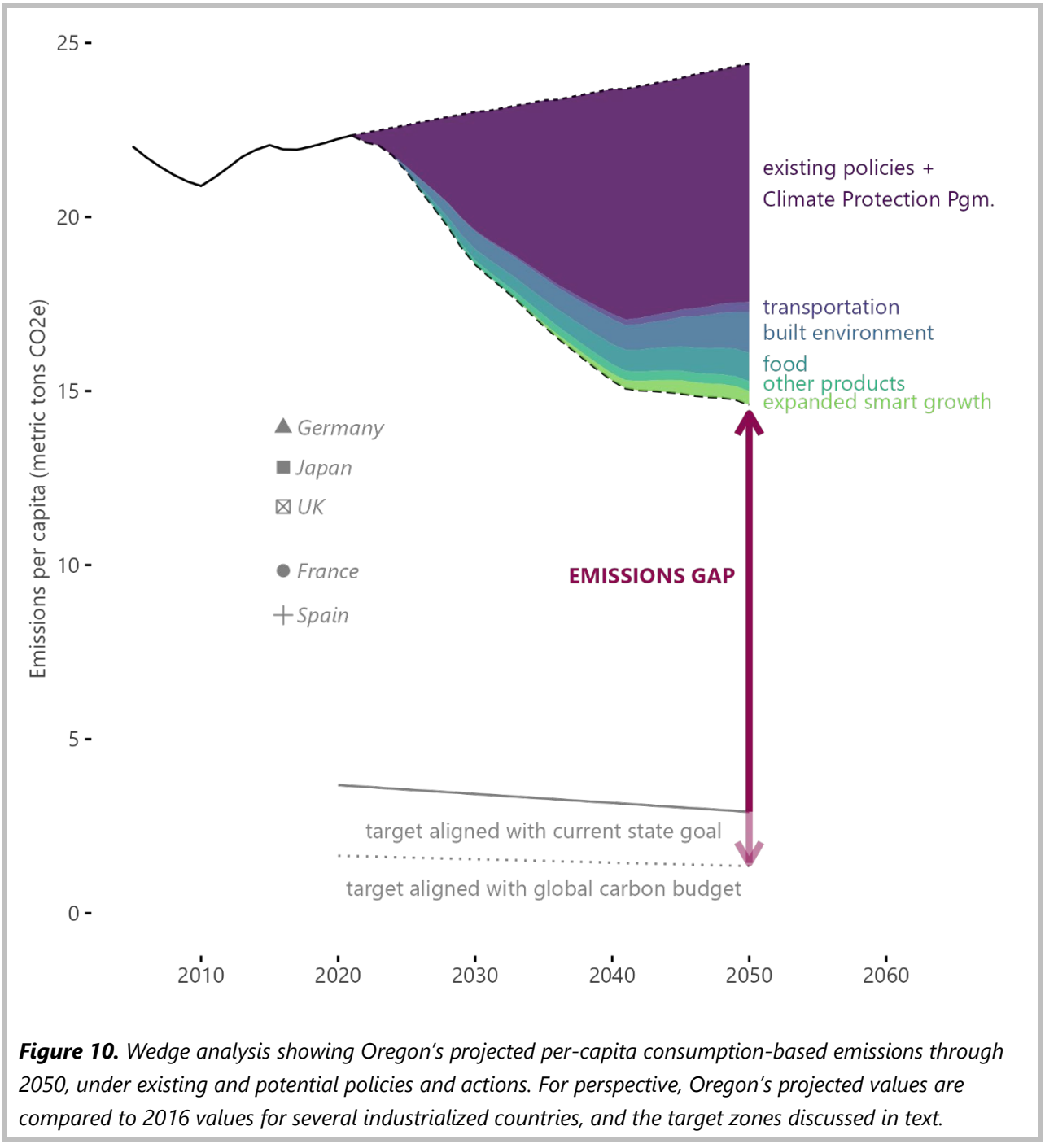


Figure 10. *Wedge analysis showing Oregon's projected per-capita consumption-based emissions through 2050, under existing and potential policies and actions. For perspective, Oregon's projected values are compared to 2016 values for several industrialized countries, and the target zones discussed in text.*

The final value, after a number of ambitious changes, is 14.6 metric tons per capita. This is far above either target zone. The distance between the target zones and Oregon's estimates for 2050 can be called "the emissions gap."

Closing the Gap

Figure 10 provides perspective by plotting per-capita emissions in 2016 for a number of industrialized countries, based on the research of Wang and colleagues.[64] These authors found that, across 15 industrialized countries other than the US, consumption-based emissions ranged from 8.5 to 16.7 metric tons CO2e/person, including 8.6 for Spain, 9.8 for France, and 12.8 for Japan.

These are all countries with high incomes and high standards of living, and the 2016 results represent conventional levels of technology. They suggest that substantially lower consumption-based emissions are possible without extraordinary changes in lifestyle or untested technology.

Nonetheless, even the lowest international values in Wang's results do not reach the target zones. Both Oregon and the rest of the world have further emissions reductions to make.

Oregon Can Lead by Example

One important characteristic of SEI's wedge analysis is the assumptions it makes about decarbonization efforts outside of Oregon. The wedge analysis anticipates changes in emissions intensities related to products and services due to existing state of Oregon policies. However, it does not assume there are *general* reductions in emissions intensities for supply chains outside of Oregon. It does not assume that other state and national governments will make changes beyond current U.S. policies.

Decarbonization efforts by other U.S. states, other nations, and individual industries and businesses could reduce Oregon's consumption-based emissions well beyond the projections in **Figures 8** and **9**. While Oregon does not have regulatory control outside its borders, there are ways Oregon could encourage emissions mitigation efforts elsewhere.

At a federal level, Oregon can advocate for additional federal investments and regulation. On a regional level, Oregon can contribute to partnerships such as the Pacific Coast Collaborative, to share best practices and incubate initiatives. International partnerships may be valuable in that they acknowledge Oregon's role in emissions in high-producing regions such as China, and the mutual dependence of nations.

At any level, Oregon can "lead by example," demonstrating for all our state's commitment to a fair and equitable decarbonization effort. For example, Oregon could signal support for regions that implement decarbonization efforts, through implementation of in-state programs that incentivize the purchase of lower-carbon goods and discourage the purchase of carbon-intensive products.

The Central Role of Consumption

Another important characteristic of the wedge analysis in **Figures 8** and **10** is that it assumes personal consumption will continue to grow (see SEI's technical report for details). This drives up emissions across the board over the decades between 2021 and 2050.

Meanwhile, Oregon's recent CBEI results suggest that growth in consumption itself – and not population growth – has been the strongest factor driving the increase in Oregon's consumption-based emissions.[65] Simply put, Oregon households, governments and businesses have been buying more stuff.

To reduce consumption-based emissions to target levels, the pattern of consumption itself needs to be addressed. The chapter in SEI's technical report, "Closing the emissions gap: addressing consumption at a systemic level", is largely concerned with the question of how patterns of consumption might be transformed.

Public Opinion Supports "Consuming Less"

2023 public opinion research by the Oregon Values and Beliefs Center[66] (with a sample size of 3,414) asked respondents their positions on pairs of statements. It found that 61% of Oregon residents agree that "our country would be better off if we all consumed less." Only 39% of residents agreed more with the alternative "we need to buy and consume to support a strong economy." Majority support for "consuming less" was found among residents of all regions of the state, genders, and age groups studied.

Similarly, 76% of residents believe that "climate change requires us to change our way of life, drive less, and live more simply," while only 24% believe that "if climate change becomes a problem, we can deal with it later." Again, majority support for "consuming less" was found among all regions of the state, genders, and age groups studied, and gained support from 93% of self-identified Democrats, 49.5% of self-identified Republicans, and 78% of others.

SEI's examination includes discussion of broad concepts like human well-being and doughnut economics, as well as specific policy and action ideas. The latter include:

- Investing in infrastructure to better enable low-carbon lifestyles.
- Internalizing externalities (social costs) into the pricing of goods and services.
- Providing public services (such as education, healthcare, parks and open spaces) to enhance quality of life in ways that don't require increased private consumption.
- Providing incentives and supports for organizations that prioritize sustainability and community well-being over consumption, as well as businesses that produce low-carbon food, goods, materials and services; and

- Redesigning economic measurement, for example adding the cost of pollution to economic measures or utilizing indicators that improve on GDP.

Consideration of these or other policies should explicitly incorporate the ways the effects of policies are mediated by income, and specifically, how policies distribute burdens and benefits across different socio-economic groups. In support of policies that prioritize human well-being and equity, the State could make policy processes more inclusive and consultative; pursue measures that support disproportionately affected populations, along with long-term transition assistance for those who stand to lose from structural change; and tailor policies based on differences in impact.

Recommendations for Action

Oregon DEQ, after consultation with the State's Climate Action Commission, offers the following three recommendations to address the challenges of consumption-based emissions and to reap the potential community, social, economic and environmental benefits of proactive solutions.

Recommendation One: Create a State Consumption-Based Goal

The Oregon Legislature, in consultation with the Climate Action Commission, should broaden the State's existing GHG emissions reduction goals to include consumption-based emissions.

Goals signal priorities and expectations, and adopting a goal to reduce consumption-based emissions would validate the importance of such efforts. Oregon can achieve more emissions reductions per dollar spent by expanding its policy response to consider consumption-based emissions alongside sector-based emissions.[67]

The State's existing policy framework – with goals to reduce sector-based emissions and no comparable goals to reduce consumption-based emissions – has limited the State's response to global warming. Adopting a parallel consumption-based goal would enable a more robust and cost-effective approach to reducing GHG emissions.

A consumption-based goal would also:

- Acknowledge a comprehensive view of Oregon's "carbon footprint" and our shared responsibility for reducing it.
- More formally allow Oregon to consider the broader impacts of climate actions.
- Emphasize principles of fairness and equity at both local and global scales. Locally, Oregon's consumption-based emissions inventory demonstrates the inequitable way in which higher-income Oregon residents contribute more to climate change than lower-income ones. Globally, the inventory illustrates how Oregon's consumption leads to impacts in communities across the globe.

To the extent that goals enable action, efforts to reduce Oregon's consumption-based emissions will support in-state decarbonization efforts, and in parallel, progress to achieve sector-based goals.

Additional perspective on goals, including examples of consumption-based emissions goals proposed or adopted in other communities, is provided in a chapter of SEI's technical report.

Is it Possible to have Multiple State Goals to Reduce GHG Emissions?

Yes. Both inventories (sector-based and consumption-based) assess different sets of emissions, with only modest overlap. No single metric can adequately represent all of Oregon's responsibility or opportunity. By way of precedent, other significant State efforts, such as those aimed at achieving educational, health care, and economic outcomes, similarly rely on a "dashboard" of metrics, as opposed to a single measure. Such a dashboard concept could be expanded to include other key climate-related metrics, such as emissions from the State's inventory of natural and working lands.

Recommendation Two: Take Targeted Actions to Reduce Consumption-Based Emissions

The Oregon Legislature, Oregon Climate Action Commission, and state agencies should increase actions to reduce consumption-based greenhouse gas emissions.

Particular attention should be given to policies which:

- Address **high-impact categories** of emissions, including food and embodied carbon in the built environment, and activities with high emissions reduction potential.
- **Enable consumer awareness and choices** that reduce greenhouse gas impacts through structural and policy changes that make low-carbon choices easier and more affordable, equitable and accessible. This is important because there are limitations to what individual consumer action can achieve in the face of current infrastructure, policies, and price signals that make low-carbon consumption difficult and/or expensive.[68]
- **Align with other statewide priorities**, such as increasing affordable housing, reducing negative health outcomes, and reducing food insecurity.
- **Consider "product stewardship" approaches**, which engage producers of products and materials *sold* into Oregon. This approach creates potential for reducing emissions, generating co-benefits, and maintaining a level playing field between in-state and other producers.
- **Center human well-being** in design, paying particular attention to equity considerations, including needs and opportunities for low-income, BIPOC, and residents in rural areas.[69]
- **Engage cross-cutting/cross-sector approaches** that can reduce multiple sets of emissions while also generating co-benefits to society. For example, enhanced smart growth policies have potential to reduce emissions not only from transportation, but also embodied carbon in infrastructure and buildings, operational energy use (heating,

cooling, lighting), and general household consumption (fewer lawn mowers, televisions, etc.). More walkable neighborhoods also offer health and community benefits.

- **Minimize rebound effects** by focusing on reducing consumption of commodities with high emissions intensities.[70]

Recommendation Three: Update the Consumption-Based Inventory Regularly

Oregon DEQ should update the State's consumption-based greenhouse gas emissions inventory on a timely and more frequent basis. As data sources and analytical methods improve, DEQ should consider adopting best available methods.

Oregon pioneered consumption-based emissions accounting, producing the first such inventory at the subnational scale in North America, representing state emissions in 2005. It updated the inventory for calendar years 2010, 2015 and 2021. Regular updates to CBEI would be greatly facilitated by securing dedicated staff time and budget.

In addition, new data sets and methodological approaches are emerging that may improve overall outcomes. Additional details regarding both current and potential future methodologies can be viewed in DEQ's inventory report.

Conclusion

Oregon's climate and economy are inexorably tied to the rest of the world. One metric ton of carbon dioxide emitted has the same disruptive impact on Oregon's people, economy and environment regardless of whether it is emitted in Portland, Pennsylvania or Portugal. Negative impacts from climate change are imposing increasingly disruptive economic costs on Oregon.

This report finds that Oregon's modest gains in reducing local emissions are overshadowed by the surge in global emissions driven by our consumption. Meanwhile, Oregon has cost-effective opportunities to reduce emissions through in-state programs and policies, and should pursue these opportunities, even if some of the emissions reductions occur outside of state borders.

To truly combat climate pollution, Oregon should adopt a comprehensive and integrated approach to emissions by incorporating the consumption-based perspective, which provides important, actionable opportunities. Reducing consumption-based emissions could have positive impacts for people and all living things, not just in Oregon, but across the planet.

[1] The emissions associated with supply chains of any complexity can be estimated with the use of the Leontief matrix, which uses linear algebra to aggregate the inputs over a mathematically infinite series of suppliers that are associated with producing any given economic output. Russian-American economist Wassily Leontief was awarded the Nobel Prize in Economics in 1973 for his work to develop this branch of economic analysis.

[2] This deficiency is not particularly relevant when conducting a broad statewide emissions inventory. When it is important to distinguish the carbon footprints of competing items in the same commodity, that analysis can be performed using process life cycle assessment.

[3] This 2021 sector-based estimate is preliminary and expressed in absolute terms (metric tons of CO2E). On a per capita basis, sector-based emissions in 2021 were 32.6% lower than in 1999. This could be viewed as compelling evidence that Oregon's historic focus on reducing emissions, albeit emissions informed by the SBI, has resulted in progress in reducing that subset of emissions.

[4] Vulnerability of low-income residents is noted in the Oregon Health Authority's "Climate and Health in Oregon 2023" report, available on this webpage.

[5] For details on the data, assumptions, and methodology behind this wedge analysis, please refer to SEI's technical report.

[6] This assumption is for illustration purposes only and should not be taken as an indication or prediction by DEQ regarding future actions by the Environmental Quality Commission to re-establish the Climate Protection Program.

[7] One exception to this is the report's inclusion of additional or enhanced "smart growth" policies. Oregon's Climate Friendly and Equitable Communities program is already established, but DEQ has identified significant opportunities to expand and enhance that work. From a consumption-based perspective, enhanced smart growth is particularly important because it holds potential to reduce emissions across many different categories of emissions. See this report's section on "smart growth."

[8] One precedent was recently established by the Oregon legislature. ORS 459A.869 requires certain "producers" that sell into Oregon "covered products" (defined as packaging, printing/writing paper and food serviceware) to join and pay membership fees to a producer responsibility organization (PRO). These "producers" include companies that sell packaged goods. ORS 459A.941 requires the PRO to use a portion of these membership fees to pay into a state fund which can be used to provide grants and loans to both public and private organizations, in order to fund projects that reduce the environmental impacts of covered products. Producers begin paying membership fees in 2025, with state receipts beginning in 2026.

[9] This is a preliminary finding in Oregon's 2021 SBI update.

[10] Comprehensive information about the state's current programs and policies to reduce transportation-sector emissions can be found here.

[11] See the discussion following Table 3-2 in DEQ's inventory report for details regarding this point.

[12] Weber, Christopher L., and H. Scott Matthews. "Food-miles and the relative climate impacts of food choices in the United States." Environmental Science & Technology, vol. 42, no. 10, 2008, pp. 3508-3513.

[13] Please see this report for more information. This is part of a series of meta-analyses of food impacts.

[14] See for example DEQ's life cycle assessment of drinking water delivery systems.

[15] See SEI's technical report for details about lighter-weight vehicles. Also see *Consumer Reports*.

[16] Reducing air and car travel can lead to reduced soil and water pollution. For example, see Fay, L., & Shi, X. (2012). Environmental impacts of chemicals for snow and ice control: State of the knowledge. *Water, Air, & Soil Pollution*, 223, 2751-2770.

And - Kampa, M., & Castanas, E. (2008). Human health effects of air pollution. *Environmental Pollution*, 151(2), 362-367.

[17] In the last fifteen years, Oregon DEQ has taken many steps to reduce embodied carbon in the built environment by supporting the use of lower-carbon materials and construction, such as low-carbon concretes and space-efficient homes. This work has established a strong foundation from which to continue reducing embodied carbon in greater collaboration across the state.

[18] Lewis, et. al., American Institute of Architects & Carbon Leadership Forum. (n.d.). *Embodied carbon toolkit for architects: Part 1*. Retrieved here

[19] Good Company. (n.d.). Oregon Department of Transportation Operational Greenhouse Gas Reductions: Best Practices & Recommendations. Retrieved here

[20] Oregon DEQ has significant experience with Environmental Product Declarations. DEQ has sat on PCR development committees for concrete and asphalt, collaborating with the Oregon Concrete and Aggregate Producers Association (OCAPA) to incentivize development of over 1500 EPDs for Oregon concrete producers, and providing technical assistance during the development of Oregon's Buy Clean legislation (HB 4139, 2021). The federal government has also committed substantial resources to the development of Environmental Product Declarations through the Biden Administration's Inflation Reduction Act (IRA) of 2022. The IRA provides more than $2 billion in funding to the General Services Administration (GSA) to use low embodied carbon materials in the construction and renovation of federal buildings and $2 billion to the Federal Highway Administration (FHWA) to incentivize or reimburse the use of low embodied carbon construction materials in certain transportation projects.

[21] See the DEQ report titled, *A Life Cycle Approach to Prioritizing Methods of Preventing Waste from the Residential Construction Sector in the State of Oregon*

[22] *A Life Cycle Approach to Prioritizing Methods of Preventing Waste from the Residential Construction Sector in the State of Oregon*

[23]See CBRE Research 2024

[24] Drlik-Muehleck, A., Parker, B., Balsom, A., Chroman, T., Hoang, T. A., Totty, J., & Langley, A. (2021). Upper story report: Final. Community Planning Workshop, Institute for Policy Research and Engagement, University of Oregon. Prepared for Oregon Parks & Recreation Department, Oregon Heritage – State Historic Preservation Office & Oregon Main Street.

[25] According to one recent estimate, Oregon had at least 1.5 million bedrooms that nobody is sleeping in. See this article for more information.

[26] Oregon already has several precedents for such an approach. Buy Clean Oregon (HB 4139, 2022) requires ODOT to establish a greenhouse gas reduction program that assesses the GHG emissions of concrete, asphalt, and steel used in the Agency's construction and maintenance activities. The program must also require contractors to submit Environmental Product Declarations for covered materials.

Separately, ORS 459A.944 (adopted in 2021) requires certain large producers who sell packaged goods into Oregon to evaluate and publicly disclose life cycle impacts for packaging.

[27] Supply chain initiatives that improve transparency can also be extended to expose and reduce occurrences of forced labor and human trafficking that are documented here. For example the supply chain of building materials *used in Oregon* may involve 14,000 people held in forced labor servitude and 80,000 children subject to child labor; see this DEQ housing brief.

[28] See Figure 13 of this DEQ study conducted by Quantis, Earth Advantage and the Oregon Home Builders Association

[29] Esau, et. al., Rocky Mountain Institute. Reducing Embodied Carbon in Buildings: Low-Cost, High-Value Opportunities. July 2021.

[30] See, *Low Carbon Construction in Residential Building*

[31] See, *Embodied CO2 Emissions in Steel Imports to the U.S. A White Paper on Steel Trade Carbon Competitiveness, and Decarbonization.*

[32] See *Modern Slavery's imprint in the built environment* and *Forced labor, urban migration, and the built environment*

[33] Carbon Avoided Retrofit Estimator, CARE

[34] Find more information at REFED

[35] Oregon Department of Environmental Quality. (2019). *Oregon Wasted Food Measurement Study Summary Report.*

[36] This study found significant declines in beef consumption in children, adolescents, and adults, while consumption remained consistent in older adults: Lau, C. S., Fulgoni, V. L., 3rd, Van Elswyk, M. E., & McNeill, S. H. (2023). Trends in Beef Intake in the United States: Analysis of the National Health and Nutrition Examination Survey, 2001-2018. Nutrients, 15(11), 2475. DOI here

[37] U.S. per capita fluid milk consumption has been trending downward for more than 70 years and fell at a faster rate during the 2010s than in each of the previous six decades. See Hayden Stewart and Fred Kuchler. USDA ERS - Fluid Milk Consumption Continues Downward Trend, Proving Difficult to Reverse. (2022).

[38] Stark, A., Gale, F., & Murphy-Gregory, H. (2023). Just Transitions' Meanings: A Systematic Review. Society & Natural Resources, 36(10), 1277–1297. DOI here.

[39] For example Wolfson, J. A., Musicus, A. A., Leung, C. W., Gearhardt, A. N., & Falbe, J. (2022). Effect of Climate Change Impact Menu Labels on Fast Food Ordering Choices Among US Adults: A Randomized Clinical Trial. JAMA Network Open, 5(12), e2248320. DOI here

[40] This is in part from NYC's efforts to cut consumption-based emissions in government spending. Resilient Cities Network, & Rustow, A. (2023, October 16). *New York City's hospitals, schools, and businesses are committed to reducing food-based emissions by 33% by 2030*. Resilient Cities Network.

[41] REFED - Cost-Savings associated with food waste reduction

[42] More information available from Mayo Clinic

[43] This figure does not include emissions associated with the fuels or electricity used to operate appliances and electronic devices. Such emissions are included in both Oregon's consumption- and sector-based

inventories and are already the subject of significant climate-related policy and programs. As such, this report focuses on additional "life cycle" emissions, which are dominated by production and supply chains.

[44] More than 96% of production phase emissions associated with clothing consumed by Oregon households occurred outside of the United States. For appliances and electronics, emissions outside of Oregon's borders contribute 99.7% and 96.0%, respectively, of production phase emissions. Additional details on the geographic distribution of Oregon's consumption-based greenhouse gas emissions can be found in DEQ's inventory report (add link).

[45] See an expanded discussion of this dynamic in this report prepared for DEQ by the University of Michigan, with support of the Oregon Sustainability Board.

[46] See DEQ Popular Packing Attributes

[47] Requiring all packaging to be "recyclable" or "compostable" without goals or sideboards involving climate or other environmental impacts holds the potential to actually increase greenhouse gas emissions. The primary reason for this is because environmental impacts of many materials (including packaging) are often dominated by their production, and the production of different (competing) materials can result in very different impacts.

[48] The recent passage of Right to Repair legislation (SB 1596, 2024), a law intended to facilitate the repairability of consumer electronic equipment, while limited in scope, should also reduce emissions by extending product lifespans and thereby reduce the purchase (and production) of new devices.

[49] By the numbers, recycling of post-consumer waste from Oregon in 2022 reduced global greenhouse gas emissions by approximately 3.1 million metric tons of CO2e; near-term improvements (2025 – 2027) in recycling were projected (2023) to reduce emissions further by less than an additional 20,000 metric tons per year, largely as a consequence of expanding collection opportunities and improving the ratio of commingled recyclables that are properly separated and sent to the appropriate commodity market. New information suggests that the climate benefits of modernization are likely higher than the 2023 estimate. Implementation of the Recycling Modernization Act should also prevent backsliding and loss of existing emissions reduction benefits (3.1 million metric tons of CO2e/year), some of which remain at risk in the absence of policy reform. In addition to the modest gains from near-term improvements, analysis by DEQ found that recycling modernization yielded significant other benefits involving reduction of air and water pollution.

[50] National Association of Realtors. (2023, April). National community and transportation preferences survey.

[51] Fletcher, C. N., Garasky, S. B., Jensen, H. H., & Nielsen, R. B. (2010). Transportation Access: A Key Employment Barrier for Rural Low-Income Families. *Journal of Poverty*, *14*(2), 123–144. https://doi.org/10.1080/10875541003711581

[52] Jones, C., & Kammen, D. M. (2014). Spatial Distribution of U.S. Household Carbon Footprints Reveals Suburbanization Undermines Greenhouse Gas Benefits of Urban Population Density. Environmental Science & Technology, 48(2), 895–902. DOI here

[53] National Association of Realtors. (2023, April). National community and transportation preferences survey.

[54] Arup. (2016). Cities alive: Towards a walking world (2nd ed.).

[55] Ewing, R., Schieber, R. A., & Zegeer, C. V. (2003). Urban Sprawl as a Risk Factor in Motor Vehicle Occupant and Pedestrian Fatalities. American Journal of Public Health, 93(9), 1541–1545. DOI here

[56] Malambo, P., Kengne, A. P., Villiers, A. D., Lambert, E. V., & Puoane, T. (2016). Built Environment, Selected Risk Factors and Major Cardiovascular Disease Outcomes: A Systematic Review. PLOS ONE, 11(11), e0166846. DOI here

[57] Jones, C. M., Wheeler, S. M., & Kammen, D. M. (2018). Carbon Footprint Planning: Quantifying Local and State Mitigation Opportunities for 700 California Cities. Urban Planning, 3(2), 35–51. DOI here

[58] In terms of mitigation potential, chief among these are HB 2021 (2021) (clean energy targets for investor-owned electric utilities), and Advanced Clean Cars II, which requires all new passenger cars, SUVs and light-duty pickup trucks by 2035 to be battery electric or plug-in hybrid electric vehicles. Also included in the existing policies are DLCD's Climate-Friendly and Equitable Communities requirements, Oregon's Advanced Clean Trucks rule, federal Corporate Average Fuel Economy standards, the Oregon Clean Fuels Program, changes to Oregon building codes (specifically, the Oregon Energy Efficiency Specialty Code and Oregon Residential Specialty Code), the renewable natural gas portfolio requirement of Oregon SB 98 (2019), and elements of the federal American Innovation and Manufacturing (AIM) Act that require a reduction in U.S. production and consumption of hydrofluorocarbons.

[59] This assumption is for illustration purposes only and should not be taken as an indication or prediction by DEQ regarding future actions by the Environmental Quality Commission to re-establish the Climate Protection Program.

[60] The emissions reductions shown for some existing policies are adjusted to account for synergistic effects of additional measures and according to a hierarchy of sequencing that is designed to highlight the contribution of measures that reduce and shift consumption, relative to measures that merely reduce the emissions intensity of consumption. As described in further detail in SEI's technical report, the wedge analysis calculates abatement potential first for measures that reduce/avoid consumption, then for measures that shift consumption (e.g., to lower-carbon alternatives within a category), and finally for measures that reduce the energy and/or carbon intensity of consumption. For example, smaller homes will reduce energy use in buildings, resulting in fewer emissions available for reduction from HB 2021 (decarbonized electricity). If the model were designed to discount the impact of additional policies, the potential contribution of existing policies (plus CPP) in 2050 would be 41.0 million MTCO2e (as opposed to the 36.7 million MTCO2e shown). Again, this is because the model assumes that policies such as HB 2021 would still decarbonize electricity consumption, but there would be more consumption in the absence of additional measures such as smaller homes and enhanced building utilization, so total reductions achieved by HB 2021 (and other policies, such as Clean Cars) would be higher.

[61] For example, the modeled replacement for Oregon's Climate Protection Program will reduce emissions at industrial facilities in Oregon; their emissions (and by extension, emissions reductions) are only included in the CBEI and Figure 8 for the fraction of industrial output that is ultimately consumed by Oregon (or become part of the supply chain for commodities consumed by Oregon).

[62] Figures 8, 9, and 10 represent estimates of emissions reduction potential net of estimated rebound effects. Rebound effects occur when consumers save money as a result of an outcome (such as reducing the wasting of food or shifting from meat to plant-based foods), and then use the resulting savings to engage in another consumption activity that has associated emissions. Rebound effects are discussed further in SEI's technical report. While many climate mitigation assessments do not account for rebound effects, DEQ believes that rebound effects can occur and so has chosen to include an estimation of them

in this report. Rebound effects are not identified separately from emissions reductions (except deep inside SEI's models), but rather are subtracted from estimates of gross emissions reduction; reductions associated with additional measures shown in this report are net emissions reductions, after rebound effects are taken into account.

[63] Abatement potential shown in this report does not include reductions in transportation service, wholesale/retail, or disposal emissions associated with reduced consumption of specific goods or services, so the full abatement potential is likely larger than reported here.

[64] Wang, Z., Yan, H., Gao, X., Liang, Q., Mi, Z., & Liu, L. (2024). Have consumption-based CO2 emissions in developed countries peaked? Energy Policy, 184, 113894. https://doi.org/10.1016/j.enpol.2023.113894

[65] See Figure 3-13 and accompanying text in DEQ's inventory report.

[66] Oregon Values and Beliefs Center – Success and Wellbeing.

[67] In its technical report, SEI prepared a limited marginal abatement cost curve that evaluated the costs to achieve six different consumption-based outcomes. Of those, four were found to offer potential cost savings to Oregon consumers – that is, the gross cost to implement is expected to be lower than what households and others would save from reduced purchasing expenses. The other two options were found to have costs that were positive, but still below higher estimates of the social cost of carbon. Put differently, all six options generated emissions reductions that could save society more (in reduced impacts of climate change) than the options would cost to implement.

[68] Given hundreds of consumption actions that an individual might make in a given week, the ideal approach is to make all choices better (lower-carbon) ones, rather than expecting millions of Oregonians to understand carbon footprints and constantly engage in decisions about complex trade-offs.

[69] SEI's evaluation of policy options (located in the companion documents to this report) includes significant additional assessment of equity considerations.

[70] "Emissions intensities" refer to the emissions per dollar spent on various commodities. The "rebound effect" refers to *increases* in emissions that result when consumers save money via an efficiency measure (e.g., installing a high-efficiency furnace) and then use the savings in some other environmentally-damaging way. Emissions intensities can be used to understand and reduce rebound effects; by focusing consumption reductions on commodities with higher-than-average emissions intensities, they improve the likelihood that rebound effects will be relatively smaller. In contrast, focusing consumption reductions on commodities with low emissions intensities can result in rebound effects that are larger than the original emissions reduction, leading to a net increase in emissions. Emissions intensities for various commodities can be calculated using DEQ's CBEI model and are discussed in further detail in DEQ's inventory report.