June 10, 2020

Via Electronic Filing

Public Utility Commission of Oregon
Attn: Filing Center
201 High St. SE, Suite 100
Salem, OR 97301

Re: Docket No. UE 374 – In the Matter Of PacifiCorp, dba Pacific Power, Request for General Rate Revision

Enclosed please for filing the Opening Testimony and Exhibits on the Supplemental Filing of Ezra Hausman (Sierra Club/300-305) on Behalf of Sierra Club in the above-referenced docket.

If you have any questions or require any additional information, please do not hesitate to contact me.

Respectfully submitted,

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Docket No. UE 374
Exhibit Sierra Club/300
Witness: Ezra D. Hausman, Ph.D.

BEFORE THE PUBLIC UTILITY COMMISSION

OF OREGON

UE 374

In the Matter of

PACIFICORP d/b/a PACIFIC POWER,

Request for a General Rate Revision

Opening Testimony of Ezra D. Hausman, Ph.D.

On Behalf of Sierra Club

June 10, 2020

TABLE OF CONTENTS

LIST OF EXHIBITS

Sierra Club/301	Resume of Ezra D. Hausman, Ph.D.
Sierra Club/302	Oregon Governor Kate Brown's Executive Order No. 20-04
Sierra Club/303	Oregon Governor Kate Brown's Executive Order No. 17-20
Sierra Club/304	Selected Public Data Responses
Sierra Club/305	Oregon Global Warming Commission's 2018 Biennial Report to the Legislature for the 2019 Legislative Session

I. PROFESSIONAL QUALIFICATIONS

Q. Please state your name, occupation, and business address.

A. My name is Ezra D. Hausman, Ph.D. I am an independent consultant doing business as Ezra Hausman Consulting, operating from offices at 77 Kaposia Street, Auburndale, Massachusetts 02466.

Q. What is your professional and educational background?

A. I have served as an independent consulting analyst and expert in energy market issues since 2014. Before that, from 2005 until early 2014, I was employed at Synapse Energy Economics, Inc., a research and consulting company located in Cambridge, Massachusetts, where I served as Vice President, and Chief Operating Officer. At Synapse, and continuing as an independent consultant, I served as an analyst and expert in several areas, including: state and regional energy, capacity, and transmission planning, including both utility resource planning and long-term (multi-decadal) climate-constrained resource planning; regulatory and ratemaking proceedings; electricity and generating capacity market design and analysis; electric system dispatch modeling; economic analysis of environmental and other regulations, including greenhouse gas regulation, in electricity markets; economic analysis, price forecasting, and asset valuation; quantification of the economic and environmental benefits of displaced emissions; energy efficiency and renewable energy programs and policies; and regulation and mitigation of greenhouse gas emissions.

I have provided testimony before public utility commissions or legislative committees in Arizona, Florida, Illinois, Indiana, Iowa, Kansas, Louisiana, Maryland, Massachusetts, Minnesota, Mississippi, Missouri, New Hampshire, New Jersey, Nevada, North Carolina, Oregon, South Carolina, South Dakota, Utah, Vermont, Virginia, Washington, DC, and Washington State, as well as at the Federal level. I have provided expert representation for stakeholders at the PJM ISO, the California ISO, the Midcontinent ISO, and at the Federal Energy Regulatory Commission ("FERC"). While most of my testimony and analytical work has centered on issues in electricity market economics, I have also brought my expertise as a scientist to bear on cases involving greenhouse gas regulation and mitigation in the United States.

Before joining Synapse, I was employed from 1998 through 2004 as a Senior Associate at Tabors Caramanis and Associates ("TCA") of Cambridge, Massachusetts. In 2004, TCA was acquired by Charles River Associates ("CRA"), where I remained until I joined Synapse in 2005. At TCA/CRA, I performed a wide range of electricity market and economic analyses and price forecast modeling studies. These included asset valuation studies, market transition cost/benefit studies, market power analyses, and litigation support. I have extensive experience with market simulation, production cost modeling, and resource planning methodologies and software.

I hold a BA in Psychology from Wesleyan University, an MS in Environmental Engineering from Tufts University, an SM in Applied Physics from Harvard University, and a PhD in Atmospheric Chemistry from Harvard University. I have provided a detailed resume as Exhibit Sierra Club/301.

Q. Have you ever provided testimony before the Public Utility Commission of Oregon?

A. Yes. I was among the witnesses to file joint testimony in support of the PacifiCorp 2020 Multi-State Protocol under Docket No. UM 1050.

II. SCOPE OF TESTIMONY AND RECOMMENDATIONS TO THE COMMISSION

Q. What is the scope of your testimony in this proceeding?

A. I am providing testimony on the depreciable lives of PacifiCorp's ("Company") coal-fired assets addressed in the supplemental testimony of PacifiCorp witness Chad A. Teply.[1] I also address the Company's related request for an Exit Order for several of these assets. While I support the Company's request for Exit Orders in general, I show that it is in the interest of Oregon ratepayers to accelerate the Exit Date for all of PacifiCorp's coal plants to December 31, 2025.

Q. What is your recommendation for this Commission?

A. I recommend that the Commission issue Exit Orders for each of the Company's coal-fired generating units with an Exit Date of 2025, regardless of the depreciable lives used by the Company. If the Commission elects not to issue such Exit Orders at this time, I recommend that it direct PacifiCorp to update its Integrated Resource Plan ("IRP") analysis using current load, electricity price, and gas price expectations, along with updated renewable and storage resource costs, to determine whether retaining its coal-fired units beyond December 31, 2025 is in Oregon ratepayers' interest.

[1] PAC/1700 (May, 2020).

III. PACIFICORP MULTI-STATE PROTOCOL

Q. Is the Sierra Club, a signatory of the PacifiCorp 2020 Multi-State Protocol ("MSP"), approved by this Commission in January 2020?[2]

A. Yes.

Q. Were you personally involved in the settlement process that led to that protocol?

A. Yes. I participated in the settlement discussions on behalf of Sierra Club. Further, I joined witnesses representing PacifiCorp, Commission Staff, Oregon Citizens' Utility Board ("CUB"), and Alliance of Western Energy Consumers ("AWEC") in filing joint testimony before this Commission in support of the stipulation.[3]

Q. PacifiCorp witness Etta Lockey testified that Sierra Club, among the signatories to the 2020 Multi-State Protocol, "agreed to support the Oregon Exit Dates set forth in the 2020 Protocol."[4] Is Sierra Club bound to recommend that the Commission approve the Exit Dates PacifiCorp requests in this case?

A. No. The joint testimony, in which I participated, also states that "[n]othing in the 2020 Protocol limits or expands the Commission's right or obligation to: (1) determine fair, just, and reasonable rates; (2) consider the effect of changes in

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[2] Order No. 20-024, *In the matter of PacifiCorp, dba Pacific Power, Request to Initiate an Investigation of Multi-Jurisdictional Issues and Approve an Inter-Jurisdictional Cost Allocation Protocol*, Docket No. UM 1050 (Jan. 23, 2020) [hereinafter "Order No 20-024"].

[3] Stipulating Parties/100, Stipulating Parties' Joint Testimony of Etta Lockey, Steve Storm, Bob Jenks, Bradley G. Mullins, and Ezra Hausman, Docket No. UM 1050 December 2019 [hereinafter "MSP Joint Testimony"].

[4] PAC/200 at Lockey/14:6-9.

laws, regulations, or circumstances when determining fair, just, and reasonable rates; or (3) establish different allocation policies and procedures for purposes of allocating costs and revenue within that state to different customers or customer classes."[5] It goes on to note that "the 2020 Protocol does not affect or negate the Stipulating Parties right to address changed or unforeseen circumstances and will not bind or be used against a party if that party concludes the 2020 Protocol no longer produces results that are just, reasonable, or in the public interest."[6]

Finally, in its Order approving the Protocol, the Commission specifically noted that there is "uncertainty" about the Exit Dates in the 2020 Protocol, that the Commission "will need to engage in detailed review in a separate proceeding to establish appropriate Oregon exit dates" and "will require an evidentiary record that makes a strong case for the exit dates [the Commission] ultimately adopt[s]."[7]

Q. Have you identified "changed or unforeseen circumstances" that are material to the Commissions consideration of Oregon Exit Dates for PacifiCorp's coal-fired generating units?

A. Yes. In his supplemental testimony, PacifiCorp witness Mr. Chad Teply describes changes that the Company made to the depreciable lives of several of the Company's coal-fired resources since its 2013 depreciation study, and the reasons for these changes.[8] However, there have been additional significant changes in

[5] MSP Joint Testimony at Lockey, Storm, Jenks, Mullins, Hausman/7:6-11.
[6] *Id*. at Lockey, Storm, Jenks, Mullins, Hausman/7:12-15.
[7] Order No. 20-024 at 7.
[8] PAC/1700.

both legal and factual circumstances since the Company filed its updated depreciation study, its 2019 IRP, and the Protocol, such that the Exit Dates in the Protocol are no longer just, reasonable, or in the public interest. For the reasons I describe, the Oregon Exit Dates for the several of PacifiCorp's coal-fired generating units should be earlier than the dates recommended in the 2020 Protocol and the Company's current filing.

IV. CHANGES IN LEGAL CIRCUMSTANCES

Q. What changes in legal and/or regulatory circumstances have occurred since the filing of the PacifiCorp 2020 MSP with the Commission that it should consider in setting Oregon Exit Dates for PacifiCorp's coal-fired units?

A. There have been several. On March 20, 2020, Governor Kate Brown issued Executive Order No. 20-04 entitled "Directing State Agencies to Take Action to Reduce and Regulate Greenhouse Gas Emissions."[9] Executive Order 20-04 was an update to Governor Brown's previous Executive Order 17-20,[10] which order stated that "Oregon is committed to meeting the International Paris Agreement targets to reduce greenhouse gas emissions by 26 to 28 percent below 2005 levels by 2025."[11]

In EO 20-04, Governor Brown cited the urgent risk posed by climate change to public health and to "Oregon's economic vitality, natural resources, and

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[9] Ore. Exec. Order No. 20-04, *Directing State Agencies to Take Action to Reduce and Regulate Greenhouse Gas Emissions* (Mar. 20, 2020) [hereinafter "EO 20-04"] (attached as Exhibit Sierra Club/302).

[10] Ore. Exec. Order No. 17-20, *Accelerating Efficiency in Oregon's Built Environment to Reduce Greenhouse Gas Emissions and Address Climate Change* (Nov. 6, 2017) (attached as Exhibit Sierra Club/303).

[11] *Id.* at Page 1.

environment", and the fact that "the world's leading climate scientists, including those in the Oregon Climate Change Research Institute, predict that these serious impacts of climate change will worsen if prompt action is not taken to curb emissions."[12] She further declared that "[i]t is in the interest of utility customers and the public generally for the utility sector to take actions that result in rapid reductions of GHG emissions, at reasonable costs, to levels consistent with the GHG emissions reduction goals set forth in . . . this Executive Order, including transitioning to clean energy resources and expanding low carbon transportation choices for Oregonians."[13]

Q. **Is the role of the Public Utility Commission addressed in EO 20-04?**

A. Yes. EO 20-04 specifically directed the Public Utility Commission to "[d]etermine whether utility portfolios and customer programs reduce risks and costs to utility customers by making rapid progress towards reducing GHG emissions consistent with Oregon's reduction goals." [14]

The EO calls for the State of Oregon to reduce greenhouse gas ("GHG") emissions "(1) at least 45 percent below 1990 emissions levels by 2035; and (2) at least 80 percent below 1990 emissions levels by 2050." [15] State agencies are directed to "exercise any and all authority and discretion vested in them by law to help facilitate Oregon's achievement of the GHG emissions reduction goals".[16]

[12] Sierra Club/302, EO 20-04 at Page 1.
[13] *Id.* at Ordering ¶ 5(A).
[14] *Id.* at Ordering ¶ 5(B)(1).
[15] *Id.* at Ordering ¶ 2.
[16] *Id.* at Ordering ¶ 3(A).

Q. Has the Commission indicated how it intends to comply with EO 20-04?

A. Yes. On May 15, 2020, the Commission provided a Report on EO 20-04, wherein the Commission stated that "the PUC has been delegated broad discretion to ensure that utilities' actions are consistent with the public interest, and to adopt and incorporate state policy in our decision-making, and we will consider how EO 20-04 relates to our decisions within each action we take to administer our enabling statutes."[17]

With respect to utility resource planning, the Commission proposed the following activities:"[18]

- Considering options to incorporate the social cost of carbon into utility Integrated Resource Plans (IRPs) and avoided cost proceedings
- Updating the IRP guidelines to more explicitly consider the costs and risks of meeting the state's GHG emission reduction targets under the new timelines set forth in EO 20-04
- Considering utilities' resource procurement activities to determine if non-price scoring criteria appropriately capture the risk of each potential resource's impact on the utility's progress toward meeting the state's GHG reduction goals

The Commission also identified, with respect to regulatory activities, that it could "help achieve GHG reductions by taking EO 20-04's articulation of the public interest and statement of energy policy into account in [its] ongoing regulatory proceedings" by, among other actions, "[e]xploring whether a prudency review of a utility investment should include consideration of whether utilities' actions are consistent with EO 20-04" and "[e]valuating whether depreciation schedules used

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[17] Ore. Pub. Util. Comm'n, Report on Executive Order 20-04 at 7 (May 15, 2020) *available at* https://www.oregon.gov/puc/utilities/Documents/EO20-04PUC-Report.docx.pdf [hereinafter "OPUC Report on EO 20-04"].

[18] *Id.* at 5-6. The Commission also proposed two other activities that are not relevant here.

for the recovery of utility investments and resource retirements are consistent with EO 20-04."[19]

Q. Has the Oregon Global Warming Commission made findings pertinent to this question of whether Oregon is on track to meet its GHG reduction commitments?

A. Yes. In its most recent (2018) Biennial Report to the Legislature, the Oregon Global Warming Commission ("OGWC") noted that Oregon's 2017 emissions were "well above the state's goal of 51 million $MTCO_2e$ by 2020 and the Commission's adopted interim goal of 32.7 million $MTCO_2e$ by 2035, and it does not put Oregon on a path toward achieving its long-term goal of 14 million $MTCO_2e$ by 2050."[20]

Q. Doesn't the graph on page 45 of OGWC Biennial Report suggest that PacifiCorp's emissions will be below its "share" of the state goal as of 2030, and beyond?

A. Yes. However, it also shows that, given the projections shown in that document, PacifiCorp's emissions remain at essentially their current level (and above the necessary state trajectory) until 2030. CO_2 emitted into the atmosphere today will remain in the atmosphere for an average of approximately 100 years, and will

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[19] *Id.* at 7-8.
[20] Ore. Global Warming Comm'n, *2018 Biennial Report to the Legislature for the 2019 Legislative Session*, at 5 (2018) [hereinafter "2018 OGWC Report"] (attached as Exhibit Sierra Club/304).

affect the atmospheric concentration for thousands of years.[21] We no longer have the luxury to "wait" before reducing emissions. As noted in the "Letter from the Chair" in the OGWC Report:

> The time of probabilities is now past. The first tangible effects of climate change are upon us. We see it in stronger hurricanes inundating coastal communities around the world. We see it in the smoke blanketing our state and region from forest fires that start earlier, persist longer, and burn more extensively — smoke that is attacking the lungs of our children, the elderly, and the asthmatic. We see it in half-full reservoirs and mountaintops devoid of midwinter snow.[22]

This is why EO 20-04 directs the Commission to "[p]rioritize proceedings and activities, to the extent consistent with other legal requirements, that advance decarbonization in the utility sector, and exercise its broad statutory authority to reduce GHG emissions"[23] and to "[d]etermine whether utility portfolios and customer programs reduce risks and costs to utility customers by making rapid progress towards reducing GHG emissions consistent with Oregon's reduction goals."[24] PacifiCorp proposes to continue serving Oregon customers with electricity from coal-fired generating units until 2030. Thus the Commission's declaration that it will consider "whether utilities' actions are consistent with EO 20-04" and evaluate "whether depreciation schedules used for the recovery of utility investments and resource retirements are consistent with EO 20-04"[25] is a

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[21] *See* The Intergovernmental Panel on Climate Change, Working Group 1: The Scientific Basis, *available at* https://archive.ipcc.ch/ipccreports/tar/wg1/016 htm (last accessed June 9, 2020). *See also* US EPA Center for Corporate Climate Leadership, *Atmospheric Lifetime and Global Warming Potential Defined*, *available at* https://www.epa.gov/climateleadership/atmospheric-lifetime-and-global-warming-potential-defined (last accessed June 9, 2020).
[22] Sierra Club/304, 2018 OGWC Report at 8.
[23] Sierra Club/302, EO 20-04 at Ordering ¶ 5(B)(3).
[24] *Id.* at Ordering ¶ 5(B)(1).
[25] OPUC Report on EO 20-04 at 8.

germane change to the regulatory environment since the filing of the 2020 Protocol.

V. <u>CHANGES IN FACTUAL CIRCUMSTANCES</u>

Q. Have there been recent changes in economic and market circumstances that the Commission should consider in setting Exit Dates for PacifiCorp's coal-fired units?

A. Yes. The virus COVID-19 has caused a global pandemic, which has significantly affected the well-being of Oregonians, damaged the economy, and caused economic hardship throughout the state, the region, the nation, and indeed the world. One relevant impact of this pandemic is depressed current and projected electricity demand around the nation, including in the Pacific Northwest. Another impact is a decrease in wholesale energy market prices, affecting both electricity and gas forward prices. These economic changes mean that coal-fired units are far less economic to maintain and operate than they were before, and units that were economically marginal before are now strong candidates for closure (or Exit Orders.) It also means that struggling Oregonians can ill-afford to continue to support costly and risky investments when lower-cost options are available.

Q. To your knowledge, has PacifiCorp assessed the likely current and future impact of COVID-19 on its operations?

A. It is an important question, but the Company claims that it has made no such investigation. Sierra Club requested any notes, reports, memoranda, or presentations provided to its Board of Directors on this topic in Sierra Club Data

Request 5.3. The Company responded that none have been provided.[26]

Q. You mention a COVID-related decrease in current and projected energy demand as one important factual change in circumstances. What load forecast did PacifiCorp use to produce its 2019 IRP?

A. PacifiCorp used a load forecast updated in September 2018 which included a compound annual energy growth rate of 0.87% for the period 2019 through 2028.[27]

Q. Has PacifiCorp developed an updated load forecast since filing its 2019 IRP?

A. No. Sierra Club requested any such updated load forecasts in Data Request 5.1. The Company responded that "PacifiCorp has not completed a load forecast since PacifiCorp's 2019 Integrated Resource Plan was filed (docket LC 70 on October 18, 2019)."[28]

Q. Would you expect the load outlook for PacifiCorp's service territory to have changed since it prepared its forecast for the 2019 IRP in September 2018?

A. Yes. The effects of COVID-19 have reverberated throughout the national economy and have caused loads to drop around the country. The consulting firm Wood Mackenzie released two expert reports in early April entitled "Coronavirus

[26] PacifiCorp Response to Sierra Club Data Request 5.3 (Public data responses referenced in this testimony are compiled and attached as Exhibit Sierra Club/305.).
[27] PacifiCorp, *2019 Integrated Resource Plan*, Volume II, Appendix A, at 1 (Oct. 18, 2019), *available at* https://www.pacificorp.com/energy/integrated-resource-plan html [hereinafter "PAC 2019 IRP"].
[28] Sierra Club/305, PacifiCorp Response to Sierra Club Data Request 5.1.

will disrupt North America power markets for at least 18 months"[29] and "Coronavirus will disrupt WECC power markets for at least 18 months."[30] As described in the industry news website Utility Dive,[31] Wood Mackenzie finds that "American power markets are entering uncharted territory" with "lower power demand and power prices across North American power markets." For example, California experienced "load reductions of 5% to 8% on weekdays, and 1% to 4% on weekends, with the heaviest impact occurring over the morning peak hours" between March 17 and March 28.[32]

The Wood Mackenzie reports describe market impacts as of March 2020, when the overall impacts of the pandemic were just beginning. I expect that the findings would be even more dramatic today. These effects are expected to continue for many years and will certainly affect PacifiCorp's future load and resource balance. It should not be acceptable to this Commission that PacifiCorp has not even considered these factors in supporting its current filing.

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[29] Wood Mackenzie, *Coronavirus will disrupt North America power markets for at least 18 months: North America power and renewables March 2020 STO* (Apr. 1, 2020), *available at* https://www.woodmac.com/reports/power-markets-coronavirus-will-disrupt-north-america-power-markets-for-at-least-18-months-north-america-power-and-renewables-march-2020-sto-399670/.

[30] Wood Mackenzie, *Coronavirus will disrupt WECC power markets for at least 18 months: WECC power and renewables March 2020 STO* (Apr. 1, 2020), *available at* https://www.woodmac.com/reports/power-markets-coronavirus-will-disrupt-wecc-power-markets-for-at-least-18-months-wecc-power-and-renewables-march-2020-sto-399785/?utm_source=wmpardot&utm_medium=brochure&utm_campaign=wmpr_napsaprilsto.

[31] Robert Walton, *Clearer picture of coronavirus-driven grid load declines emerges in US after weeks of lockdowns*, Utility Dive (Apr. 9, 2020), *available at* https://www.utilitydive.com/news/clearer-picture-of-coronavirus-driven-grid-load-declines-emerges-in-us-afte/575777/ (The Wood Mackenzie reports themselves are propriety and I have not had an opportunity to review them firsthand.).

[32] *Id.*

Q. You mention a COVID-related decrease in current and projected energy prices as another important factual change. Did PacifiCorp witness Chad Teply address the importance of fuel costs in setting the life of a thermal generation resource?

A. Yes. Mr. Teply testified that "[f]uel cost, availability, and to an extent, fuel quality can influence the economic life of a thermal generation resource."[33] Mr. Teply was referring to the cost of fuel for the individual plant, but the reason this is important is that each plant must be able to produce electricity economically relative to alternative resources. Thus the cost of gas and electricity market purchases is an equally important consideration.

Q. What forward electricity price curve did PacifiCorp rely on for its 2019 IRP and projected coal plant retirement dates?

A. PacifiCorp relied primarily on its September 2018 "official forward price curve" ("OFPC"). [34]

Q. Has PacifiCorp updated its OFPC since filing its 2019 IRP?

A. Yes. PacifiCorp provided its OFPC dated October 30, 2019; November 8, 2019; December 31, 2019; and March 31, 2020 in response to Sierra Club Data Request 5.4.

Q. How has PacifiCorp's OFPC changed since it filed its IRP?

A. PacifiCorp's energy price expectations for 2023 forward had declined

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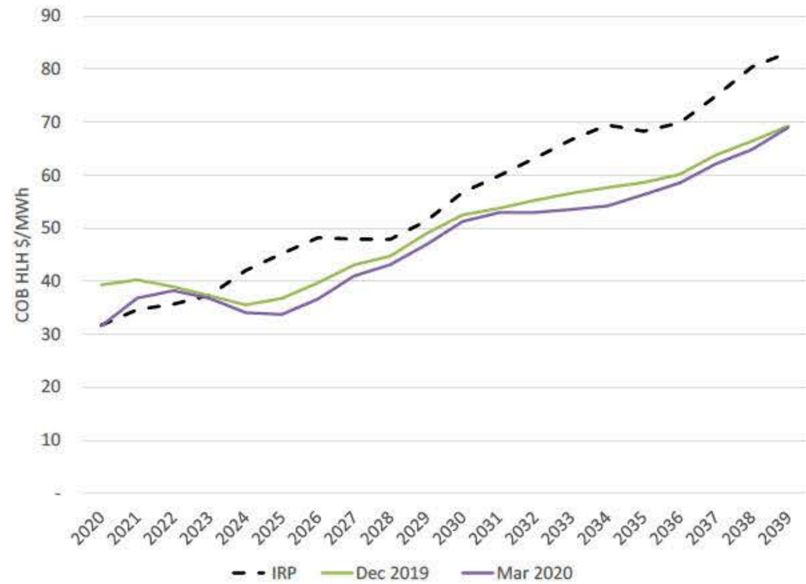
[33] PAC/1700 at Teply/5:5-6.
[34] PAC 2019 IRP, Vol. I at 180. *See also* LC 70, PAC 2019 IRP, public workpapers, Price Curves.

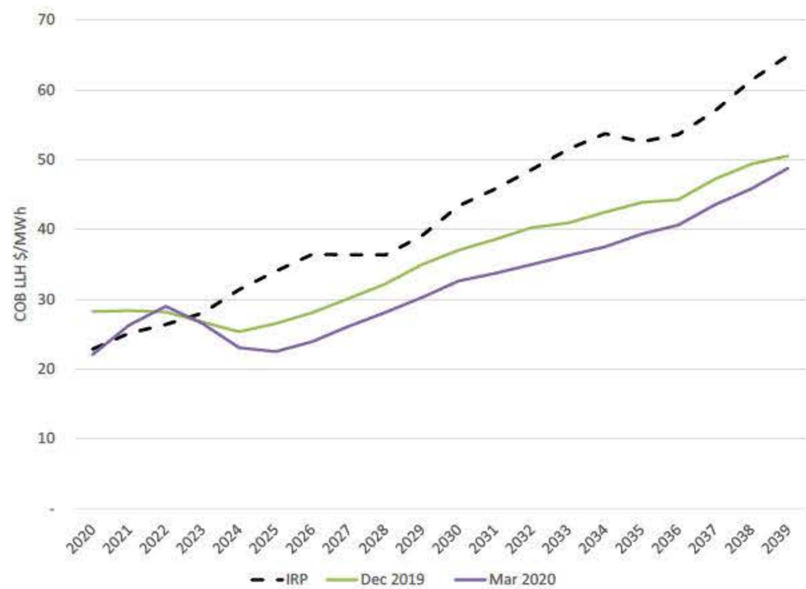
significantly by its December 2019 OFPC, and declined even further in its March 31, 2020 OFPC. *See* Figure 1. Based on currently prevailing historically low prices and the economic impact of COVID-19, which would not have been fully incorporated in the March 2020 forecast, I would expect that today's price expectations would be lower still.

Figure 1: Unweighted annual average electricity price forecasts for 2020-2039 from PacifiCorp OFPCs from the Company's 2019 IRP and subsequent forecasts.[35]

High-Load Hours



Low-Load Hours



[35] Figure 1 shows unweighted annual average prices for high-load hours and low-load hours, as defined by PacifiCorp. The OFPC provided by the Company are provided as a monthly price forecast for each category of hours. No monthly energy sales forecasts are provided that would allow a more precise weighting of the prices.

Q. Has PacifiCorp analyzed what gas price point would render its coal units non cost-effective to maintain and operate?

A. Not to my knowledge. However, Mr. Rick Link described a similar analysis the Company undertook to determine a "break-even" gas price for Selective Catalytic Reduction ("SCR") installation at Jim Bridger Units 3 and 4.[36] Mr. Link testified that the relevant nominal levelized price forecast at the time of its analysis was $5.35 per mmBtu, compared to a break-even price of $4.86 per mmBtu.[37] In other words, the break-even levelized price was about 9% lower than the then-current levelized price forecast.

Q. How does that difference compare to the difference between the OFPC PacifiCorp used in its IRP and its more recent OFPC?

A. The nominal levelized price[38] for the IRP OFPC was $49.26 for high-load hours, and $37.25 for low-load hours. The nominal levelized price for the March 31, 2020 OFPC was $43.26 for high-load hours, and $29.58 for low-load hours. This is a 12% decrease for high-load hours and 21% for low-load hours. These are significantly larger differences than the headroom above break-even prices identified by Mr. Link. Because these are electricity prices, not gas prices, they are even more directly relevant to the economics of PacifiCorp's coal units.

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[36] PAC/700 at Link/106:1-107:18.
[37] *Id.* at Link/107:7-9.
[38] Evaluated at a discount rate of 8%. Mr. Link does not specify the discount rate the Company used to calculate its nominal levelized price, but the calculation is largely insensitive to this parameter.

Q. In your opinion, would the change in the OFPC have a significant impact on the economic viability of PacifiCorp's coal-fired units?

A. Yes, my opinion is that it would have a very large impact on the viability of units that, as shown in the Company's 2019 IRP, were already each uneconomic or marginal on their own. Although I have no way of performing the full analysis, new price curves show that were the Company to perform its retirement analysis today it would find that retiring several additional coal-fired units would best serve ratepayer interest.

Q. In your opinion, would PacifiCorp's 2018 coal unit analysis likely have produced different results, had it been prepared with current electricity forward prices and load expectations?

A. Yes. As shown above, we know that PacifiCorp's expectation for future electricity prices as early as March 31, 2020 were significantly lower than its expectations when it prepared the 2019 IRP. Load is also expected to be significantly lower than previously projected due to the impacts of COVID-19 on the economy. All of these developments show that the economic outlook for PacifiCorp's coal plants is worse than it appeared in 2018 and early 2019 when the company prepared the IRP analysis. It is highly likely that a greater number of unit retirements would be justified were the analysis redone today, based on current market expectations.

Q. In your opinion, would PacifiCorp's assessment of the depreciable lives of its coal units have been different, had the Company considered current electricity forward prices?

A. Yes. As Mr. Teply testified, "increased run-rate fuel costs . . . can also drive economic life decisions for individual resources."[39] Again, the impact of lower electricity market and gas prices is the same as the impact of higher coal prices in terms of its impact on coal unit viability.

Q. In its May 2020 report on EO 20-04, the Commission proposed "considering options to incorporate the social cost of carbon into utility Integrated Resource Plans (IRPs) and avoided cost proceedings."[40] In your opinion, how would this affect PacifiCorp's coal unit analysis?

A. Consideration of the social cost of carbon would further impair the economics of PacifiCorp's coal plants and push them toward earlier retirement. In fact, PacifiCorp did analyze such a scenario in its 2019 IRP, and found that the lowest-cost option using the social cost of carbon was "Portfolio: Social Cost of Carbon (P-18)."[41] This scenario included a number of early retirements, including all four Jim Bridger units in 2026 or earlier.[42] Compounded with the other updated factors discussed above, I would expect such an analysis to strongly support a large number of coal unit retirements by 2025.

[39] PAC/1700 at Teply/5:12-13.
[40] OPUC Report on EO 20-04 at 5.
[41] PAC 2019 IRP, Vol. I at 235, Table 8.11.
[42] *Id.* at Vol . II, Appendix L at 244, Table L.2; Vol. II, Appendix M at 312.

VI. ADDITIONAL COSTS AND RISKS OF CONTINUED RELIANCE ON COAL-FIRED GENERATION

Q. In addition to the changed circumstances discussed above, are there other important costs and risks associated with PacifiCorp's continued reliance on coal-fired generation of which the Commission should be aware?

A. Yes. The extraordinary risk to the climate associated with continuing to emit large quantities of CO_2 into the atmosphere is well established, and was discussed above and in Exhibits Sierra Club/302, Sierra Club/303, and Sierra Club/304. In addition, as described by PacifiCorp witness Chad Teply, "[e]xisting, evolving, and emerging air emissions standards, water intake and effluent discharge standards, and solid waste regulations may have impacts on the economics of operating an asset. New regulations or changes to existing air, water or solid waste regulations influence the timing of capital expenditures for compliance and the subsequent operating and maintenance costs."[43]

Oregon ratepayers face increased risk of Regional Haze rule compliance costs the longer they are bound to PacifiCorp's coal-fired units. The Hunter, Huntington, and Wyodak plants will likely be subject to these additional costs in the future. This issue was discussed by PacifiCorp witness Chad A. Teply in his supplemental testimony filed in this matter on May 28, 2020.

In particular, many of PacifiCorp's coal units are running absent modern pollution controls. In its IRP and elsewhere, PacifiCorp minimizes the risk that it may have

[43] PAC/1700 at Teply/5:16-20.

to comply with federal clean air and water statutes and curb its GHG emissions within the next few years. Nevertheless, these risks are real and must be factored into consideration of the economic lives of the company's coal units. For example, EPA has already determined that Wyodak,[44] Dave Johnston 3,[45] Hunter 1 and 2, and Huntington 1 and 2[46] require costly selective catalytic converter technology under the federal Clean Air Act's Regional Haze rule. Unlike the vast majority of other utilities, PacifiCorp has not fully complied with the Regional Haze rule's best available retrofit technology ("BART") program. Instead, the Company has repeatedly chosen to fight compliance. EPA made a number of final determinations nationwide, in the 2010 to 2015 timeframe, to curb hazing-forming emissions from coal plants.[47] Because these pollutants impair visibility in national parks and wilderness areas, utilities are required to make continuous progress reducing emissions until natural visibility conditions are reached. To my knowledge, all western utilities except PacifiCorp have complied with EPA's BART program.

PacifiCorp has continued to rely on litigation to forestall implementation of pollution controls under the BART program at its Utah and Wyoming coal plants rather than comply with the Clean Air Act, including in its 2019 IRP.[48] The company has sued EPA for adopting federal implementation plans under the

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[44] 79 Fed. Reg. 5032 (Jan. 30, 2014) (EPA imposed a 2019 SCR deadline for this unit.).
[45] *Id.* (EPA required that PacifiCorp either retire this unit or install SCR by 2027.).
[46] 81 Fed. Reg. 43894 (Jul. 5, 2016) (EPA required that PacifiCorp install SCR at all 4 Utah units by August, 2021.).
[47] 76 Fed. Reg. 38997 (July 5, 2011); 79 Fed. Reg. 5032; 80 Fed. Reg. 19220 (Apr. 10, 2015), 81 Fed. Reg.43894.
[48] PAC 2019 IRP, Vol. I at 46-47.

Clean Air Act to protect some of the nation's most iconic national parks.[49] These lawsuits have been successful in delaying compliance, such that all of EPA's BART requirements for Utah and Wyoming were stayed pending final resolution by the 10th Circuit Court of Appeals. However, should this litigation strategy ultimately fail, the company is also moving to convince both state DEQs and EPA to roll back existing SCR requirements.

Importantly, even were PacifiCorp to escape regulation under the BART program, the Clean Air Act still mandates steady reductions in haze-forming pollutants through 2064. Therefore, while PacifiCorp continues its fight against BART retrofits, the states are moving forward as required to assess pollution emissions from all sources that impact national parks and wilderness areas. By July 31, 2021, each state must submit its plan setting out its goals to track progress towards natural visibility conditions.[50] This second phase will require Utah and Wyoming to demonstrate that they are making "reasonable progress" toward achieving natural visibility conditions in parks and wilderness areas. This means that *all* of PacifiCorp's still-operating units, including Hunter 3 and David Johnston 1 and 2 may be saddled with additional pollution control requirements. In short, SCRs could be required under two of the Regional haze rule's programs for Wyodak, Dave Johnston 3, Hunter 1 and 2, and Huntington 1 and 2. With EPA action on these plans, PacifiCorp could be faced with either greater expense for ratepayers in states that retain an allocation of costs for these units, or a shutdown of the

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[49] Hunter and Huntington impair visibility in Arches, Zion, Bryce, Canyonlands, and Grand Canyon National Parks.
[50] 82 Fed. Reg. 3078 (Jan. 10, 2017)

units. Oregon could avoid this risk, and possibly gain certainty in its share of decommissioning costs, by issuing Exit Orders with an Exit Date of December 31, 2025 for each of the units.

Another risk to PacifiCorp's coal units is GHG regulation from state and/or federal legislation. PacifiCorp appears to be betting on favorable political winds to protect it in this area as well, hoping that efforts to reduce climate-harming emissions can be forestalled in the coming years despite both the well-known harm to human health and the environment, and the climate commitments of Oregon and other states the company serves. For example, PacifiCorp noted in its 2019 IRP that the "election of Donald Trump as U.S. President reduces the likelihood of federal climate change legislation in the near term."[51] However, litigation over the Clean Power Plan has yet to resolve whether EPA can curtail coal plant GHG emissions, and there is the potential for further carbon regulation, possibly as soon as the new Congress in 2021. For these reasons, in my opinion, it is risky for PacifiCorp to make these broad assumptions about future compliance costs.

Q. Have these market trends impacted electricity generation from coal in the U.S. and in the region?

A. Yes. A combination of factors – closely related to what I have described above – have led to substantial decreases in coal-fired electric generation across the country. As a result, EIA reports that coal consumption in the U.S. in March of

[51] PAC 2019 IRP, Vol. I at 43.

this year was 34.3% lower than in March of 2019.[52] These general trends around the nation that have led to the deterioration of coal plant economics are also an important factor in and around the PacifiCorp service areas. At the same time, renewable and storage resources are becoming increasingly affordable alternatives. For example, Xcel Colorado's 2017 All-Source Solicitation received a large number of bids for renewable resources, some of which were coupled with storage, at prices far below expectations.[53] If PacifiCorp proposes to keep its coal-fired units in Oregon rates for the next decade despite these trends and the many risks I have described, it should demonstrate to this Commission that they remain the most economic alternative, using the most recently available data reflective of current market conditions.

Q. You mention several factors that would support earlier retirement of coal plants, and in particular for an early exit for Oregon from PacifiCorp's coal plants. Did PacifiCorp witness Chad Teply recognize the impact of these factors in setting the depreciable lives of its assets?

A. Yes. In his supplemental testimony, Mr. Chad Teply proposed several accelerations of the depreciable lives of the Company resources based, at least in part, on fuel costs, environmental regulations, compliance obligations, and policy and market drivers.[54] First, the company proposed "accelerating the depreciable life of Cholla Unit 4 from 2028 to 2025 to align with the unit's approved Regional

[52] U.S. Energy Information Administration, Key Indicators, *available at* https://www.eia.gov/electricity/ (last accessed June 7, 2020).
[53] Robert Walton, *Xcel solicitation returns 'incredible' renewable energy, storage bids, Utility Dive* (Jan. 8, 2018), *available at* https://www.utilitydive.com/news/xcel-solicitation-returns-incredible-renewable-energy-storage-bids/514287/.
[54] PAC/1700 at Teply/3:19-10:8.

Haze Rule compliance obligation timeline."[55] Second, company proposed to accelerate the depreciable life of Craig Unit 1 from 2026 to 2025 for the same reason.[56] Third, the company proposed "to accelerate the depreciable life of Colstrip Units 3 and 4 from 2032 to 2027 to facilitate least-cost, least-risk analysis, decision making, and planning as announced retirements of Colstrip Units 1 and 2 (non-company resources) in 2022 approach, and Colstrip Units 3 and 4 economics and joint owner business planning decisions are made in the interim."[57]

Q. Has PacifiCorp recognized the impact of these factors on its coal fleet in any recent filings with this Commission?

A. Yes. In its 2019 IRP, PacifiCorp's preferred plan included accelerated retirement dates for many of its coal units relative to its 2017 IRP. Using its System Optimizer model, PacifiCorp evaluated a wide range of portfolios including accelerating the retirement dates of several of its coal-fired units. The preferred portfolio, denoted "P-45CNW", included earlier retirements of several coal units and resulted in present value savings of hundreds of millions of dollars over portfolios that retained all of the coal units.[58]

Those earlier retirements are reflected in the current case, as reflected in Table 1 of Ms. Lockey's direct testimony; in fact, for Jim Bridger Units 2-4, the Company is requesting an Exit Date that precedes the retirement date in the 2019 IRP. In support of this earlier Exit Date, Ms. Lockey testified:

[55] *Id.* at Teply/9:2-4.
[56] *Id.* at Teply/9:9-11.
[57] *Id.* at Teply/9:15-19.
[58] *See* PAC 2019 IRP, Vol. II, Appendix K (PVRR results for all scenarios).

> An Exit Date of 2025 for Jim Bridger Units 2-4 aligns with Oregon's policy to transition from coal-fired resources. In addition, the Exit Date for Jim Bridger Units 2-4 represents a trade-off between the potential for continued NPC benefits associated with including the units in rates through the operational lives identified in the 2019 IRP, and the certainty of decommissioning and remediation liability of Jim Bridger Units 2-4, commensurate with Oregon's current allocation. Per the 2020 Protocol, if Oregon exits a coal-fired resource in advance of closure, Oregon receives certainty with regard to the level of decommissioning and remediation costs allocated to Oregon; for Jim Bridger Units 2-4, Oregon will only be allocated its estimated share of decommissioning and remediation costs. To the extent that actual decommissioning and remediation costs incurred at the time of closure differ from what was estimated, and Oregon has already exited the units, that cost variance will not be recovered from Oregon customers.[59]

Ms. Lockey did not explain why this same logic would not apply to the Hunter, Huntington, and Wyodak units, or any other units that PacifiCorp proposes to retain in Oregon rate base beyond 2025. It is true that the 2020 MSP Agreement calls for later Exit Dates for these units, but as discussed above, that date is not binding on this Commission. The Company should be required to show, using the most updated assumptions, why certain units should be kept online longer at the possible expense of certainty in decommissioning and remediation liability.

In fact, the Company's IRP analysis showed that retiring any of the Hunter or Huntington units individually *in 2022* would produce a net benefit for ratepayers under the Company's base case (medium gas price, medium CO_2 emissions cost) scenario.[60] While this does not necessarily mean that there would have been a present value benefit to retiring these units together at such an early date, or in combination with the other units that are to be retired early, I have seen no

[59] PAC/200 at Lockey 16:18- 17:11.
[60] PAC 2019 IRP, Volume II, Appendix R, at 598, Table R.4.

evidence that the Company ever tested this question. It certainly has not done so based on current market conditions and expectations.

Q. Have you reviewed the Company's analysis of the "trade-off" described by Ms. Lockey to determine if it would apply equally to PacifiCorp's other coal-fired units?

A. My understanding is that there is no such analysis. In response to Sierra Club Data Request 6.1,[61] PacifiCorp stated that "[t]he Oregon Exit Date for Jim Bridger Units 2-4 and all other coal units was a negotiated outcome as part of the 2020 Protocol. Please refer to UM 1050 for the approval of the 2020 Protocol. *There is no further analysis to provide.*"

If Oregon were to order a December 31, 2025 exit for PacifiCorp's other coal-fired generating units, it would achieve the same benefit described by Ms. Lockey for Jim Bridger, to wit: "Oregon receives certainty with regard to the level of decommissioning and remediation costs allocated to Oregon…[t]o the extent that actual decommissioning and remediation costs incurred at the time of closure differ from what was estimated, and Oregon has already exited the units, that cost variance will not be recovered from Oregon customers."[62] It would also eliminate any responsibility Oregon ratepayers would otherwise have for capital costs associated with extending the life of these units, for additional environmental compliance, or for recovery from possible catastrophic failures.[63]

[61] Sierra Club/304, PacifiCorp Response to Sierra Club Data Request 6.1 (emphasis added).
[62] PAC/200 at Lockey/17:5-11.
[63] 2020 MSP at 41:862-867 (Sec. 6.5.1).

VII. RECOMMENDED OREGON EXIT DATES

Q. What is your recommendation for Exit Dates for the state of Oregon?

A. I recommend that the Commission issue Oregon Exit Orders for all of PacifiCorp's coal-fired resources with Exit Dates of no later than December 31, 2025.

Q. Are you recommending a change to the depreciation dates proposed by Mr. Teply?

A. No. Because the Commission has the mechanism of issuing Exit Orders to protect Oregon ratepayers from prolonged exposure to the costs and risks associated with PacifiCorp's coal-fired units, I do not believe it is necessary to also further modify the depreciable lives of these units.

Q. Is your recommendation consistent with requirements under SB 1547?

A. Yes. Under SB 1547, the Oregon Legislature indicated its intention to eliminate coal-fired electricity from the state's generation mix, stating that "[o]n or before January 1, 2030, an electric company shall eliminate coal-fired resources from its allocation of electricity."[64] Accordingly, while electric companies must eliminate coal-fired resources no later than January 1, 2030, there is no requirement to continue utilizing coal-fired resources up and until December 31, 2029. The only question is how quickly to do so, as long as it is *on or before* January 1, 2030. As shown above, there are many reasons to support an earlier Exit Date, including the directives in EO 20-04, the fact that the OGWC found Oregon to be lagging in

[64] SB 1547 §1(d)(2) (Ore. 2016).

meeting its GHG mitigation commitments, the fact that these units may no longer be economically justified, and the fact that lower-cost, cleaner alternatives are likely available in the short run.

Q. Has any other state in PacifiCorp's service area established earlier Exit Dates than those proposed by PacifiCorp in this proceeding?

A. Yes. PacifiCorp and other utilities are under obligation to cease supplying any power from coal plants to customers in the state of Washington as of December 31, 2025 pursuant to the Washington Clean Energy Transformation Act ("CETA"). At that time all other PacifiCorp states, including Oregon, will have to elect whether to take on Washington's shares of PacifiCorp coal-fired units, and whether they are willing to assume additional risk for decommissioning and remediation costs.

Q. Is PacifiCorp supportive of Washington's 2025 Exit Date?

A. Yes. PacifiCorp supported these dates as part of the 2020 MSP.

Q. Please summarize your opinion on why this Commission should order a 2025 Oregon Exit Date for all of PacifiCorp's coal fired generating units.

A. Given the mechanisms laid out in the 2020 MSP for exiting from coal-fired generating units, and the fact that Washington State intends to exit all of PacifiCorp's coal-fired units as of December 31, 2025, the *earliest* reasonable Oregon Exit Date for all of PacifiCorp's coal-fired units (except those expected to be retired earlier) is December 31 2025. This is also the *most reasonable* date, given the costs and risks of continuing to rely on coal-fired electricity; the state's commitments to rapidly reduce emissions as laid out in Executive Orders 17-20 and 20-03, and the Commission's report on implementation of EO 20-04; OGWC's alarm that the state is behind on its emissions reduction trajectory; and other trends in the region, including the declining outlook for electricity load over the next several years and the increasingly favorable economics of renewable energy and storage options.

By issuing Oregon Exit Orders for these plants effective December 31, 2025, the Commission can ensure that Oregon minimizes risk and makes an orderly and timely transition to lower-cost clean energy resources and minimizes costs and risks for ratepayers, consistent with the mandate of EO 20-04.

VIII. RECOMMENDATIONS AND CONCLUSION

Q. What are your recommendations for the Commission?

A. I recommend that the Commission issue Exit Orders in this case for all of PacifiCorp's coal units, with Exit Dates no later than December 31, 2025, regardless of the depreciable lives used by the Company. If the Commission elects not to issue such Exit Orders at this time, I recommend that it direct PacifiCorp to update its IRP analysis using current load, electricity price, and gas price expectations, along with updated renewable and storage resource costs, to determine whether retaining its coal-fired units beyond December 31, 2025 is in Oregon ratepayers' interest. I recommend that this updated analysis incorporate the social cost of carbon as indicated in the Commission's report on EO 20-04.

Q. Does this conclude your testimony?

A. Yes.

Docket No. UE 374
Exhibit Sierra Club/301
Witness: Ezra Hausman

PUBLIC UTILITY COMMISSION OF OREGON

UE 374

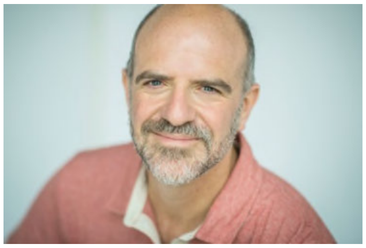
SIERRA CLUB EXHIBIT 301

Exhibits Accompanying the Opening Testimony of Ezra D. Hausman, Ph.D.

Curriculum Vitae of Ezra D. Hausman, Ph.D.

Ezra D. Hausman, Ph.D.

Curriculum Vitae



I am an independent consultant in energy and environmental economics.

I have worked for over two decades as an energy market expert with a focus on market design and market restructuring, planning and ratemaking, energy efficiency programs, environmental regulation, and pricing of energy, capacity, transmission, losses and other electricity-related services. I have performed market analysis, provided expert testimony, led workshops and working groups, and provided other support in both regulated and restructured electricity markets for clients including federal and state agencies, offices of consumer advocate, legislative bodies, cities and towns, non-governmental organizations, foundations, industry associations, and resource developers.

I hold a Ph.D. in atmospheric science from Harvard University, an S.M. in applied physics from Harvard University, an M.S. in water resource engineering from Tufts University, and a B.A. in psychology from Wesleyan University.

PROFESSIONAL EXPERIENCE

Ezra Hausman Consulting, Newton, MA. President, March 2014 – Present.
I provide research, analysis, expert testimony, and policy support services in regulatory, litigation, and stakeholder processes covering a wide range of electric sector and electriciuty market issues. The focus of my consulting work includes:

- Ratemaking and regulatory proceedings
- Wholesale market design and analysis for electricity, generating capacity, and related services
- Demand-side management program design and cost/benefit analysis
- Interaction of air quality and environmental regulations with electricity markets
- Analysis and implementation of the Clean Power Plan and other greenhouse gas rules
- Clean Air Act enforcement support
- Long-term electric power system planning
- Energy efficiency and renewable energy programs and policies
- Consumer and environmental protection
- Market power and market concentration analysis in electricity markets.

Synapse Energy Economics Inc., Cambridge, MA.
Chief Operating Officer, March 2011 – February 2014;

Vice President, July 2009 – February 2014;
Senior Associate, 2005-2009.

- Conducted research, wrote reports, and presented expert testimony pertaining to consumer, environmental, and public policy implications of electricity industry regulation. Provided expert support and representation in planning, greenhouse gas mitigation, and other stakeholder processes.
- As Vice President and Chief Operating Officer, I was also responsible for day-to-day operations of the company, quality assurance, client service, and professional development of staff.

Charles River Associates (CRA), Cambridge, MA. Senior Associate, 2004-2005
CRA acquired Tabors Caramanis & Associates in October, 2004.

Tabors Caramanis & Associates, Cambridge, MA. Senior Associate, 1998-2004
As a member of the modeling group, developed and maintained dispatch modeling capability in support of electricity market consulting practice.

Performed modeling and analysis of electricity markets, generation and transmission systems. Projects included:

- Several market transition cost-benefit studies for development of Locational Marginal Price (LMP) based markets in US electricity markets
- Long-term market forecasting studies for valuation of generation and transmission assets,
- Valuation of financial instruments relating to transmission system congestion and losses
- Modeling and analysis of hydrologically and electrically interconnected hydropower system operations
- Natural gas market analysis and price forecasting studies
- Co-developed an innovative approach to hedging financial risk associated with transmission system losses of electricity
- Designed, developed and ran training seminars using a computer-based electricity market simulation game, to help familiarize market participants and students in the operation of LMP-based electricity markets.
- Developed and implemented analytical tools for assessment of market concentration in interconnected electricity markets, based on the "delivered price test" for assessing market accessibility in such a network
- Performed regional market power and market power mitigation studies
- Performed transmission feasibility studies for proposed new generation and transmission projects in various locations in the US
- Provided analytical support for expert testimony in a variety of regulatory and litigation proceedings, including breach of contract, bankruptcy, and antitrust cases, among others.

Global Risk Prediction Network, Inc., Greenland, NH. Vice President, 1997-1998
Developed private sector applications of climate forecast science in partnership with researchers at Columbia University. Specific projects included a statistical assessment of grain yield predictability in several crop regions around the world based on global climate indicators (Principal Investigator); a statistical assessment of road salt demand predictability in the United States based on global climate indicators (Principal Investigator); a preliminary design of a climate and climate forecast information website tailored to the interests of the business community; and the development of client base.

Hub Data, Inc., Cambridge, MA. Financial Software Consultant, 1986-1987, 1993-1997
Responsible for design, implementation and support of analytic and communications modules for bond portfolio management software; and developed software tools such as dynamic data compression technique to facilitate product delivery, Windows interface for securities data products.

Abt Associates, Inc., Cambridge, MA. Environmental Policy Analyst, 1990-1991
Quantitative risk analysis to support federal environmental policy-making. Specific areas of research included risk assessment for federal regulations concerning sewage sludge disposal and pesticide use; statistical alternatives to Most-Exposed-Individual risk assessment paradigm; and research on non-point sources of water pollution.

Massachusetts Water Resources Authority, Charlestown, MA. Analyst, 1988-1990
Applied and evaluated demand forecasting techniques for the Eastern Massachusetts service area. Assessed applicability of various techniques to the system and to regional planning needs; and assessed yield/reliability relationship for the eastern Massachusetts water supply system, based on Monte-Carlo analysis of historical hydrology.

Somerville High School, Somerville, MA. Math Teacher, 1986-1987
Courses included trigonometry, computer programming, and basic math.

EDUCATION

Ph.D., Earth and Planetary Sciences. Harvard University, Cambridge, MA, 1997

S.M., Applied Physics. Harvard University, Cambridge, MA, 1993

M.S., Civil Engineering. Tufts University, Medford, MA, 1990

B.A., Wesleyan University, Psychology. Middletown, CT, 1985

FELLOWSHIPS, AWARDS AND AFFILIATIONS

UCAR Visiting Scientist Postdoctoral Fellowship, 1997

Postdoctoral Research Fellowship, Harvard University, 1997

Certificate of Distinction in Teaching, Harvard University, 1997

Graduate Research Fellowship, Harvard University, 1991-1997

Invited Participant, UCAR Global Change Institute, 1993

House Tutor, Leverett House, Harvard University, 1991-1993

Graduate Research Fellowship, Massachusetts Water Resources Authority, 1989-1990

Teaching Fellowships:

> **Harvard University:** *Principles of Measurement and Modeling in Atmospheric Chemistry; Hydrology; Introduction to Environmental Science and Public Policy; The Atmosphere.*
>
> **Wesleyan University:** *Introduction to Computer Programming; Psychological Statistics; Playwriting and Production.*

Community Service

> *Vice President of Finance,* Congregation Dorshei Tzedek, 2018 - Ongoing
> *Academic Mentor and Athletic Coach,* SquashBusters Boston, 2014 - Ongoing
> *Judge,* Cleantech Open innovation competitions, 2015-2016
> *President*, Burr Elementary School Parent Teacher Organization, 2005-2007

EXPERT TESTIMONY AND SERVICES

Public Service Commission of the District of Columbia – 2020
Review and analysis of AltaGas d/b/a/ Washington Gas' "Climate Business Plan" and "Renewable Natural Gas" studies on behalf of Sierra Club.

New Jersey Division of Rate Counsel – 2016-Ongoing
General policy and stakeholder support on matters related to energy efficiency, renewable energy, and electrification of transportation in New Jersey.

New Jersey Board of Public Utilities – 2020-Ongoing
Expert participation is stakeholder process regarding conversion to high-efficiency street lights on behalf of Rate Counsel.

New Jersey Board of Public Utilities – 2019-Ongoing
Expert participation is stakeholder process regarding transportation electrification policies on behalf of Rate Counsel.

Washington Utilities and Transportation Commission – 2020-Ongoing
Expert witness on behalf of the Sierra Club regarding potential sale of ownership sale in Colstrip generating unit.

Utah Public Service Commission (Docket No. 18-035-36) – 2020-Ongoing
Expert witness on behalf of the Sierra Club in Rocky Mountain Power depreciation case.

PacifiCorp Multi-State Protocols Stakeholder Process – 2019-Ongoing
Participation on behalf of Sierra Club in stakeholder process to establish protocols for allocation of resource costs ad benefits among PacifiCorp states.

Advisory Consulting for Natural Resources Defense Council – 2019-2020
Provide advisory and technical support to analysis team.

Memphis Light, Gas and Water – Power Supply Alternatives Study (2019-Ongoing)
Expert support for Sierra Club participation in Power Supply Advisory Team.

Washington Utilities and Transportation Commission (Dockets UE-190334 and UG-190335) – 2019
Expert witness on behalf of the Sierra Club in Avista Energy rate case.

New Jersey Board of Public Utilities – 2014-Ongoing
Expert witness on behalf of the New Jersey Division of Rate Counsel, reviewing and providing testimony on cost effectiveness and program design of various New Jersey gas and electric utility energy efficiency programs.

Public Service Commission of South Carolina (Docket No. 2018-319-E) – 2019
Expert witness on behalf of the Sierra Club in Duke Energy Carolinas rate case.

Public Service Commission of South Carolina (Docket No. 2018-318-E) – 2019
Expert witness on behalf of the Sierra Club in Duke Energy Progress rate case.

Virginia State Corporation Commission (Case No. PUR-2018-00065) – 2018
Expert witness on behalf of the Sierra Club in Dominion Power IRP proceeding.

Missouri Public Service Commission (Case No. EO-2018-0038) – 2018
Expert services in support of Sierra Club's participation in integrated resource planning process.

Florida Public Service Commission (Docket No. 20170225-EI) – 2017-2018
Expert witness on behalf of the Sierra Club in FPL Determination of Need proceeding.

North Carolina Utilities Commission (Docket No. E-7, SUB 1146) – 2017-2018
Expert witness on behalf of the Sierra Club in Duke Energy Carolinas rate case.

North Carolina Utilities Commission (Docket No. E-2, SUB 1142) – 2017
Expert witness on behalf of the Sierra Club in Duke Energy Progress rate case.

Idaho Public Utilities Commission (Case No. AVU-E-17-01) – 2017
Expert witness on behalf of the Sierra Club in Avista Corporation rate case.

Iowa Utilities Board (Docket No. RPU-2017-0002) –- 2017
Expert witness on behalf of the Sierra Club for Interstate Power and Light petition for ratemaking principles for proposed 500 MW wind project.

Washington Utilities and Transportation Commission (Dockets UE-170033 and UG-170034) – 2017
Expert witness on behalf of the Sierra Club in Puget Sound Energy (PSE) rate case.

Clean Power Plan Modeling in PJM and MISO – 2016-2017
Participation on behalf of the Sustainable FERC Project in ISO initiative to model scenarios for state compliance with federal greenhouse gas mitigation rules.

California ISO/PacifiCorp Market Integration – 2015-2017
Technical support to Sierra Club in stakeholder review and participation in all relevant proceedings in California.

United States Department of Justice – US District Court Dallas, TX Division (U.S. vs. Luminant Generation Company, LLC, and Big Brown Power Company, LLC) – Ongoing
Expert witness on behalf of the United States Department of Justice on clean air act enforcement case.

United States Department of Justice – US District Court for the Eastern District of Missouri (Civil Action No. 4:11-CV-00077) – 2013-Ongoing
Expert witness on behalf of the United States Department of Justice on successful prosecution of clean air act case.

Missouri Public Service Commission (Case No. EO-2015-0084) – 2014-2015
Expert services in support of Sierra Club's participation in integrated resource planning process.

Missouri Public Service Commission (File No. ER-2014-0258) – 2014-2015
Expert witness on behalf of the Sierra Club in Ameren Missouri rate case.

Arizona Corporation Commission (Docket No. E-01345A-11-0224) – 2014
Expert witness on behalf of the Sierra Club regarding Arizona Public Service petition for rate treatment for acquisition of an additional ownership share of the Four Corners generating units.

Missouri Public Service Comission (Docket No. ET-2014-0085) – 2013
Testimony on behalf of the Missouri Solar Energy Industries Association regarding Union Electric (d/b/a Ameren Missouri) motion to suspend payment of solar rebates.

Missouri Public Service Comission (Docket No. ET-2014-0059 and ET-2014-0071) – 2013
Testimony on behalf of the Missouri Solar Energy Industries Association regarding Kansas City Power and Light Company's motions to suspend payment of solar rebates.

Eastern Interconnect Planning Collaborative (EIPC) – 2012-2013
Expert support on behalf of coalition of NGO stakeholders in transmission and resource planning process, including development and review of modeling assumptions and interim results, and development of comments.

Puget Sound Energy (PSE) – 2012-2013
Expert participant in PSE's 2013 IRP stakeholder process on behalf of the Sierra Club.

Washington Utilities and Transportation Commission (Docket Nos. UE-111048 and UG-111049) – 2011
Testimony on behalf of the Sierra Club regarding the cost of operating the Colstrip power plant and other power procurement issues.

Kansas Corporation Commission (Docket No. 11-KCPE-581-PRE) - 2011
Presented written and live testimony on behalf of the Sierra Club regarding Kansas City Power and Light request for predetermination of ratemaking principles.

Vermont Department of Public Service - 2011
Provided scenario analysis of the costs and benefits of various electric energy resource scenarios in support of the state Comprehensive Energy Plan.

Massachusetts Department of Energy Resources – 2009-2011
Served as expert analyst and modeling coordinator for analysis related to implementation of the Massachusetts Global Warming Solutions Act.

Iowa Office of Consumer Advocate – 2010-2011
Assisted Consumer Advocate in evaluating a proposed power purchase agreement for the output of the Duane Arnold nuclear power station.

Missouri Public Service Commission (Docket No. EW-2010-0187) – 2010
Expert participant on behalf of the Sierra Club in stakeholder process to develop a "demand side investment mechanism" in Missouri.

Louisiana Public Service Commission (Docket No. R-28271 Subdocket B) – 2009-2010
Expert participant on behalf of the Sierra Club in Renewable Portfolio Standard Task Force considering RPS for Louisiana.

Joint Fiscal Committee of the Vermont Legislature – 2008-2010
Serving as lead expert advising the Legislature on economic issues related to the possible recertification of the Vermont Yankee nuclear power plant.

Town of Littleton, NH – 2006-2010
Serving as expert witness on the value of the Moore hydroelectric facility.

Nevada Public Service Commission (Docket No. 08-05014) – August 2008
Presented prefiled and live testimony on behalf of Nevadans for Clean Affordable Reliable Energy regarding the proposed Ely Energy Center and resource planning practices in Nevada.

Mississippi Public Service Commission (Docket No. 2008-AD-158) – July 2008
Presented written and live testimony on behalf of the Sierra Club regarding the resource plans filed by Entergy Mississippi and Mississippi Power Company.

Kansas House of Representatives - Committee on Energy and Utilities – February 2008
Presented testimony on behalf of the Climate and Energy Project of the Land Institute of Kansas on a proposed bill regarding permitting of power plants. Focus was on the risks and costs associated with new coal plants and on their contribute to global climate change.

Vermont Public Service Board (Docket No. 7250) – 2006-2008
Prepared report and testimony in support of the application of Deerfield Wind, LLC. For a Certificate of Public Good for a proposed wind power facility.

Iowa Utilities Board (Docket No. GCU-07-1) – October, 2007 – January 2008

Presented wrtten and live testimony on behalf of the Iowa Office of Consumer Advocate regarding the science of global climate change and the contribution of new coal plants to atmospheric CO_2.

Nevada Public Service Commission (Docket No. 07-06049) – October 2007
Presented prefiled direct testimony on behalf of Nevadans for Clean Affordable Reliable Energy regarding treatment of carbon emissions costs and coal plant capital costs in utility resource planning.

Massachusetts General Court, Joint Committee on Economic Development and Emerging Technologies – July 2007
Presented written and live testimony on climate change science and the potential benefits of a revenue-neutral carbon tax in Massachusetts.

Town of Rockingham, VT – 2006-2007
Served as expert witness on the value of the Bellows Falls hydroelectric facility.

South Dakota Public Utilities Commission (Case No EL05-22) – June 2006
Minnesota Public Utilities Commission (Docket TR-05-1275) – December 2006
Submitted prefiled and live testimony on the contribution of the proposed Big Stone II coal-fired generator to atmospheric CO_2, global climate change and the environment of South Dakota and Minnesota, respectively.

Arkansas Public Service Commission (Docket No. 06-070-U) – October 2006
Submitted prefiled direct testimony on inclusion of new wind and gas-fired generation resources in utility rate base.

Federal Energy Regulatory Commission (Docket Nos. ER055-1410-000 and EL05-148-000) – May-Sept 2006

- Participant in settlement hearings on proposed capacity market structure (the Reliability Pricing Model, or RPM) on behalf of State Consumer Advocates in Pennsylvania, Ohio and the District of Columbia
- Invited participant on technical conference panel on PJM's proposed Variable Resource Requirement (VRR) curve
- Filed Pre- and post-conference comments and affidavits with FERC
- Participated in numerous training and design conferences at PJM on RPM implementation.

Illinois Pollution Control Board (Docket No. R2006-025) – June-Aug 2006
Prefile and live testimony presented on behalf of the Illinois EPA regarding the costs and benefits of proposed mercury emissions rule for Illinois power plants.

Long Island Sound LNG Task Force – January 2006
Presentation of study on the need for and alternatives to the proposed Broadwater LNG storage and regasification facility in Long Island Sound.

Iowa Utilities Board (Docket No. SPU-05-15) – November 2005

Presented written and live testimony on whether Interstate Power and Light's should be permitted to sell the Duane Arnold Energy Center nuclear facility to FPLE Duane Arnold, Inc., a subsidiary of Florida Power and Light.

PUBLICATIONS AND REPORTS

Hausman, E., The Worst of Both Worlds: Why the Ohio Legislature's OVEC Bailout Bill would Harm Consumers, Impede Competition, Increase Pollution, and Impair the Health and Welfare of Ohioans for Decades. White paper produced on behalf of The Sierra Club, June 2017.

Hausman, E., Risks and Opportunities for PacifiCorp - State Level Findings: Utah, Produced on behalf of the Sierra Club, October 2014.

Hausman, E., Risks and Opportunities for PacifiCorp - State Level Findings: Oregon, Produced on behalf of the Sierra Club, October 2014.

Hausman, E., Risks and Opportunities for PacifiCorp in a Carbon Constrained Economy, Produced on behalf of the Sierra Club, October 2014.

Luckow, P., E. Stanton, B. Biewald, J. Fisher, F. Ackerman, E. Hausman, 2013 Carbon Dioxide Price Forecast, Synapse Energy Economics, November 2013.

Stanton, E., T. Comings, K. Takahashi, P. Knight, T. Vitolo, E. Hausman, Economic Impacts of the NRDC Carbon Standard: Background Report prepared for the Natural Resources Defense Council, Synapse Energy Economics for NRDC, June 2013

Comings T., P. Knight, E. Hausman, Midwest Generation's Illinois Coal Plants: Too Expensive to Compete? (Report Update) Synapse Energy Economics for Sierra Club, April 2013

Stanton E., F. Ackerman, T. Comings, P. Knight, T. Vitolo, E. Hausman, Will LNG Exports Benefit the United States Economy? Synapse Energy Economics for Sierra Club, January 2013

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Wilson R., P. Luckow, B. Biewald, F. Ackerman, and E.D. Hausman, 2012 Carbon Dioxide Price Forecast, Synapse Energy Economics, October 2012.

Fagan B., M. Chang, P. Knight, M. Schultz, T. Comings, E.D. Hausman, and R. Wilson, The Potential Rate Effects of Wind Energy and Transmission in the Midwest ISO Region. Synapse Energy Economics for Energy Future Coalition, May 2012.

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Hausman E.D., T. Comings, K. Takahashi, R. Wilson, and W. Steinhurst, Electricity Scenario Analysis for the Vermont Comprehensive Energy Plan 2011. Synapse Energy Economics for Vermont Department of Public Service, September 2011.

Wittenstein M., E.D. Hausman, Incenting the Old, Preventing the New: Flaws in Capacity Market Design, and Recommendations for Improvement. Synapse Energy Economics for American Public Power Association, June 2011.

Johnston L., E.D. Hausman, B. Biewald, R. Wilson, and D. White. 2011 Carbon Dioxide Price Forecast. Synapse Energy Economics White Paper, February 2011.

Hausman E.D., V. Sabodash, N. Hughes, and J. I. Fisher, Economic Impact Analysis of New Mexico's Greenhouse Gas Emissions Rule. Synapse Energy Economics for New Energy Economy, February 2011.

Hausman E.D., J. Fisher, L. Mancinelli, and B. Biewald. Productive and Unproductive Costs of CO2 Cap-and-Trade: Impacts on Electricity Consumers and Producers. Synapse Energy Economics for National Association of Regulatory Utility Commissioners, National Association of State Utility Consumer Advocates, National Rural Electric Cooperative Association, and American Public Power Association, July 2009.

Peterson P., E. Hausman, R. Fagan, and V. Sabodash, Report to the Ohio Office of Consumer Counsel, on the value of continued participation in RTOs. Filed under Ohio PUC Case No. 09-90-EL-COI, May 2009.

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Hausman E.D., J. Fisher and B. Biewald, Analysis of Indirect Emissions Benefits of Wind, Landfill Gas, and Municipal Solid Waste Generation. Synapse Energy Economics Report to the Air Pollution Prevention and Control Division, National Risk Management Research Laboratory, U.S. Environmental Protection Agency, July 2008.

Hausman E.D. and C. James, Cap and Trade CO2 Regulation: Efficient Mitigation or a Give-away? Synapse Enegy Ecomics presentation to the ELCON Spring Workshop, June 2008.

Hausman E.D., R. Hornby and A. Smith, Bilateral Contracting in Deregulated Electricity Markets. Synapse Energy Economics for the American Public Power Association, April 2008.

Hausman E.D., R. Fagan, D. White, K. Takahashi and A. Napoleon, LMP Electricity Markets: Market Operations, Market Power and Value for Consumers. Synapse Energy Economics for the American Public Power Association's Electricity Market Reform Initiative (EMRI) symposium, "Assessing Restructured Electricity Markets" in Washington, DC, February 2007.

Hausman E.D. and K. Takahashi, The Proposed Broadwater LNG Import Terminal Response to Draft Environmental Impact Statement and Update of Synapse Analysis. Synapse Energy Economics for the Connecticut Fund for the Environment and Save The Sound, January 2007.

Hausman E.D., K. Takahashi, D. Schlissel and B. Biewald, The Proposed Broadwater LNG Import Terminal: An Analysis and Assessment of Alternatives. Synapse Energy Economics for the Connecticut Fund for the Environment and Save The Sound, March 2006.

Hausman E.D., P. Peterson, D. White and B. Biewald, RPM 2006: Windfall Profits for Existing Base Load Units in PJM: An Update of Two Case Studies. Synapse Energy Economics for the Pennsylvania Office of Consumer Advocate and the Illinois Citizens Utility Board, February 2006.

Hausman E.D., K. Takahashi, and B. Biewald, The Glebe Mountain Wind Energy Project: Assessment of Project Benefits for Vermont and the New England Region. Synapse Energy Economics for Glebe Mountain Wind Energy, LLC., February 2006.

Hausman E.D., K. Takahashi, and B. Biewald, The Deerfield Wind Project: Assessment of the Need for Power and the Economic and Environmental Attributes of the Project. Synapse Energy Economics for Deerfield Wind, LLC., January 2006.

Hausman E.D., P. Peterson, D. White and B. Biewald, An RPM Case Study: Higher Costs for Consumers, Windfall Profits for Exelon. Synapse Energy Economics for the Illinois Citizens Utility Board, October 2005.

Hausman E.D. and G. Keith, Calculating Displaced Emissions from Energy Efficiency and Renewable Energy Initiatives. Synapse Energy Economics for EPA website 2005

Rudkevich A., E.D. Hausman, R.D. Tabors, J. Bagnal and C Kopel, Loss Hedging Rights: A Final Piece in the LMP Puzzle. Hawaii International Conference on System Sciences, Hawaii, January, 2005 (accepted).

Hausman E.D. and R.D. Tabors, The Role of Demand Underscheduling in the California Energy Crisis. Hawaii International Conference on System Sciences, Hawaii, January 2004.

Hausman E.D. and M.B. McElroy, The reorganization of the global carbon cycle at the last glacial termination. Global Biogeochemical Cycles, 13(2), 371-381, 1999.

Norton F.L., E.D. Hausman and M.B. McElroy, Hydrospheric transports, the oxygen isotope record, and tropical sea surface temperatures during the last glacial maximum. Paleoceanography, 12, 15-22, 1997.

Hausman E.D. and M.B. McElroy, Variations in the oceanic carbon cycle over glacial transitions: a time-dependent box model simulation. Presented at the spring meeting of the American Geophysical Union, San Francisco, 1996.

PRESENTATIONS AND WORKSHOPS

American Public Power Association: Invited expert participant in APPA's roundtable discussion of the current state of the RTO-operated electricity markets. October 2013.

California Long-Term Resource Adequacy Summit (Sponsored by the California ISO and the California Public Utility Commission): Panelist on "Applying Alternative Models to the California Market Construct." February 26, 2013.

ELCON 2011 Fall Workshop: "Do RTOs Need a Capacity Market?" October 2011.

Harvard Electricity Policy Group: Presentation on state action to ensure reliability in the face of capacity market failure. February 2011.

NASUCA 2010 Annual Conference: "Addressing Climate Change while Protecting Consumers." November 2010.

NASUCA Consumer Protection Committee: Briefing on the Synapse report entitled, "Productive and Unproductive Costs of CO_2 Cap-and-Trade." September 2009.

NARUC 2009 Summer Meeting: Invited speaker on topic: "Productive and Unproductive Costs of CO2 Cap-and-Trade." July, 2009.

NASUCA 2008 Mid-Year Meeting**:** Invited speaker on the topic, "Protecting Consumers in a Warming World, Part II: Deregulated Markets." June 2008.

Center for Climate Strategies: Facilitator and expert analyst on state-level policy options for mitigating greenhouse gas emissions. Serve as facilitator/expert for the Electricity Supply (ES) and Residential, Commercial and Industrial (RCI) Policy Working Groups in the states of Colorado and South Carolina. 2007-2008.

NASUCA 2007 Mid-Year Meeting**:** Invited speaker on the topic, "Protecting Consumers in a Warming World" June 2007.

ASHRAE Workshop on estimating greenhouse gas emissions from buildings in the design phase: Participant expert on estimating displaced emissions associated with energy efficiency in building design. Also hired by ASHRAE to document and produce a report on the workshop. April, 2007.

Assessing Restructured Electricity Markets An American Public Power Association Symposium: Invited speaker on the history and effectiveness of Locational Marginal Pricing (LMP) in northeastern United States electricity markets, February, 2007.

ASPO-USA 2006 National Conference: Invited speaker and panelist on the future role of LNG in the U.S. natural gas market, October, 2006.

Market Design Working Group: Participant in FERC-sponsored settlement process for designing capacity market structure for PJM on behalf of coalition of state utility consumer advocates, July-August 2006.

***NASUCA 2006 Mid-Year Meeting*:** Invited speaker on the topic, "How Can Consumer Advocates Deal with Soaring Energy Prices?" June 2006.

Soundwaters Forum, Stamford, CT: Participated in a debate on the need for proposed Broadwater LNG terminal in Long Island Sound, June 2006.

Energy Modeling Forum: Participant in coordinated academic exercise focused on modeling US and world natural gas markets, December 2004.

Massachusetts Institute of Technology (MIT): Guest lecturer in Technology and Policy Program on electricity market structure, the LMP pricing system and risk hedging with FTRs. 2002-2005.

LMP: The Ultimate Hands-On Seminar. Two-day seminar held at various sites to explore concepts of LMP pricing and congestion risk hedging, including lecture and market simulation exercises. Custom seminars held for FERC staff, ERCOT staff, and various industry groups. 2003-2004.

Learning to Live with Locational Marginal Pricing: Fundamentals and Hands-On Simulation. Day-long seminar including on-line mock electricity market and congestion rights auction, December 2002.

LMP in California. Led a series of seminars on the introduction of LMP in the California electricity market, including on-line market simulation exercise. 2002.

Resume updated May 2020

Docket No. UE 374
Exhibit Sierra Club/302
Witness: Ezra Hausman

PUBLIC UTILITY COMMISSION OF OREGON

UE 374

SIERRA CLUB EXHIBIT 302

Exhibits Accompanying the Opening Testimony of Ezra D. Hausman, Ph.D.

Oregon Governor Kate Brown’s Executive Order No. 20-04

Office of the Governor
State of Oregon

EXECUTIVE ORDER NO. 20-04

DIRECTING STATE AGENCIES TO TAKE ACTIONS TO REDUCE AND REGULATE GREENHOUSE GAS EMISSIONS

WHEREAS, climate change and ocean acidification caused by greenhouse gas (GHG) emissions are having significant detrimental effects on public health and on Oregon's economic vitality, natural resources, and environment; and

WHEREAS, climate change has a disproportionate effect on the physical, mental, financial, and cultural wellbeing of impacted communities, such as Native American tribes, communities of color, rural communities, coastal communities, lower-income households, and other communities traditionally underrepresented in public processes, who typically have fewer resources for adapting to climate change and are therefore the most vulnerable to displacement, adverse health effects, job loss, property damage, and other effects of climate change; and

WHEREAS, climate change is contributing to an increase in the frequency and severity of wildfires in Oregon, endangering public health and safety and damaging rural economies; and

WHEREAS, the world's leading climate scientists, including those in the Oregon Climate Change Research Institute, predict that these serious impacts of climate change will worsen if prompt action is not taken to curb emissions; and

WHEREAS, the Intergovernmental Panel on Climate Change has identified limiting global warming to 2 degrees Celsius or less as necessary to avoid potentially catastrophic climate change impacts, and remaining below this threshold requires accelerated reductions in GHG emissions to levels at least 80 percent below 1990 levels by 2050; and

WHEREAS, Oregon, as a member of the U.S. Climate Alliance, has committed to implementing policies to advance the emissions reduction goals of the international Paris Agreement; and

WHEREAS, GHG emissions present a significant threat to Oregon's public health, economy, safety, and environment; and

WHEREAS, the transition from fossil fuels to cleaner energy resources can significantly reduce emissions and increase energy security and the resilience of Oregon communities in the face of climate change; and

WHEREAS, emissions from the transportation sector are the single largest source of GHG emissions in Oregon; and

WHEREAS, actions to reduce GHG emissions in Oregon's transportation sector will provide substantial public health co-benefits by reducing air pollutants from the combustion of gasoline and diesel fuel that are harmful to human health; and

WHEREAS, the rapid transition from internal combustion engines to zero-emission vehicles will play a key role in reducing emissions from the transportation sector and advancing the state's GHG emissions reduction goals; and

WHEREAS, zero-emission vehicles provide multiple benefits to Oregonians, including lower operating, maintenance, and fuel costs, and lower emissions of GHGs and other pollutants; and

WHEREAS, the Legislature established ambitious goals for the adoption of zero-emission vehicles in Senate Bill 1044 (2019); and

WHEREAS, rapid actions and investments by Oregon's utility sector to reduce GHG emissions and improve the resilience of the energy system in the face of climate change and wildfire risk can reduce risks for utility customers; and

WHEREAS, transitioning the traditional natural gas supply to renewable natural gas can significantly reduce GHG emissions; and

WHEREAS, energy efficiency standards in the built environment can reduce operating costs, save renters and homeowners money on their utility bills, improve the comfort and habitability of dwellings, and reduce GHG emissions; and

WHEREAS, product energy efficiency standards reduce costs for consumers, save energy, and reduce GHG emissions; and

Office of the Governor
State of Oregon

WHEREAS, in the absence of effective federal engagement on these issues, it is the responsibility of individual states to take immediate actions to address climate change and ocean acidification; and

WHEREAS, after thorough hearings within the Oregon Legislature, a majority of both chambers support addressing climate change, and the failure of the Oregon Legislature to attain quorum has thwarted legislative action to achieve science-based GHG emissions reduction goals; and

WHEREAS, given the urgency and severity of the risks from climate change and ocean acidification, and the failure of the Legislature to address these immediate harms, the executive branch has a responsibility to the electorate, and a scientific, economic, and moral imperative to reduce GHG emissions and to reduce the worst risks of climate change and ocean acidification for future generations, to the greatest extent possible within existing laws; and

WHEREAS, existing laws grant authority to state agencies to take actions to regulate and encourage a reduction of GHG emissions in a variety of circumstances; and

WHEREAS, the Legislature through the Emergency Board took action on March 9, 2020, to provide permanent funding to the executive branch to pursue executive action on reducing GHG emissions; and

WHEREAS, considering climate change in agency planning and decision making will help inform decisions regarding climate change risks and avoid higher mitigation and adaptation costs in the future; and

WHEREAS, all agencies with jurisdiction over the sources of GHG emissions will need to continue to develop and implement programs that reduce emissions to reach the state's GHG goals; and

WHEREAS, all agencies with jurisdiction over natural and working landscapes in Oregon will need to prepare and plan for the impacts of climate change and take actions to encourage carbon sequestration and storage; and

WHEREAS, the Legislature previously established the goal of achieving GHG levels "at least 75 percent below 1990 levels" by 2050, and our State has an urgent, moral obligation to set and achieve more ambitious GHG reduction goals.

NOW, THEREFORE, **IT IS HEREBY DIRECTED AND ORDERED:**

1. State Agencies. The following state commissions and state agencies are subject to the directives set forth in this Executive Order:

A. Business Oregon;

B. Department of Administrative Services (DAS);

C. Department of Consumer and Business Services Building Codes Division (BCD);

D. Department of Land Conservation and Development (DLCD) and Land Conservation and Development Commission (LCDC);

E. Environmental Justice Task Force;

F. Environmental Quality Commission (EQC) and Department of Environmental Quality (DEQ);

G. Oregon Department of Agriculture (ODA);

H. Oregon Department of Energy (ODOE);

I. Oregon Department of Fish and Wildlife (ODFW);

J. Oregon Department of Forestry (ODF);

K. Oregon Department of Transportation (ODOT) and Oregon Transportation Commission (OTC);

L. Oregon Global Warming Commission;

M. Oregon Health Authority (OHA);

N. Oregon Water Resources Department (OWRD);

0. Oregon Watershed Enhancement Board (OWEB); and

P. Public Utility Commission of Oregon (PUC).

Office of the Governor
State of Oregon

EXECUTIVE ORDER NO. 20-04
PAGE FIVE

2. **GHG Emissions Reduction Goals.** Consistent with the minimum GHG reduction goals set forth in ORS 468A.205(1)(c), this Executive Order establishes science-based GHG emissions reduction goals, and calls for the State of Oregon to reduce its GHG emissions (1) at least 45 percent below 1990 emissions levels by 2035; and (2) at least 80 percent below 1990 emissions levels by 2050.

3. **General Directives to State Agencies.** From the date of this Executive Order, the state commissions and state agencies listed in paragraph 1 are directed to take the following actions:

   A. GHG Reduction Goals. Agencies shall exercise any and all authority and discretion vested in them by law to help facilitate Oregon's achievement of the GHG emissions reduction goals set forth in paragraph 2 of this Executive Order.

   B. Expedited Agency Processes. To the full extent allowed by law, agencies shall prioritize and expedite any processes and procedures, including but not limited to rulemaking processes and agency dockets, that could accelerate reductions in GHG emissions.

   C. Agency Decisions. To the full extent allowed by law, agencies shall consider and integrate climate change, climate change impacts, and the state's GHG emissions reduction goals into their planning, budgets, investments, and policy making decisions. While carrying out that directive, agencies are directed to:

      (1) Prioritize actions that reduce GHG emissions in a cost-effective manner;

      (2) Prioritize actions that will help vulnerable populations and impacted communities adapt to climate change impacts; and

      (3) Consult with the Environmental Justice Task Force when evaluating climate change mitigation and adaptation priorities and actions.

   D. Report on Proposed Actions. The following agencies are directed to report to the Governor by May 15, 2020, on proposed actions within their statutory authority to reduce GHG emissions and mitigate climate change impacts: DEQ, DLCD, ODA, ODOE, ODFW, ODF, ODOT, OWRD, OWEB, and PUC.

EXECUTIVE ORDER NO. 20-04
PAGE SIX

E. Participation in Interagency Workgroup on Climate Impacts to Impacted Communities. The Governor's Office will convene an interagency workgroup on climate impacts to impacted communities to develop strategies to guide state climate actions, with participation by the following agencies and commissions: DEQ, DLCD, ODA, ODF, ODFW, ODOE, ODOT, OHA, OWEB, OWRD, PUC, Environmental Justice Task Force, Oregon Global Warming Commission, Oregon Parks and Recreation Department, and Oregon Sustainability Board.

4. **Directives to the Environmental Quality Commission and the Department of Environmental Quality.** In addition to the general directives set forth in paragraph 3, the EQC and DEQ are directed to take the following actions:

A. Oregon's Clean Fuel Standards. Pursuant to its authority under ORS 468A.265 *et seq.* and other applicable laws, the EQC and DEQ shall take actions necessary to amend the low carbon fuel standards, and the schedule to phase in implementation of those standards, with the goal of reducing the average amount of GHG emissions per unit of fuel energy by 20 percent below 2015 levels by 2030, and 25 percent below 2015 levels by 2035.

B. Clean Fuel Credits for Electrification. The EQC and DEQ are directed to advance methods accelerating the generation and aggregation of clean fuels credits by utilities that can advance the transportation electrification goals set forth in Senate Bill 1044 (2019).

C. Sector-specific GHG Cap and Reduce Program. Pursuant to its authority under ORS 468A.005 *et seq.* and other applicable laws, the EQC and DEQ shall take actions necessary to:

(1) Cap and reduce GHG emissions from large stationary sources of GHG emissions, consistent with the science-based emissions reduction goals set forth in paragraph 2 of this Executive Order;

(2) Cap and reduce GHG emissions from transportation fuels, including gasoline and diesel fuel, consistent with the science-based emissions reduction goals set forth in paragraph 2 of this Executive Order; and

Office of the Governor
State of Oregon

(3) Cap and reduce GHG emissions from all other liquid and gaseous fuels, including natural gas, consistent with the science-based emissions reduction goals set forth in paragraph 2 of this Executive Order.

D. Regulation of Landfill Methane Emissions. The EQC and DEQ shall take actions necessary to reduce methane gas emissions from landfills, as defined in ORS 459.005(14), that are aligned with the most stringent standards and requirements for reducing methane gas emissions from landfills adopted among the states having a boundary with Oregon.

E. Reduction of Food Waste. The EQC and DEQ are directed to take actions necessary to prevent and recover food waste, with the goal of reducing food waste by 50 percent by 2030, to reduce GHG emissions resulting from such waste, including but not limited to engaging with states and other jurisdictions, industry, food retailers, and brand manufacturers to develop and implement strategies to prevent and recover food waste.

F. Timeline and Implementation.

(1) No later than May 15, 2020, DEQ shall submit a report to the Governor regarding an estimated timeline for rulemaking necessary for implementing the directives of paragraph 4(A)—(B) and paragraph 4(D)—(E), above.

(2) DEQ shall submit a preliminary report to the Governor by May 15, 2020, regarding program options to cap and reduce emissions from large stationary sources, transportation fuels, and other liquid and gaseous fuels that can commence no later than January 1, 2022. A final report shall be due by June 30, 2020.

(3) Reports submitted pursuant to paragraph 4 of this Executive Order also should detail DEQ's plans to engage impacted communities during the rulemaking process, in a manner consistent with ORS chapter 183.

5. **Directives to the Public Utility Commission of Oregon.** In addition to the general directives set forth in paragraph 3, the PUC is directed to consider the following factors and values, consistent with state law:

A. Statement of Public Interest. It is in the interest of utility customers and the public generally for the utility sector to take actions that result in rapid reductions of GHG emissions, at reasonable costs, to levels consistent with the GHG emissions reduction goals set forth in paragraph 2 of this Executive Order, including transitioning to clean energy resources and expanding low carbon transportation choices for Oregonians.

B. Regulatory Considerations. Executive Order 00-06, which ensures that the PUC maintains its independence in decision making, is reaffirmed. The directives in this Executive Order are consistent with Executive Order 00-06. When carrying out its regulatory functions, the PUC is directed to:

(1) Determine whether utility portfolios and customer programs reduce risks and costs to utility customers by making rapid progress towards reducing GHG emissions consistent with Oregon's reduction goals;

(2) Encourage electric companies to support transportation electrification infrastructure that supports GHG reductions, helps achieve the transportation electrification goals set forth in Senate Bill 1044 (2019), and is reasonably expected to result in long-term benefit to customers;

(3) Prioritize proceedings and activities, to the extent consistent with other legal requirements, that advance decarbonization in the utility sector, and exercise its broad statutory authority to reduce GHG emissions, mitigate energy burden experienced by utility customers, and ensure system reliability and resource adequacy;

(4) Evaluate electric companies' risk-based wildfire protection plans and planned activities to protect public safety, reduce risks to utility customers, and promote energy system resilience in the face of increased wildfire frequency and severity, and in consideration of the recommendations made by the Governor's Council on Wildfire Response 2019 Report and Recommendations;

(5) Convening periodic workshops for purposes of assisting electric companies, consumer-owned utilities, and operators of electrical distribution systems to develop and share best practices for mitigating wildfire risk; and

(6) In cooperation with Oregon Housing and Community Services, establish a public process to address and mitigate differential energy burdens and other inequities of affordability and environmental justice, including rate design and other programs to mitigate energy burden.

6. **Directives to the Department of Consumer and Business Services Building Codes Division.** In addition to the general directives set forth in paragraph 3, BCD is directed to take the following actions:

A. Energy Efficiency Goal for New Construction. BCD, through its advisory boards and committees, and in cooperation with ODOE, is directed to adopt building energy efficiency goals for 2030 for new residential and commercial construction. That goal shall represent at least a 60 percent reduction in new building annual site consumption of energy, excluding electricity used for transportation or appliances, from the 2006 Oregon residential and commercial codes.

B. Code Progress and Updates. BCD, through its advisory boards and committees, and in cooperation with ODOE, is directed to evaluate and report on Oregon's current progress toward achieving the goal for new residential and commercial buildings, pursuant to paragraph 6(A) of this Executive Order, and options for achieving steady progress toward the goal over the next three code cycles (2023, 2026, and 2029). Pursuant to its authority under ORS 455.500, BCD also is directed to update the Reach Code on the same timeline. No later than September 15, 2020, BCD should submit a report to the Governor on current progress and options for achieving the goals over the next three code cycles. The report should be updated every three years thereafter.

C. Baseline Metrics and Reductions. BCD, in cooperation with ODOE, is directed to agree on metrics, based on best practice and academic research, to inform the baseline and reductions associated with the code updates set forth in paragraph 6(B).

7. **Directives to the Oregon Department of Energy.** In addition to the general directives set forth in paragraph 3, ODOE is directed to take the following actions:

A. Energy Efficiency Standards. ODOE is directed to pursue emissions reductions by establishing and updating energy efficiency standards for products at least to levels equivalent to the most stringent standards among West Coast jurisdictions, including grid-connected appliances that can be utilized to manage end-use flexible electrical loads. ODOE also is directed to periodically evaluate and update those standards, as practicable, to remain at least equivalent to the most stringent standards among West Coast jurisdictions.

B. Rulemaking. ODOE is directed to take actions necessary to establish and update energy efficiency standards for products sold or installed in Oregon that include but are not limited to the following:

(1) High CRI fluorescent lamps;

(2) Computers and computer monitors;

(3) Faucets;

(4) Shower heads;

(5) Commercial fryers;

(6) Commercial dishwashers;

(7) Commercial steam cookers;

(8) Residential ventilating fans;

(9) Electric storage water heaters; and

(10) Portable electric spas.

C. Timeline. Any rulemaking necessary to implement the directives set forth in paragraph 7(B) should be completed by September 1, 2020.

D. Third-Party Validation for Cost Savings. ODOE, in cooperation with BCD, is directed to contract with a third party consulting firm to assess cost implications, including long-term energy cost savings, of the energy efficiency and building code actions set forth in paragraph 6(A)—(B) of this Executive Order.

8. **Directives to the Department of Administrative Services.** In addition to the general directives set forth in paragraph 3, DAS is directed to take the following actions:

   A. Procurement Model for Zero-Emission Vehicles. DAS is directed to develop a statewide policy and plan for state agencies to follow for procuring zero-emission vehicles, which local governments and special government bodies may use as a model program for furthering adoption of zero-emission vehicles for their fleets. The model program shall provide for a rate of procurement of zero-emission vehicles consistent with the findings and goals set forth in ORS 283.398 and the provisions of ORS 283.327. The model program may provide for DAS to participate in, sponsor, conduct, or administer cooperative procurements in accordance with ORS 279A.200 to ORS 279A.225, under which DAS, local governments, and special government bodies may procure zero-emission vehicles.

   B. GHG Implications of Contracting. DAS is directed to review existing state procurement laws and practices to identify potential improvements that can reduce GHG emissions, consistent with the GHG reduction goals set forth in paragraph 2 of this Executive Order. DAS shall provide a report to the Governor no later than September 15, 2020, detailing options.

   C. GHG Reduction Goals and Electrification Goals. DAS is directed to support the state in meeting the GHG reduction goals set forth in paragraph 2 of this Executive Order, and the zero-emission vehicle adoption goals set forth in Senate Bill 1044 (2019), through the rapid conversion of state fleets to zero-emission vehicles, and the expansion of electric vehicle charging infrastructure for public buildings. DAS shall provide a report to the Governor no later than September 15, 2020, detailing its plan.

9. **Directives to the Oregon Transportation Commission, Oregon Department of Transportation, Land Conservation and Development Commission, Environmental Quality Commission, and Oregon Department of Energy.**

**Office of the Governor
State of Oregon**

A. In a letter from the Governor, dated September 23, 2019, the OTC, LCDC, EQC, and ODOE were directed to prioritize implementation of the Statewide Transportation Strategy, adopted by the OTC. Those agencies are further directed to include the following elements in their implementation of the Statewide Transportation Strategy:

(1) Establishment of GHG emissions reduction performance metrics; and

(2) Amendments to the Transportation Planning Rule that direct changes to the transportation plans of metropolitan planning areas to meet GHG reduction goals.

B. ODOT and DLCD are directed to identify and implement means to provide financial and technical assistance to metropolitan planning areas for amendment to transportation and land use plans that meet the state GHG reduction goals, or more stringent goals adopted by a metropolitan planning area.

C. Implementation of the directives set forth in paragraph 9(A)—(B) shall be at the highest level within the agencies, with regular and direct reporting to the Governor. The first report shall be made to the Governor no later than June 30, 2020.

10. **Directives to the Oregon Department of Transportation.** In addition to the general directives set forth in paragraph 3, ODOT is directed to take the following actions:

A. In consultation with DEQ, ODOE, other appropriate state agencies, and public utilities, ODOT is directed to conduct a statewide transportation electrification infrastructure needs analysis, with particular focus on rural areas of the state, across use types and vehicle classes, to facilitate the transportation electrification goals set forth in Senate Bill 1044 (2019). The study should be completed no later than June 30, 2021.

B. ODOT is directed to develop and apply a process for evaluating the GHG emissions implications of transportation projects as part of its regular capital planning and Statewide Transportation Improvement Program planning processes. ODOT shall provide a report on the process to the Governor no later than June 30, 2021.

11. **Directives to Oregon Health Authority.** In addition to the general directives set forth in paragraph 3, OHA is directed to take the following actions:

    A. OHA is directed to deliver a report to the Governor, the Oregon Global Warming Commission, and the Environmental Justice Task Force no later than September 1, 2020, on the public health impacts of climate change in Oregon, with particular emphasis on the risks faced by vulnerable communities, including Oregon's nine federally recognized Native American tribes, communities of color, low income communities, and rural communities. OHA is directed to update the report annually.

    B. OHA is directed to study the impacts of climate change on youth depression and mental health in Oregon and deliver a report to the Governor no later than June 30, 2021.

    C. OHA and the Oregon Occupational Safety and Health Administration (OSHA) are directed to jointly develop a proposal for standards to protect workplace employees from exposure to wildfire smoke and excessive heat. The proposal should be completed no later than June 30, 2021.

12. **Directives to Oregon Global Warming Commission.** In addition to the general directives set forth in paragraph 3, the Global Warming Commission is directed to take the following actions:

    A. In coordination with ODA, ODF, and OWEB, the Oregon Global Warming Commission is directed to submit a proposal to the Governor for consideration of adoption of state goals for carbon sequestration and storage by Oregon's natural and working landscapes, including forests, wetlands, and agricultural lands, based on best available science. The proposal shall be submitted no later than June 30, 2021.

    B. Consistent with its reporting requirements in House Bill 3543 (2007), the Oregon Global Warming Commission shall also include reporting on progress toward the GHG reduction goals set forth in paragraph 2 of this Executive Order, and the zero-emission vehicle adoption goals set forth in SB 1044 (2019).

Office of the Governor
State of Oregon

EXECUTIVE ORDER NO. 20-04
PAGE FOURTEEN

13. **Effectiveness.** This Executive Order will remain in effect unless and until it is superseded by statute or another Executive Order.

Done at Salem, Oregon, this I ely of March, 2020.

k4.Lthil"
Kate Brown
GOVERNOR

ATTEST:

____

Bev Clarno
SECRETARY OF STATE

Docket No. UE 374
Exhibit Sierra Club/303
Witness: Ezra Hausman

PUBLIC UTILITY COMMISSION
OF OREGON

UE 374

SIERRA CLUB EXHIBIT 303

Exhibits Accompanying the Opening Testimony of Ezra D. Hausman, Ph.D.

Oregon Governor Kate Brown's Executive Order No. 17-20

Office of the Governor
State of Oregon

EXECUTIVE ORDER NO. 17-20

ACCELERATING EFFICIENCY IN OREGON'S BUILT ENVIRONMENT TO REDUCE GREENHOUSE GAS EMISSIONS AND ADDRESS CLIMATE CHANGE

WHEREAS, climate change presents a significant threat to our livelihoods, economic security, environment, health, and well-being.

WHEREAS, there has been an increase in extreme weather events, including more frequent and intense heat waves and wildfires. According to the Oregon Climate Change Research Institute and other regional studies, the best available science indicates Oregon is at risk of serious impacts to its natural resources due to climate change.

- Water resources are being affected by decreased winter snowpack, changes to seasonal runoff patterns, decreased precipitation in Eastern Oregon, and increased intensity and occurrence of flooding.
- Agricultural resources are being affected by increases in temperatures.
- Ocean acidification is increasing and there are changes in ocean currents.
- Significant parts of the Oregon coastal region, stretching 363 miles, will be impacted by an expected rise in sea level up to 1 to 4 feet by 2100, incurring billions of dollars of damages and losses to roadways and structures.
- Climate change impacts threaten the State's agricultural, fishing, timber, recreation, and tourism industries, thereby threatening the livelihood of the State's residents and an important source of Gross State Product for the state.

WHEREAS, energy efficiency leads to significant greenhouse gas reductions that are essential to meeting our state greenhouse gas reduction goals and addressing climate change.

WHEREAS, Oregon is committed to meeting the international Paris Agreement targets to reduce greenhouse gas emissions by 26 to 28 percent below 2005 levels by 2025.

WHEREAS, Oregon has adopted goals to reduce greenhouse gas emissions to 10 percent below 1990 levels by 2020 and at least 75 percent below 1990 levels by 2050 as described in ORS 468A.20.

WHEREAS, saving energy by using less energy in buildings is one of the least cost ways to achieve emissions reductions in the energy system – often with a net financial savings over the life of these energy efficiency measures, in particular as energy efficiency technology continues to improve.

WHEREAS, studies have found that building codes in Oregon have had a 97 percent compliance rate; and as building codes become more energy efficient, we will continue to strive toward excellence in construction and building codes, which are applicable statewide and provide uniformity and predictability for building owners and contractors and equity for residents and businesses.

WHEREAS, Oregon is an international leader in energy efficiency, has in-state energy efficiency expertise, and a skilled workforce to continue to be a leader; and Oregon can build on its reputation through emphasis on state leadership, building codes for newly constructed buildings, and retrofits for existing buildings.

WHEREAS, energy efficiency is a critical and growing portion of the State's clean energy economy. Investments in energy efficiency sustain a workforce of over 40,000 jobs statewide; 70 percent of these are small businesses with 11 employees or fewer. Investments in energy efficiency result in an average annual increase of gross state product of over $132 million, and the resulting reduction in energy costs generates an additional $32 million per year.

WHEREAS, low income and other underserved communities often struggle to access energy efficiency programs that will save them money and improve housing quality over the long-term and the State can take steps to implement policies that increase the availability of energy efficiency to these residents.

WHEREAS, state government has a responsibility to lead by example in its adoption of energy efficiency to achieve a more cost-effective and clean energy future.

WHEREAS, energy efficiency actions increase the health, safety, and resiliency of Oregon's buildings and homes, resulting in lower health care costs borne by the State and its residents.

EXECUTIVE ORDER NO. 17-20
PAGE 3

WHEREAS, an energy system with distributed generation, energy efficiency, and storage capacity can build resiliency in the face of climate change related disruptions and other disasters.

NOW, THEREFORE, IT IS HEREBY DIRECTED AND ORDERED:

1. **Definition.** For purposes of this Executive Order, "state agency" shall be defined as any agency within the Executive Department as defined in ORS 174.112, other than the Oregon Secretary of State, Oregon State Treasury, Oregon Department of Justice, and Oregon Bureau of Labor and Industries.

2. **Statement of Policy.** It is the policy of the State of Oregon to establish an aggressive timeline to achieve net zero energy ready buildings as a standard practice in buildings across the state. Review and regular improvements to the energy provisions of the state building code will occur on at least a three-year cycle for residential and commercial buildings. Directives in this Executive Order related to energy efficiency, electric vehicle readiness, and solar installation readiness are essential to meeting this policy, as is a focus on retrofitting older, less-efficient buildings and demonstrating energy efficiency leadership in state-owned and state-leased buildings.

3. **Energy Efficiency Leadership in State Buildings**

   A. <u>High Performance Energy Targets for Existing State Buildings</u>. State agencies will use high performance energy use targets for remodels in all existing state-owned buildings. Department of Administrative Services (DAS) and Oregon Department of Energy (ODOE) are directed to consider ASHRAE 100 Standard pathways and work with all state agencies to adopt targets for any remodels that begin after the date of this executive order. State agencies that are not meeting energy use targets will work with ODOE and DAS to undertake energy retrofits to increase the efficiency of their buildings. ODOE is directed to report on and track all state-owned building energy use to guide agencies to implement tactical and achievable energy use reductions. ODOE will work with all agencies to benchmark and identify buildings for retrofits. A database of all eligible state-owned buildings will be created by June 1, 2018.

B. Carbon-Neutral Operations for New State Buildings. DAS and ODOE are directed to work with state agencies to ensure that new state owned buildings permitted after January 1, 2022 and used primarily for office and other commercial work space are designed to be able to operate as carbon-neutral buildings defined with full fuel-cycle considerations that are inclusive of, but not limited to, off-site renewable energy and other provisions of ASHRAE standard 189.1. In addition, DAS and ODOE are directed to analyze feasible options with the Department of Environmental Quality that would lower the embodied carbon of building materials in new construction of state buildings.

C. Statewide Plug-Load Strategy. DAS and ODOE are directed to develop a statewide plug-load management strategy and strategies for other occupant behavior changes to reduce energy uses not regulated by codes and standards. DAS and ODOE will develop a plug load strategy by January 1, 2019, and DAS will update policies for behavior-based efficiency by January 1, 2020.

D. Energy Efficient Equipment. DAS, with support from ODOE, is directed to ensure that all equipment purchased by the state meets high-efficiency energy and water use specifications by incorporating efficiency standards into procurement requirements. DAS and ODOE will develop procurement requirements in the 2018-19 fiscal year.

E. Lifecycle Cost Analysis. ODOE is directed to analyze state building costs, including lifecycle energy and water use costs or savings, when considering energy and water upgrades for state buildings. By January 1, 2019, ODOE, working with DAS, will develop analysis tools that can inform the high performance energy use targets and carbon neutral requirements for state buildings referenced above.

4. **Increasing Energy and Water Efficiency in New Construction Across the State**

A. Solar Ready Building Construction. The appropriate advisory board(s) and the Department of Business and Consumer Services Building Codes Division (BCD) are directed to conduct code amendment of the state building code to require all newly constructed buildings will be ready for the installation of solar panels and related technologies by October 1, 2020 for residential structures and October 1, 2022 for commercial structures. BCD may establish limited specific exemptions to this solar-ready policy for buildings where solar applications are infeasible.

B. Electric Vehicle Ready Building Construction. The appropriate advisory board(s) and BCD are directed to conduct code amendment of the state building code to require that parking structures for all newly constructed residential and commercial buildings are ready to support the installation of at least a level 2 EV charger by October 1, 2022. BCD may establish limited specific exemptions related to types of parking lots, such as temporary parking lots.

C. Zero-Energy Ready Homes. The appropriate advisory board(s) and BCD are directed to conduct code amendment of the state building code to require newly constructed residential buildings to achieve at least equivalent performance levels with the 2017 U.S. Department of Energy Zero Energy Ready Standard by October 1, 2023.

D. Increasing Energy Efficiency in Commercial Construction. The appropriate advisory board(s) and BCD are directed to conduct code amendment of the state building code to require, by October 1, 2022, that newly constructed commercial buildings, averaged across building types, will exceed International Energy Conservation Code and ASHRAE 90.1 by achieving at least equivalent performance levels with the measurable prescriptive energy efficiency portions of the most current version of ASHRAE 189.1 that are construction-related.

E. Helping Key, Expanding Industries to Save Costs by Reducing their Energy Footprint. ODOE, in consultation with BCD, is directed to work with industry stakeholders to identify key high-energy use industries that have the potential to realize significant cost savings and energy savings through building code amendments as it relates to their industrial building types. ODOE and BCD are directed to provide the Governor with a report of its analysis and findings by January 1, 2019.

F. Improved State Standards for Appliances. ODOE is directed to work with appliance industry stakeholders to identify categories of appliances for improved efficiency standards, while considering appliance standards of other states, potential efficiency gains, potential costs, and supply chains for the regional market for appliances. ODOE is directed to provide the Governor with a report of its analysis and identify categories of appliances for improved efficiency by November 1, 2018.

G. High Efficiency Water Fixtures. The appropriate advisory board(s) and BCD are directed to conduct code amendment of the state building code to require high-efficiency water fixtures in all new buildings by January 1, 2020.

H. Increased Water Efficiency in On-Site Reuse. The appropriate advisory board(s) and BCD are directed to conduct code amendment of the state building code to require water efficiency improvements in all newly constructed commercial buildings through standards for capture and safe reuse of water for irrigation purposes by October 1, 2025.

5. Increasing Energy Efficiency through Retrofits of Existing Buildings Across the State

A. Energy Trust of Oregon Pilot Programs. Oregon Public Utility Commission (PUC) is directed to work with the Energy Trust of Oregon and interested stakeholders to expand meter-based savings pilot programs, including pay-for-performance pilot programs, by January 1, 2019. PUC shall consider inclusion of pilot programs, which do not significantly raise energy efficiency delivery costs, and that focus on existing single family homes, multi-family residential buildings, commercial buildings, and methods to incentivize energy efficiency in building stock that is significantly below current building code requirements.

B. Prioritizing Energy Efficiency in Affordable Housing to Reduce Utility Bills. ODOE, PUC, and Oregon Housing and Community Services (OHCS) are directed to work together to assess energy use in all affordable housing stock and develop a ten-year plan for achieving maximum efficiency, as well as a continuum of efficiency levels up to maximum efficiency in affordable housing across the state by January 1, 2019. As part of the assessment, the agencies shall consider new resources and best practices and shall seek assistance from Energy Trust of Oregon and Bonneville Power Administration. OHCS is directed to expand its existing multi-family energy program and green energy path requirements, including a manufactured home replacement program through pilot programs and initiatives, while considering multiple values from energy efficiency improvements, such as health and habitability.

C. Coordination of Data. ODOE and PUC are directed to support and assist private sector partners in efforts to coordinate sharing of data that shows projected energy use reductions in the region. This data will be made available to the public to inform energy efficiency policies, as appropriate, by January 1, 2020.

D. Evaluation of Energy and Resiliency Efforts. ODOE and PUC are directed to evaluate the state's distributed energy resources and the efficiency of energy systems needed to improve Oregon's recovery from a disaster situation. ODOE and PUC are directed to provide the Governor with a report of their analysis and findings by January 1, 2019.

6. **Analysis of Cost**. State agencies are expected to implement this Executive Order using the least cost methods available. ODOE and BCD, in consultation with DAS, PUC, and OHCS, are directed to adopt a cost-analysis tool through a process that involves meaningful public input by December 1, 2019. State agencies shall use this cost analysis tool to determine whether any directive in this Executive Order should be deferred for one year or, if specific to a building code related directive, to the next building code cycle, due to significant cost at the time of implementation of that directive. All state agency processes for determining deferment of a directive in this Executive Order must include at least one public meeting that allows interested stakeholders to provide input.

Office of the Governor
State of Oregon

7. **Implementation.** The implementation of this Executive Order shall be coordinated through a Built Environment Efficiency Working Group, which will also identify any structural barriers or barriers to information sharing that may slow the progress of any directive in this Executive Order. The Built Environment Efficiency Working Group will review directives in this Executive Order, seek input from interested stakeholders, and recommend opportunities to provide equitable access to clean energy by removing barriers to achieving energy efficiency in the built environment to the Governor and state agencies. The Built Environment Efficiency Working Group shall include the following agencies: DAS, ODOE, BCD, PUC, and OHCS. Agencies shall implement each directive in this Executive Order using their existing internal processes and established rulemaking procedures, including recommendations from any boards. This Executive Order is intended to be consistent with obligations under federal and state law and shall be interpreted as to not violate any requirement of federal or state law.

8. The Governor encourages the Secretary of State, the State Treasurer, the Attorney General, and the Commissioner of the Bureau of Labor and Industries to adopt policies and practices to accelerate efficiency in the built environment consistent with measures in this Executive Order. DAS and ODOE are directed to assist the above-mentioned officials and entities of state government in accomplishing these objectives as they may request.

Done at Portland, Oregon, this 6th day of November, 2017.

Kate Brown
GOVERNOR

ATTEST:

Dennis Richardson
SECRETARY OF STATE

Docket No. UE 374
Exhibit Sierra Club/304
Witness: Ezra Hausman

PUBLIC UTILITY COMMISSION OF OREGON

UE 374

SIERRA CLUB EXHIBIT 304

Exhibits Accompanying the Opening Testimony of Ezra D. Hausman, Ph.D.

Oregon Global Warming Commission's 2018 Biennial Report

Oregon Global Warming Commission

2018 Biennial Report to the Legislature

FOR THE 2019 LEGISLATIVE SESSION

TOP Mt. Washington from Black Butte Ranch near Sisters, Oregon. Smoke from Mili Fire, 2017 BOTTOM Oregon Convention Center towers on a smoky day in Portland, Oregon.

TABLE OF CONTENTS

Oregon Global Warming Commission

Voting Members*

Angus Duncan (Chair)	President, Bonneville Environmental Foundation
Catherine Macdonald (Vice-Chair)	North America Natural Climate Solutions Director, The Nature Conservancy
David Anderson	CEO, NW Natural
Sam Pardue	CEO, Indow Windows
Khanh Pham	Manager of Immigrant Organizing, Asian Pacific American Network of Oregon
Maria Pope	President, Portland General Electric
Cheryl Shippentower	Ecologist, Confederated Tribes of the Umatilla Indian Reservation

Non-Voting and Ex Officio Members

Richard Devlin	Council Member, Northwest Power and Conservation Council
Lillian Shirley	Director, Oregon Health Authority
Tom Potiowsky	Director of Northwest Economic Research Center at Portland State University
Alexis Taylor	Acting Director, Oregon Department of Agriculture
Janine Benner	Director, Oregon Department of Energy
Richard Whitman	Acting Director, Oregon Department of Environmental Quality
Peter Daugherty	State Forester, Oregon Department of Forestry
Matt Garrett	Director, Oregon Department of Transportation
Tom Byler	Director, Oregon Department of Water Resources
Megan Decker	Chair, Oregon Public Utility Commission
Michael Dembrow	Oregon State Legislature, Senate
Alan Olsen	Oregon State Legislature, Senate
David Brock Smith	Oregon State Legislature, House of Representatives
Ken Helm	Oregon State Legislature, House of Representatives

*Four voting member positions of the Commission are vacant at the time of this Report

KeepOregonCool
Oregon Global Warming Commission

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Current and Past Commission Reports: https://www.keeporegoncool.org/reports/
Oregon's Climate Conversation Blog: https://www.keeporegoncool.org/oregon-climate-conversation/
Contact us and sign up to receive email notices: https://www.keeporegoncool.org/contact-us/

Our children, and theirs, will be living for decades with the worsening consequences of our failure to take timely action when we knew we should.

Executive Summary

The Oregon Global Warming Commission (OGWC) is submitting this Biennial Report in advance of the 2019 legislative session. This is the first report to be published in an even-numbered year, an approach that the Commission will seek to follow in future in order to allow its insights and input to be considered earlier in the legislative development process. Since this report comes close on the heels of the 2017 OGWC Biennial Report, we are emphasizing three previous key takeaways that are further supported by another year's worth of data. We are also drawing two new conclusions based on new data from Oregon's largest electric utilities and from Oregon's consumption-based greenhouse gas (GHG) emissions inventory.

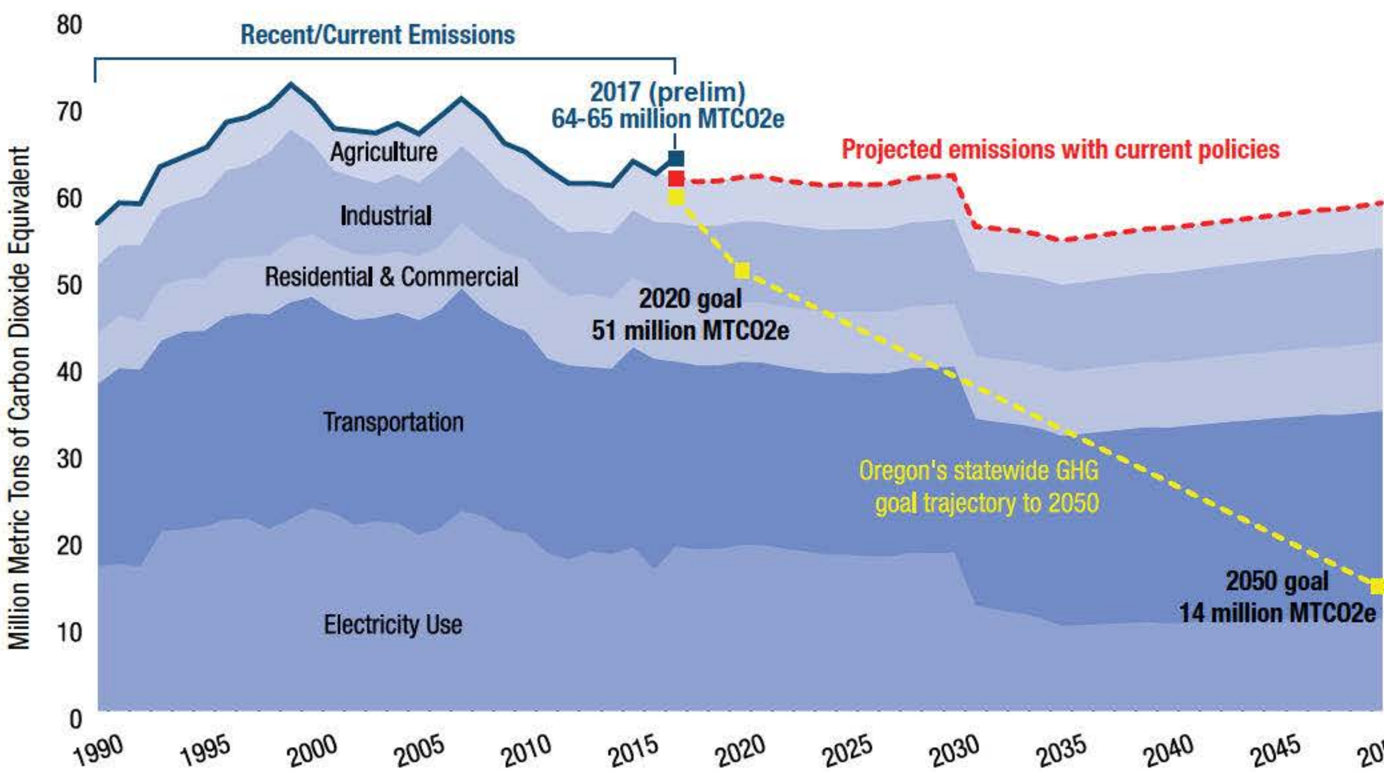
1. Oregon is warming. The consequences are already becoming challenging for many Oregonians. Adaptation actions are necessary, as mitigation alone will not prevent serious impacts.

On a plain reading of the evidence, climate change is occurring in real time. Its effects are being felt in Oregon and around the world today, and not in some distant and uncertain future. If we ended GHG emissions tomorrow, climate change effects would persist and worsen for decades to come. Cutting climate change off from its GHG fuel is like stopping a ship's engines: it does not stop the inertial forward motion but only allows it to gradually slow. Our children, and theirs, will be living for decades with the worsening consequences of our failure to take timely action when we knew we should. Bad as that is, further delay only makes it worse.

2. Oregon's GHG goals are not likely to be met with existing and currently planned actions.

Although we do not yet have a verified 2017 total from Oregon Department of Environmental Quality (DEQ), we are able to report a preliminary value of 64-65 million metric tons of carbon dioxide equivalent (MTCO2e) for the state's total GHG emissions in 2017. This reverses the slight decrease the state achieved in 2016, returning to approximately the same level as in 2015. This level is well above the state's goal of 51 million MTCO2e by 2020 and the Commission's adopted interim goal of 32.7 million MTCO2e by 2035, and it does not put Oregon on a path toward achieving its long-term goal of 14 million MTCO2e by 2050 (Figure 1).

Figure 1. Oregon past and projected greenhouse gas emissions compared to goals



These data and trends make abundantly clear that additional climate action is needed. With this in mind, the OGWC passed a resolution in October 2018 acknowledging the critical work to date of the Legislature's Joint Committee on Carbon Reduction. The resolution urges the state of Oregon to fully develop an economy-wide GHG cap and trade proposal — or a comparably effective pricing mechanism — for legislative action in 2019. Such a proposal will, in combination with other state and local government investments and policies, and private sector initiatives, bring Oregon's GHG emissions under control and on a trajectory to comply with the state's legislatively-enacted reduction goals; and will identify and act on priority climate change adaptation measures.

3. Rising transportation emissions are driving increases in statewide sector-based GHG emissions.

Adapting Oregon communities to facilitate public transit, biking, and walking is an important part of reducing transportation emissions.

Transportation GHG emissions have risen during each of the past three years and have grown from 35% of the statewide total in 2014 to 39% in 2016. In 2018, the Oregon Department of Transportation (ODOT) published a Monitoring Report to document progress — and the absence of progress — in implementing the 2013 *Statewide Transportation Strategy* (STS) to reduce GHGs. The Oregon Transportation Commission also formally adopted the STS in the Oregon Transportation Plan in 2018. However, STS adoption is only advisory and has no specific programmatic implications unless the Legislature chooses otherwise.

ODOT's Monitoring Report identified a number of areas of short-term positive progress offset by other areas of stalled progress or negative trends, particularly in the rising GHG emissions from light-duty vehicles. Oregon should prioritize moving STS recommendations forward, especially policies that incentivize low-carbon choices such as deploying electric vehicles and charging systems; electrifying transit and increasing transit service; and adapting Oregon's communities to facilitate public transit, biking, and walking. Adopting an economy-wide cap on GHG emissions would reinforce these programmatic incentives for cleaner vehicles and fuels.

4. New data from Oregon's largest electric utilities indicate an emissions reduction trajectory that is in general alignment with Oregon's 2050 goal. GHG emissions from natural gas use appear to be relatively constant, but there is ongoing interest in strategies, for reducing the carbon intensity of natural gas.

From 2014 to 2016, emissions from electricity use decreased from 30% to 26% of the state's total emissions. New projections provided by Oregon's two largest electric utilities indicate that by 2050, given certain assumptions, they expect to achieve reductions of at least 80% below their 2005 levels. This reflects both steep declines in

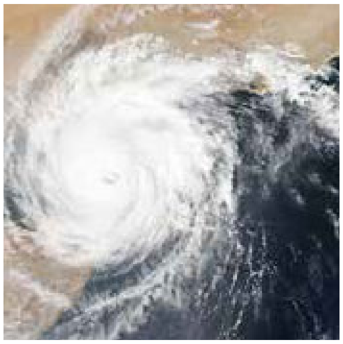
the cost of renewable generation and the anticipated outcomes of recent changes to state laws that will displace coal generation and require new renewables. Adopting an economy-wide GHG emissions cap, in addition to ensuring continued investment in energy efficiency and renewables, would lock in these electricity-sector reductions.

GHG emissions from natural gas use are expected to remain at their current levels (about 11 to 14% of total sector-based GHG emissions), unless additional actions are taken to reduce the carbon intensity of natural gas. Oregon's largest natural gas utility has a GHG reduction goal of 30% from 2015 levels by 2035. A statewide study, requested by the Legislature in SB 334 (2017), inventoried all potential sources of biogas and renewable natural gas available in Oregon and identified financial, informational, market, policy, and regulatory barriers facing project development (Oregon Department of Energy, 2018). The inventory indicates that if barriers can be addressed, there is potential for a substantial amount of renewable natural gas to be produced in Oregon.

5. New data on statewide consumption-based GHG emissions show a steady increase over time driven by household demand.

DEQ reports annual GHG emissions data, using a sector-based emissions inventory approach and on a less frequent basis it also publish a consumption-based inventory to quantify GHG emissions across the life cycle of goods and services consumed in Oregon. Oregon's consumption-based emissions show a steady rise from approximately 61 million MTCO2e in 1990, 79.6 million MTCO2e in 2005, 80.2 million MTCO2e in 2010, and 89 million MTCO2e in 2015. Nearly two-thirds of Oregon's consumption-based emissions are associated with just five highest-emitting categories: vehicles, food and beverages, appliances, services, and construction. Household demand is overwhelmingly the driver of consumption-based emissions. From this perspective, the emissions Oregonians are responsible for are still increasing every year through what we consume, but those emissions are more and more occurring globally, in other countries from which we import these goods. The two inventories viewed together provide a broader understanding of both our emissions and our opportunities to reduce them.

2018 Letter from the Chair



The time of probabilities is now past. The first tangible effects of climate change are upon us. We see it in stronger hurricanes inundating coastal communities around the world. We see it in half-full reservoirs and mountaintops devoid of midwinter snow.

"Owing to past neglect, in the face of the plainest warnings, we have now entered upon a period of danger…The era of procrastination, of half-measures, of soothing and baffling expedients, of delays, is coming to its close. In its place we are entering a period of consequences…We cannot avoid this period; we are in it now."

—

Winston Churchill, in the House of Commons, November 1936

Government and leadership have come a long way from Churchillian rhetoric in those dark days leading up to World War II, and not in any direction that should give us comfort. As grim as the world's prospects were in the 1930s, at least there were Churchills and Roosevelts summoning us to the great tasks of those times.

We've looked for that kind of leadership throughout the 30 years or so that climate change has loomed as an existential threat to our society and our children's future. Rarely have we found it. Identifying such a profound climate threat has been difficult in the absence of immediate physical evidence that the climate is changing, but not more difficult than inferring a threat from a rearming Nazi Germany. Most of the world, and most of the United States, then and now, chose to look elsewhere, to more immediate opportunities, smaller tasks, and narrower challenges. Climate science, after all, spoke in data sets and modeled probabilities. Outcomes remained fuzzy around the edges. Our leaders would have to ask us to make often uncomfortable changes in budgets, policies, and livelihoods, to forestall . . . probabilities.

The time of probabilities is now past. The first tangible effects of climate change are upon us. We see it in stronger hurricanes inundating coastal communities around the world. We see it in the smoke blanketing our state and region from forest fires that start earlier, persist longer, and burn more extensively — smoke that is attacking the lungs of our children, the elderly, and the asthmatic. We see it in half-full reservoirs and mountaintops devoid of midwinter snow. (See Section 1 of this Report for links between earlier projections of climate effects and the realized effects of today.)

Progress and Slippage

In this Report, the Global Warming Commission reviews Oregon's successes and our remaining challenges in meeting our greenhouse gas emissions goals. This letter reflects my profound concern, after 10 years as commission chair, about whether we are rising to the challenges in meaningful and sufficient ways.

I wrote the first of these letters as a foreword to our 2009 Report to the Legislature. In that letter I described as "unvarnished good news" the wind projects and solar cell manufacturing, the "green buildings," and the energy-efficient land use choices that we thought would make Oregon a leader for dark but not hopeless times. The country had just elected a president committed to addressing climate issues. Congress was debating national carbon cap legislation. Countries around the world were telegraphing their parallel commitments to a global climate strategy.

Indeed, much has been accomplished in the 10 years since then, especially in the realm of energy technologies that are replacing the nation's fleet of superannuated coal plants with cleaner (but, let us be clear, still not *clean*) gas supplies, and with wind and solar plants that are offering ever-lower costs and higher efficiencies. This cleaner, carbon-free electricity, we speculated then, could power an emerging fleet of electric cars, trucks, buses, and possibly even aircraft.

Momentum is still evident globally. In 2018, two of the last three holdouts from the Paris Climate Accord, Nicaragua and Syria, signed on. Only the United States of America, once a global leader for responsible climate action, now remains outside the global accord, its policies dominated by feckless politicians who are indifferent or outright hostile to the tested, peer-reviewed findings of science. This is leadership of a sort, but of a sort that will lead the country over the climate cliff.

So it falls to us as Oregonians and Washingtonians and Californians, as citizens of San Francisco and Portland and Chicago and New York, to demonstrate what real leadership is in coping with the slow-motion but inexorable emergency we face. It falls to us to rescue the country from itself, to bear our share of the burden, and realize our share of the promise to the rest of the world.

Oregon's Emissions Inventories

The Inventory Section of this 2018 Report carries both encouraging and challenging news. We can be legitimately energized by accomplishments and opportunities in the electric utility sector. The past 10 years have seen:

- PGE's decision to end coal burning at Oregon's only in-state coal plant at Boardman;
- a negotiated agreement between environmental groups and our two large electric utilities, validated by the 2016 Legislature, to terminate coal-generated electricity imports by 2030 and to sharply increase renewables in the mix;

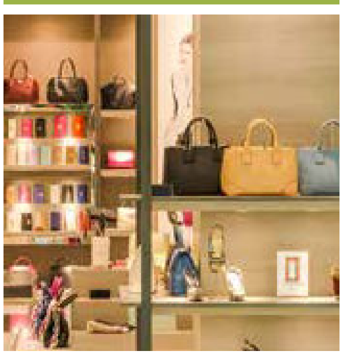
- PGE's corporate commitment to "deep decarbonization," and the determination of NW Natural to seriously explore the potential of renewable gas and hydrogen.

The combined effects of these commitments, if fully realized, should drive utility emissions to, and below, a proportional share of Oregon's greenhouse gas goals (see Section 3, on Oregon utility emissions).

The mounting challenge we face is with transportation emissions, which have been rising since 2013 after several years of flat-lining or incrementally dropping. Other states are showing the same rise in transportation emissions as the effects of the 2008 Great Recession retreat. More miles (Oregon Office of Economic Analysis, 2017)[1] are being driven in larger and less fuel-efficient cars, while the Trump administration undermines the effectiveness of national vehicle fuel economy standards.

And, the strategy of negotiated change that has been successful with two electric utilities may not work so well with Oregon's 3 million vehicle owners/drivers. Alternative vehicles are entering the market, but slowly, notwithstanding that electric vehicle purchase costs are coming down, their operating costs are far lower than those for gasoline and diesel vehicles, and the miles that can be driven between charging sessions is dramatically up.[2]

As Oregon consumers purchase more goods and services, a share of these are imported from producers in other countries, often where carbon efficiencies are poorer than here.



To lock in real emissions reductions and shore up slippage, leadership on climate issues from the Oregon Legislature and the Governor is crucial in 2019. A carbon cap will inform Oregon drivers of both the costs of failure and the rewards of success, while encouraging movement to more cost- and carbon-efficient travel. The cap (first called for in Governor Kulongoski's Advisory Group Report in 2003) is the largest missing building block in Oregon's carbon strategy. The Joint Committee on Carbon Reduction chaired by Senate President Peter Courtney and House Speaker Tina Kotek, and including admirable membership from both chambers, ensures that this issue is getting serious legislative treatment at long last.

Consumption-Based Emissions

Oregon's consumption-based inventory tracks our state's greenhouse gas footprint as measured by the emissions we create with our consumption choices. Through it, we can calculate — and choose to take responsibility for — the emissions associated with the overseas fabrication of a product, its transport to Oregon, and its use and disposal here, even if some of the emissions may originate in Europe or Asia. These emissions numbers are rising also. This outcome is a function of increased consumption by Oregon households and businesses and is consistent with post-recession economic growth. As Oregon consumers purchase more goods and services, a share of these are imported from producers in other countries, where carbon efficiencies are often poorer than here. Increased consumption of imported goods means increased total and per capita *consumption-based emissions*. In the near future, Oregon will need to

[1] A 14% increase since 2012, or more than 4.5 billion more vehicle miles traveled in Oregon in 2016 (37.5 billion) compared to 2012 (33.0 billion), based on statistics from U.S. Federal Highway Administration, Oregon Department of Transportation, and Oregon Office of Economic Analysis. Available at https://oregon-economicanalysis.com/

[2] >300 miles for the latest Kia Niro.

confront these findings by considering consumption-based emissions reduction goals and tools, because, wherever those emissions occur, they are an outcome of our choices and will result in global climate change that affects Oregonians.

Oregon Forest Carbon Accounting

Oregon's forests are world class at capturing and holding atmospheric carbon in their trunks, roots, and soils, on a par with equally dense tropical and Alaskan rain forests. The Oregon Global Warming Commission's Forest Carbon Accounting Project worked with the U.S. Forest Service and Oregon State University scientists to reveal some striking findings: Approximately 11 billion tons of carbon dioxide equivalent are packed into Oregon forests today, and we appear to be increasing that store at somewhere between 15 million and 60 million tons CO2e annually (Oregon Global Warming Commission [OGWC], 2017).[3] We were further advised that the opportunity exists to substantially increase this uptake and storage through modest changes in forest management and harvest practices. Reducing our (mostly) energy-related emissions plus increasing forest carbon capture and sequestration could move Oregon toward overall carbon neutrality by the 2030s, and to negative carbon thereafter. That is, Oregon could go from being part of the problem to being a notable part of the global solution. In the process, we could pioneer forest carbon measures for other forested jurisdictions. The 2019 Legislature can take a significant step in this direction by including forest carbon incentives in its carbon cap legislation.

Extreme Climate Events

Section 1 of this Report outlines, in sometimes painful detail, the climate change effects Oregon and the wider world have already begun to suffer. The Fourth National Climate Assessment (2017, vol. 1) allocates a chapter to "Potential Surprises: Compound Extremes and Tipping Elements." Chapter 15 of the Assessment notes the significant ways in which "average" projections could be decidedly worse. It observes that "climatemodels are more likely to underestimate than to overestimate the amount of long-termfuture change." It notes that "compound extreme events (such as simultaneous heatand drought, wildfires associated with hot and dry conditions, or flooding associatedwith high precipitation on top of snow or waterlogged ground) can be greater thanthe sum of the parts."

"Tipping points" are generally stable conditions that can be "tipped" into highly unstable ones by a small increment of climate change — a needle that breaks the camel's back — such as a small degree of Antarctic warming that could release a rapid disintegration and melting of glacial ice, raising sea levels more rapidly than humans can adapt to them. It warns us that, as devastating as linear effects of climate change will be, the nonlinear effects may be far more so because we are unprepared to cope with them (U.S. Global Change Research Program, 2017, vol. 1, chap. 15).

[3] Forest carbon can be released or converted into different carbon pools through respiration, harvest, decomposition (e.g., after trees die from old age, disease, or pests), and fire. We can restate quantities of forest carbon as a "carbon dioxide equivalent" (CO2e) to allow one-to-one comparisons of carbon stored in trees with annual carbon dioxide emissions released when fossil fuels are burned, using standard conversion factors. Oregon's total annual sector inventory emissions are about 60 million tonnes, or metric tons, CO2e. A tonne is equal to 2,200 pounds, or 1.1 short tons.

In Oregon, those effects might include a dramatic die-off of forests (such as has occurred already in Canadian and Alaskan boreal forests and in the Russian taiga forests) or an unexpected sea-level rise that swamps Oregon coastal communities, economies, and highways.

We applaud the real progress Oregon has made in resetting our electric utilities toward a low-carbon future, and regret our failure to do the same in transportation.

Oil Companies: A Final Note

We applaud the real progress Oregon has made in resetting our electric utilities toward a low-carbon future, and regret our failure to do the same in transportation. Much of this slow slog is due to the well-financed[4] resistance from oil companies determined to extract the last dollar of profit out of a product that has no place in a decarbonized world. Upton Sinclair, the quotable muckraker from this country's first Gilded Age, said it best:

> *It is difficult to get a man to understand something when his salary depends upon his not understanding it.*

But even Upton Sinclair could not have imagined the irony of this same oil industry, while pumping more U.S. oil than ever before and laboring to protect its markets, at the same time asking for oceanfront "protection" from rising sea levels along the Texas Gulf Coast. The State of Texas is seeking $12 billion in federal funding to build "a 60-mile spine of concrete seawalls, earthen barriers, floating gates, and steel levees" to protect "one of the world's largest concentrations of petrochemical facilities, including most of Texas' 30 refineries, which represent 30% of the nation's refining capacity." The spine would include works that would reach from Louisiana to south of Houston.

"Our overall economy … is so much at risk from a high storm surge," said Republican Brazoria County Judge Matt Sebesta. Republican Senators John Cornyn and Ted Cruz both support this use of taxpayer funds to protect the oil industry from, in effect, itself. The first commitment of $3.9 billion was fast-tracked by the administration after Hurricane Harvey hit the Texas coast a year ago, knocking out a quarter of the area's oil refining capability. A Texas commission is also seeking $61 billion from Congress to "future proof" the state (Weissert, 2018).

Not Upton Sinclair, not Doonesbury, not even *The Onion* could imagine theater as absurd as this. I leave readers to draw their own conclusions.

Angus Duncan, Chair
Oregon Global Warming Commission
September 24, 2018

[4] Most recent financial filings in Washington's Measure 1631, which was on the ballot this fall, and which would have established a carbon fee in that state, showed that >75%—and perhaps as much as 99%—ofthe $31 million received by the "No on 1631" campaign was from oil companies (Lavelle, 2018).

Section 1:

Climate Change Comes to Oregon 2018

The Oregonian for Wednesday, August 15, 2018, led with the story of smoke that "choked" the Portland airshed from forest fires "filtering into Northwest Oregon from blazes in almost all directions … Washington, British Columbia, Eastern Oregon … [and] Northern California." The Oregon Department of Environmental Quality (DEQ) issued an air quality advisory warning people to stay indoors if possible, especially children, seniors, and those with respiratory conditions.

The Oregon Smoke Blog for August 21 read: "Currently all Oregon counties except Coos and Curry are under air quality advisories."[5]

Less than a year earlier, Portlanders had awakened to a similar brownish haze obscuring the sky and the same public health advisory. DEQ said 2017 was "different" from earlier bad fire years in that "the entire state is … blanketed by smoke" coming not only from the Eagle Creek Fire in the Columbia Gorge but also from a dozen fires ranging from the Rogue River to Mt. Hood, as well as from fires in Canada and California. DEQ called the condition "rare" (DEQ, 2018).

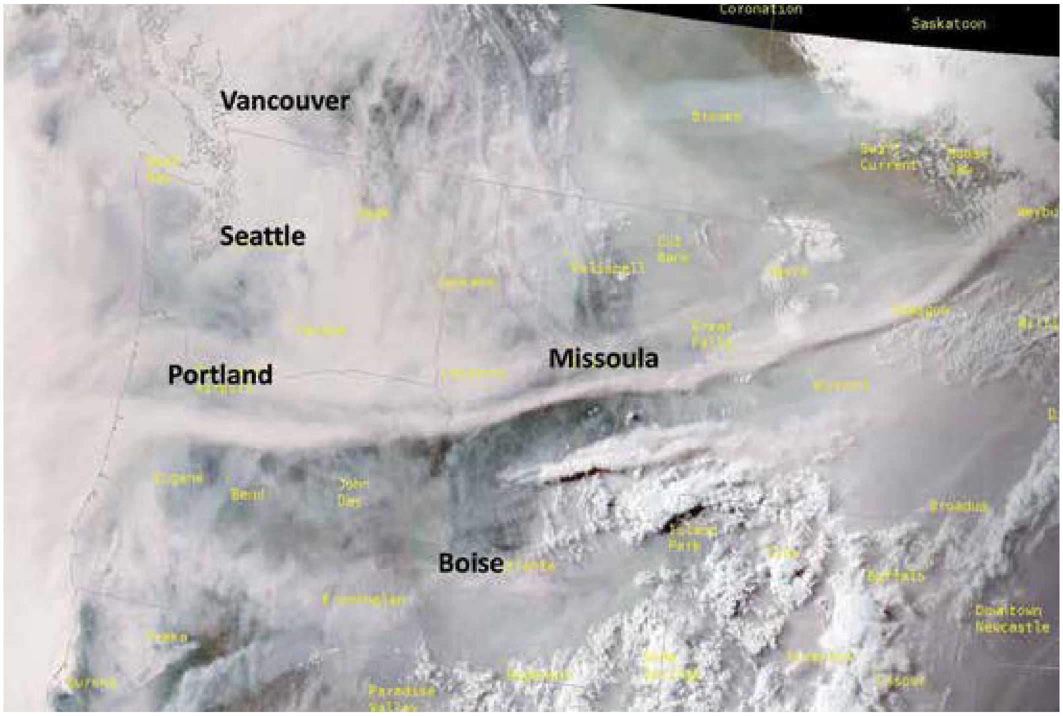
But it's not, anymore.

Larger forest and grassland fires are now more frequent, a consequence of warmer, drier summers. The fire season begins earlier and ends later (Dalton et al., 2017, chapter 5).

On August 15 of this year, the National Interagency Fire Center reported fires burning in all 13 states west of the 100th meridian, a total of 108 "active large fires," four of which were contained. On August 22, the Forest Service reported via Twitter that "23 large fires burning nearly 440,000 acres" in Oregon (@ForestServiceNW). The 80,000-acre "Substation Fire" near The Dalles, Oregon, in July burned 1–2 million bushels of wheat at a cost of >$5 million. Farmers in the fire's path "got wiped out, most of their crop if not all," said Tara Simpson of the Oregon Wheat Commission (*The Oregonian/OregonLive,* July 20, 2018).

Fire season is starting earlier in the spring and lasting later into the fall in Oregon. The Taylor Creek/Klondike Fire was set off by lightning strikes in mid-July 2018. The two fires grew and merged into August, topping 150,000 acres. By mid-September the fires were largely contained at 170,000 acres, and crews were switching over to mop-up duties. Then, dry, warm, and windy fall days allowed

[5] "Oregon Smoke Information," http://oregonsmoke.blogspot.com



Smoke across the Pacific Northwest.

Source: National Weather Service/Spokane, August 13, 2018, satellite image, https://twitter.com/NWSSpokane/status/1029192999446740992

TOP: August 5,2018.
BOTTOM: October 19, 2018.

the fire to flare up again on October 15, burning several thousand additional acres of Siskiyou Mountains forestland, threatening homes in Agness, Oregon, on the Rogue River, and forcing evacuations. The Northwest Interagency Coordination Center now estimates containment by November 30.[6]

The Oregon Department of Forestry estimates gross state costs of wildfire control in 2018 at more than $100 million, of which Oregon's share will exceed $40 million after federal cost-sharing. Oregon's net fire-fighting costs averaged $39 million per year over the last six years (2013–2018), or five times the annual average of about $7.5 million per year over the preceding five years (2008–2012).[7]

At least Oregon communities have been spared the devastation suffered in California: deaths and whole neighborhoods destroyed in Redding and Paradise this year and in Santa Rosa last year. Of California's 15 largest fires (by acreage), 12 have occurred since 2000, three of them in the last two years (Berke, 2018). Some Californians are anticipating a near year-round fire season from now on.[8]

Oregon communities have not been spared other impacts, however. Last year's Eagle Creek Fire closed Interstate 84 for three weeks, disrupting personal and commercial traffic, adding costs and delays to shipping. The Oregon Shakespeare Festival in Ashland had to cancel or relocate 26 performances from its outdoor theater in 2018, more than in its smoke-plagued 2017 season. Each cancellation directly costs the

[6] Photography and Taylor Creek/Klondike Fire information from Facebook fire postings by fire control officials, October 2018, https://www.facebook.com/pg/TaylorCreekandKlondikeFires/photos/?tab=album&album_id=234917240676541

[7] Email communication, October 26, 2018, from Bobbi Doan, public information officer, citing Oregon Department of Forestry estimates for FY 2018 and FY 2019.

[8] "In California, it's always fire season now." Curbed Los Angeles News, June 5, 2018.

festival $50,000 in lost revenues — an estimated $2 million total loss in 2018 — and costs the Ashland community thousands more in forgone lodging, food, and drink revenues (Flaccus, September 25, 2018). In 2017, the central Oregon town of Sisters canceled its September Folk Festival, a major tourist draw and community moneymaker (estimated lost community earnings in excess of $1 million).

Over the last several decades, warmer and drier conditions during the summer months have contributed to an increase in fuel aridity and enabled more frequent large fires, an increase in the total area burned, and a longer fire season.

Here's how the Oregon Climate Change Research Institute, in its 2017 *Oregon Climate Assessment*, described prevailing conditions:

> Over the last several decades, warmer and drier conditions during the summer months have contributed to an increase in fuel aridity and enabled more frequent large fires, an increase in the total area burned, and a longer fire season (Dalton et al., 2017, p. 46).

And here is the Research Institute's prediction about forest wildfire from its 2010 Assessment:

> Wildfire is projected to increase in all Oregon forest types in the coming decades. Warmer and drier summers leave forests more vulnerable to the stresses from fire danger west of the Cascades. Wildfire in forests east of the Cascades is mainly influenced by vegetation growth in the winters that provides fuel for future fires. An increase in fire activity is expected for all major forest types in the state under climate change. Large fires could become more common in western Oregon forests (Oregon Climate Change Research Institute [OCCRI], 2010, p. 6).

Even earlier, in 1999, the University of Washington Climate Impacts Group wrote:

> … the net direct effect of the climatic changes is not likely to be favorable to the productivity and stability of existing forests. Warmer summers, leading to increased evapotranspiration, are likely to overwhelm any benefits of increased CO2 fertilization. Predicted climatic changes are likely to have profound … immediate and easily observed impacts — most obvious in the case of fire where increased summer temperatures and moisture deficits will substantially increase the potential for the occurrence, intensity, and extent of wildfires (Mote, Canning, Fluharty, et al, 1999, p. 67).

Past Reports to the Legislature from the Oregon Global Warming Commission and Oregon Climate Change Research Institute have emphasized predicting what Oregonians can expect *in the future* if climate change is not brought under control. But those predictions of climate effects in Oregon, predictions made in 2010 and earlier, have arrived on our doorstep in 2018: fire; flooding; drought; disease and health impacts; heat; sea-level rise; erosion of Oregon's coastline; and damage to fragile forest, grassland, aquatic, and alpine ecosystems and the plants and animals they contain.

The personal and economic consequences that once were distant predictions are becoming accomplished fact.

Therefore, this Report will be different. It reports how those earlier predictions are coming true. It reports not the future but the present.

It's not a comforting sight.

Elsewhere in the country in 2018, summer fires raged across California. Yosemite Valley closed for three weeks due to smoke and fire risk. Residences in large sections of Santa Rosa (2017) and the communities of Redding and Paradise (2018) burned, with loss of life and property. Notwithstanding adequate soil moisture content from winter precipitation in both 2017 and 2018, California experienced intense fires.

Robinson Meyer, in an article in *The Atlantic*, cited the conclusions of Professor A. Park Williams of Columbia University:

> The factor that clearly made the difference in 2017, and again in 2018, is heat. Last summer was record-breaking, or near record-breaking, hot across much of the West, and I believe July 2018 will break records or come close to it again this year. Even if the deep soils are wet following winter and spring, a hot and dry atmosphere seems to be able to overwhelm that effect (Meyer, August 10, 2018).

In fact, July 2018 was the hottest month California has ever recorded.

And, with reference to the increased extent of forest fires: "We estimate that human-caused climate change contributed to an additional 4.2 million ha [hectares] of forest fire area during 1984–2015, nearly doubling the forest fire area expected in its absence" (Abatzoglou and Williams, 2016).

Elsewhere on the planet in 2018, intense and rapidly moving fires in Greece in the summer of 2018 left 97 dead and communities devastated, with more than 1,000 buildings destroyed or damaged (Wikipedia, 2018, "2018 Attica Wildfires"). Europe coped with its worst heat wave and drought in decades; countries as far north as

Sweden were fighting forest fires above the Arctic Circle (*Daily Express*, July 25, 2018). Millions of hectares (one hectare = 2.47 acres) of Russian/Siberian taiga forest appear to have burned in 2018 (*The Siberian Times*, 13 July 2018).

Although predictions of these and other climate impacts can be summoned up from three or four decades back, just reading OCCRI's 2010 and 2017 Assessments side by side should be sobering to Oregonians and their leaders alike.

A note of qualification for what follows: Heat waves, drought, intense storms, forest fires, and other inconveniences and disasters have been suffered throughout human history. Oregon has seen its share of these events, such as the very large West-side fires during a cyclical dry period[9] in the 1930s. The difference today is in the *amplification* of naturally occurring weather events. The National Academies of Sciences, Engineering, and Medicine stated (in 2016) that:

> In many cases, it is now often possible to make and defend quantitative statements about the extent to which human-induced climate change (or another causal factor, such as a specific mode of natural variability) has influenced either the magnitude or the probability of occurrence of specific types of events or event classes (National Academies of Sciences, Engineering, and Medicine [NASEM], 2016, p.14).

Thus, climate change does not start forest fires (either lightning or careless humans do this), but climate change lengthens the calendar window for weather conducive to such fires and supplies the fire with more tinder-dry fuel that can contribute to larger and more persistent fires.

A parallel example might be a baseball player who might naturally hit 40 home runs a season; playing with performance-enhancing drugs, he might hit 60 instead. The drugs don't make him a better hitter but do increase his chances, each time he bats, of sending one into the bleachers.

So what other climate change predictions are coming about, and with what consequences? The following references should be read as illustrative; for a complete accounting, look to Oregon Climate Change Research Institute's *Third Oregon Climate Assessment Report* and to the Northwest regional section of the U.S. government's 2018 *Fourth National Climate Assessment*. Note that both data-based and anecdotal evidence of current effects are 2018 snapshots; these effects will continue to intensify in future years even if emissions growth is reversed today and systematically reduced over the next two decades or so.

The "***Then***" predictions are from the 2010 Assessment (OCCRI, 2010), unless noted otherwise.

[9] The recurring Pacific Decadal Oscillation is a naturally occurring climate cycle of roughly 30 years' duration, alternating between drier and wetter weather periods. Another naturally occurring, shorter-term cycle affecting the Pacific Northwest is from El Niño (drier, warmer) to La Niña (wetter, cooler). Climate change is superimposed on these cycles, amplifying warmer effects and, in different geographies, amplifying or diminishing precipitation.

HEAT

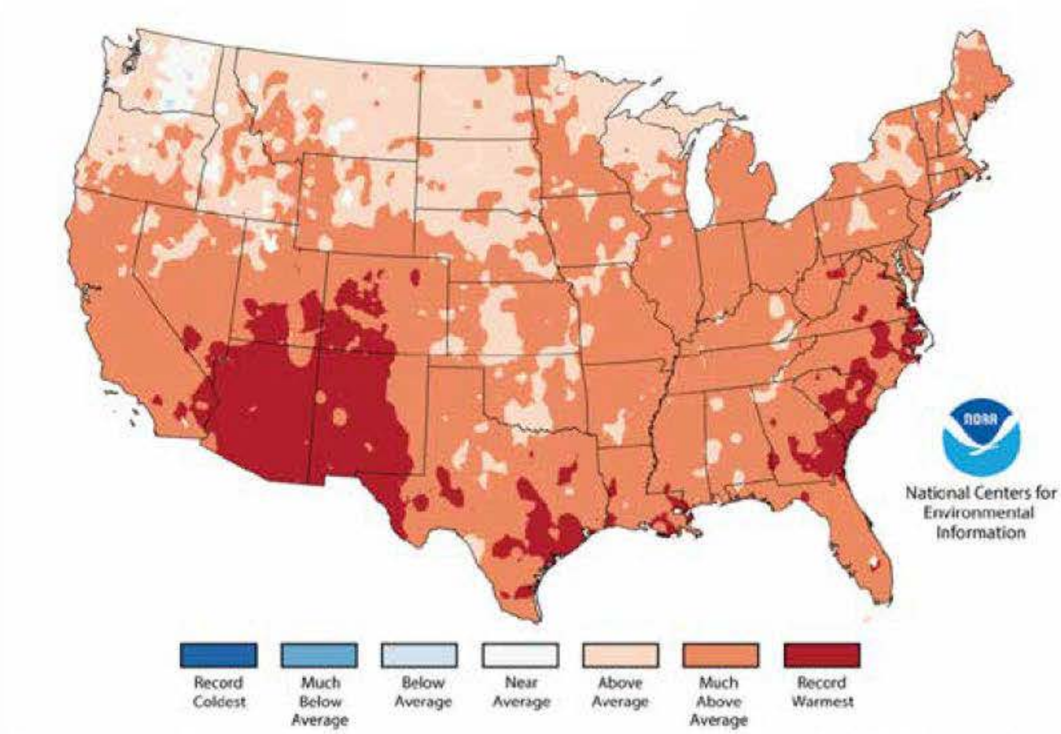
Then: The 2010 Assessment predicted that Oregon would see average temperature increases of "0.2-1°F" per decade.

Now: Oregon's average temperature has risen 1 degree F in the last 30 years (OCCRI, 2017). By August 22 of this year, Portland had set a new record for hottest days (30 days above 90 degrees F) (*Willamette Week*, August 22, 2018). Higher maximum nighttime temperatures also were recorded over the last century.

> … rising greenhouse gases have added almost 2°F to the Northwest's average temperature over the past 100 years. It follows, then, that when Oregon experienced a year (2015) that was about 5°F warmer than the 20th-century average, greenhouse gases contributed about 2°F of that (Abatzoglou, Rupp, and Mote, 2014.

In 2017, "For the third consecutive year, every state across the contiguous U.S. and Alaska had an above-average annual temperature" (NOAA, 2018).

Figure 2. Average annual temperature in 2017 ranked against average from 1895-2017



Source: National Oceanic and Atmospheric Administration (NOAA), 2018, https://www.ncdc.noaa.gov/temp-and-precip/us-maps/12/201712#us-maps-select

Elsewhere: Globally, 2018 is on track to be the fourth hottest year on record. Including 2018, the hottest four years on record have been the last four; and 17 of the 18 warmest years have occurred since 2001 (*The New York Times*, August 9, 2018). Heat waves and record temperatures have been recorded across the globe, from the Arctic to the tropics. The World Meteorological Society reports that "… heat is drying out forests and making them more susceptible to burn. A recent study found that Earth's boreal forests are now burning at a rate unseen in at least 10,000 years" (Achenbach and Fritz, July 30, 2018).

Globally, each of the decades since 1950 has been warmer than any of the decades preceding. 2010–2019 is on a course to be 1.31 degrees F warmer than the 1951–1980 mean temperature (National Oceanic and Atmospheric Administration, 2018.).

The National Oceanic and Atmospheric Administration reported in 2015 that nighttime temperatures are slightly outpacing daytime temperatures in the rate of warming. In 2017, a nationally averaged minimum was 60.9 degrees F in the contiguous U.S. — 2.5 degrees F above average (Gustin, July 11, 2018).[10] The inability of cities, and especially of their inhabitants, to cool off at night is a public health threat. It is an even greater threat in many third-world cities (and "third-world neighborhoods" in a first-world country like the U.S.), where air conditioning is rare and humidity levels are high, limiting the ability of bodies to shed heat.

Warmer nighttime temperatures close off what firefighters call the "nighttime recovery window" and allow fires to burn hot through the night, making containment more difficult (*Statesman Journal*, 10 August 2018.)

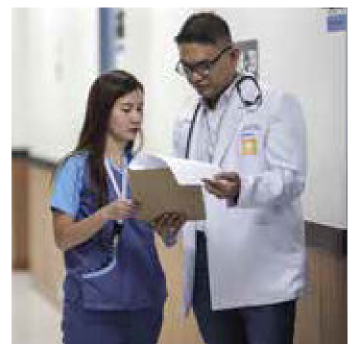
In 2018, the El Paso Chapin High School Huskies football team starts its practices at 6 a.m., when the temperature is a cool 82 degrees F in August, instead of following the more usual mid-afternoon schedule, when temperatures are expected to go above 100 degrees F (Moore and Davis-Young, August 29, 2018).

Scientists analyzed the exceptionally deadly 2003 heat wave in Europe — the hottest summer on record since 1540 — to which 70,000 deaths were attributed. They found that in Paris, the hottest city, 70% of the deaths (506 out of 735) could be ascribed to climate change amplifying the heat (Mitchell, Heaviside, Vardoulakis et al., 2016).[11]

[10] Updated 7 September with record summer 2018 temperatures.

[11] Overall, France recorded 14,802 heat-related deaths in 2003.

PUBLIC HEALTH



During the heat waves in the summer of 2015, the Oregon Health Authority recorded a spike in heat-related emergency room visits.

Apart from the direct effects of heat stress and other weather extremes on those without the means of protection — usually the poor — climate change can aggravate certain chronic disease conditions like asthma and heart disease and increase exposure to illnesses usually associated with warmer climates.

Then: The 2010 Assessment warns that:
Incidents of extreme weather (such as floods, droughts, severe storms, heat waves and fires) can directly affect human health. …Increases in summer temperatures will make heat waves a greater likelihood, causing heat-related morbidity and mortality, especially among vulnerable populations [and] could raise the threat of vector-borne diseases and emerging infections. Respiratory insults, especially among persons with preexisting lung health problems would be exacerbated by exposure to smoke from wild land and forest fires. … Air pollution and increases in pollen counts (and a prolonged pollen producing season) may increase cases of allergies, asthma and other respiratory conditions among susceptible populations (OCCRI, 2010, p. 403).

Now: "In Oregon, analysis of hospitalization and climate data showed that each 1°F increase in daily maximum temperature was associated with a nearly 3-fold increase in the incidence of heat-related illness" (Dalton, Mote, and Snover [Eds.], 2013).

The Oregon Health Authority recorded a 29% rise in emergency room visits for respiratory symptoms in the Portland metro region during the 2017 Eagle Creek Fire, indicating the increased health risks of smoke from more extensive wildfire (Oregon Health Authority, 2017). Heat-related emergency room visits spiked during the heat waves of summer 2015 (Oregon Health Authority, 2018).

Changes in our climate are also a factor in infectious diseases. Two examples in our state include (1) the number of cases of tick-borne disease in Oregon is steadily rising and is associated with warmer temperatures and changing tick habitat, and (2) the spread of a fungus that causes cryptococcal infections, which before 1999 was limited to the tropics, but is now established in Northwest soil and caused 76 cases in Oregon in 2015 (Oregon Health Authority, 2018).

In May, 2018, Oregon experienced its first-ever drinking water advisory due to cyanotoxins in finished drinking water.

The Oregon Health Authority issues health "advisories" to warn Oregonians of health risks. These include recreational use advisories for cyanotoxins produced by harmful algal blooms (HABs) that can arise in freshwater bodies across the state. The recreational use advisories warn Oregonians against ingesting water affected by the toxins through swimming, water skiing, and other water-based recreational activities. Health risks can range from gastrointestinal illness and dizziness to seizures and liver failure; young children, dogs, and livestock are especially susceptible. Conditions that foster freshwater HABs are increasing — higher air temperatures, more sunlight, lower snowpack (and thus higher water temperatures), and more intense rain events causing higher runoff of organic matter to water bodies.

While recreational use advisories have become a routine spring-through-fall occurrence, in May, 2018, Oregon experienced its first-ever drinking water advisory due to cyanotoxins in finished drinking water. Detroit Reservoir, the source of drinking-water supplies for the city of Salem and other communities, experienced a persistent bloom of cyanobacteria (blue-green algae) that resulted not only in recreational use advisories at Detroit Lake, but also led to cyanotoxin levels above safe drinking-water levels for sensitive populations such as children, the elderly, and those with compromised immune systems in downstream communities. The state declared a "state of emergency," and the Oregon National Guard distributed drinking water in affected communities (Ross, June 7, 2018; Oregon Environmental Council, 2018).

Forest wildfires can emit high levels of fine particulate matter (PM2.5), and western states, including Oregon, have high exposure risk to these toxic air pollutants. Fires from 2008 to 2012 resulted in increased premature deaths and respiratory ailments, with long-term U.S. costs, principally in the West and Southeast, upwards of $450 billion (Fann, Alman, Broome, et al., 2018). As fires and smoke become more ubiquitous, disease and cost impacts will rise.

Elsewhere: Of 244 U.S. cities analyzed for increased risk of mosquito-borne diseases (including Zika, West Nile, and Dengue fever), 94% saw significant increases in days warm enough to sustain disease-carrying mosquito species. While most of these are southern cities, they include middle and northern urban areas such as San Francisco (47 more days since 1970), Helena, Montana, and Erie, Pennsylvania Ironically, some southern cities (Phoenix, Arizona) may see a lower risk — because it becomes too hot for the mosquitos to survive (Climate Central, August 8, 2018).

TOP: Detroit Reservoir, 2015, Dave Reinert, Oregon State University.
BOTTOM: Hoodoo Ski Summit, Feb. 2015 Hoodoo webcam, 23 February 2015.

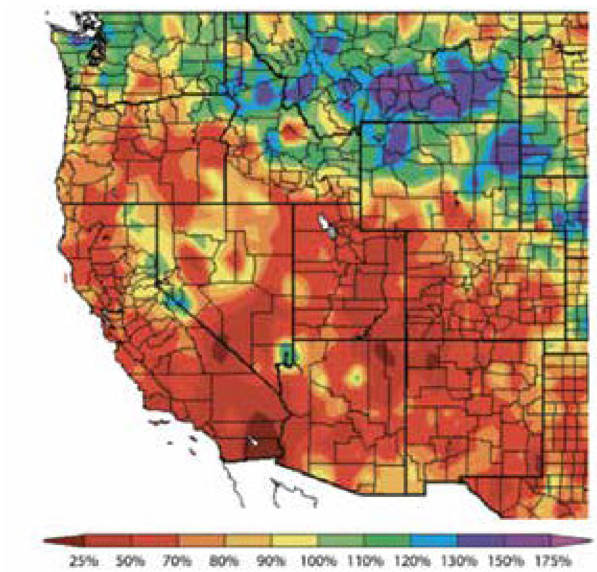
Drought and Snowpack

Then: "By mid [21st] century, Cascade Mountain snowpacks are projected to be less than half of what they were in the 20th Century" (OCCRI, 2010).

Now: While total precipitation shows no great variance, as predicted, it shows more moisture arriving as rain rather than as snow. The OCCRI Third Assessment (2017) reports the following about the year 2015, in which this effect was exceptional:

> The 2015 snow drought was a glimpse into Oregon's future. Precipitation during the winter of that year was near normal, but winter temperatures that were 5–68°F above average caused precipitation to fall more as rain instead of snow, reducing mountain snowpack accumulation (Mote, Rupp, Li, et al., October 12, 2016). This resulted in record low snowpack across the state, earning official drought declarations for 25 of Oregon's 36 counties (OCCRI, 2017, page 13). … "For each 1.8°F of warming, peak snow water equivalent in the Cascade Range can be expected to decline 22%–30% (p. 14). … Spring snowpack … decreased at nearly all stations in Oregon over the period 1955–2015 with an average decline of about 37%" (p. 19).

Figure 3. Western Drought 2017-2018



Most of Oregon saw percipitation levels 20% to 50% below average

Percentage of average precipitation October 1, 2017-September 27, 2018

Source: National Oceanic and Atmospheric Administration, 2018. US Drought Monitor, https://www.ncdc.noaa.gov/sotc/drought/201810

OCCRI Director Dr. Phil Mote and colleagues confirmed earlier predictions in reporting that "… a decline in average April 1 snow water equivalent since mid-century is roughly 15–30%. … Declining trends (in western winter snowpack) are observed across all months, states and climates, but are largest in spring, in the Pacific states, and in locations with mild winter climate" (Mote, Li, Lettenmaier, et al., 2018).

That's Oregon.

OCCRI's website posting includes an August 2, 2018, article by Dr. John Abatzoglou titled "Drought Returns to the Pacific Northwest," in which the author identifies five "flavors" of drought, including low precipitation but also low surface supply and low snowpack. He then maps these effects from 2018 to date and observes that "the maps all show an awful lot of red, indicating extreme to exceptional drought across parts of western Oregon [with] impacts that cover the gamut from fire to farms to fish" (Abatzoglou, 2018).

OCCRI Deputy Director Kathie Dello summarized the Institute's review of the 2017/18 drought summers as follows: "Low snowpack and a hot and dry summer caused water shortages for livestock, small water systems and stressed forests and other ecosystems. Multiple years of hot and dry summers [have] caused damage to Douglas-fir trees in western Oregon."[12]

[12] Personal communication/email from Kathie Dello to Angus Duncan, 1 October 2018.

Elsewhere: The Mote, Li, Lettenmaier article showed that snowpack decreases in excess of 70% also occurred at locations in California, Montana, Washington, Idaho, and Arizona (Mote, Li, Lettenmaier, et al., 2018). The Arizona State Climate Office reports that the state "is currently in our 21st year of a long-term drought." While California has a long history of wet and dry periods, in 2015 the state "experienced its lowest snowpack in at least 500 years [and] the 2012–15 period was the driest in at least 1,200 years" (Griffin and Anchukaitis, 2014; Wikipedia, 2018, "Droughts in California"). A related study ascribes "8–27 % of the observed anomaly in 2012–2014" to global warming (Williams, Seager, Abatzoglou, et al., 2015).

A 2016 NASA study found that drought conditions beginning in 1998 and afflicting countries in the Middle East are "likely the worst drought of the past nine centuries … and well outside the range of natural variability for modern times" (Cook, Anchukaitis, Touchan, et al., 2016).

In 2007, the town of Vernonia in Oregon's Coast Range suffered severe flooding for the third time in 19 years as the Nehalem River responded to 6.–7.5 inches of rain in 24 hours; other north coastal towns were hit as well.

Droughts in 2018 affected countries from western and northern Europe to South Africa to Australia. Another NASA study suggests, consistent with predictions of climate effects, that there is a "redistribution"of fresh water supplies from the middle latitudes (SW U.S./Mexico; North Africa and the Middle East; India) to the north and south. "The data are not sufficient to discern a clear climate fingerprint," says Jay Famiglietti, one of the NASA researchers, "but it sure … matches that pattern [and is] cause for concern" (Famiglietti, 2018).[13]

Extreme Weather and Flooding; Sea-Level Rise

Then: The 2010 OCCRI report noted the following: Stronger ocean storms and coastal flooding; "significant physical impacts along the coast and estuarine shorelands of Oregon; increased erosion and inundation; … wetland loss … > 1.0-meter sea level rise by 2100; … increasing storm intensities and the heights of the waves."

Now: In 2007, the town of Vernonia in Oregon's Coast Range suffered severe flooding for the third time in 19 years as the Nehalem River responded to 6.–7.5 inches of rain in 24 hours; other north coastal towns were hit as well. In November 2015, flooding shut down U.S. 101 in Tillamook, Oregon Other incidents of heavier than expected rain events have been associated with storm activity in the past two decades. However, it is not yet clear whether these recent precipitation patterns have resulted in significant new levels of winter flooding in Oregon that can be "fingerprinted" as climate-change induced. (OCCRI, 2017)

[13] Results of 2002-2016 GRACE Mission, reported in *The Washington Post*, May 16, 2018.

North Oregon coast showing 1997 high-water line (red line) moving inland by 2008 (Allan, 2009). Photos by Don Best.

Closer to the ocean, some 7,400 north coast residents live in the "inundation" zone (Dalton et al., 2017, p.35),[14] at risk from a predicted sea-level rise in 2100. Sea-level rise has been accelerating to (at least) 3.2 millimeters per year since 1993 (up from 1.2 millimeters per year between 1901 and 1990). "Tall waves, intense storms and El Niño combine with sea level rise to produce amplified coastal erosion. … The cost of adaptation to sea level rise and storm surge may be on the order of $1.5 billion through 2100" (Dalton et al., 2017, p.34-35).

Elsewhere: On average, global sea levels are rising at more than 3 millimeters per year (and rose 17 centimeters during the 20th century,[15] or almost 7 inches, from two effects of climate change: melting ice sheets and thermal expansion of ocean waters. The effect puts at risk coastal populations around the world; threatens to submerge many low-lying island nations; increases the risk of coastal flooding from stronger storm surges acting on higher sea levels (see Hurricanes Florence, Harvey, Irma, Sandy, Katrina, etc.); leads to contamination of fresh water supplies with salt water; and alters ecological habitats for many animal and plant species.

"One-hundred-year" flood zones are becoming 50-year or riskier zones. New York City, battered by flooding into lower Manhattan from Hurricane Sandy, is planning for the much worse flooding expected with a 2.5-foot global sea-level rise

[14] Defined as "within reach of the mean highest high tide projected for 2100."

[15] NASA, https://climate.nasa.gov/resources/education/pbs_modules/lesson3Overview/

by 2050. Some 40% of the U.S. population lives in coastal zones, while elsewhere around the world much poorer populations are at equivalent risk but without the means to construct barriers and other coping structures.

Hurricane Florence is pounding the Carolinas as this Report is being written, with rainfall 50% greater than it would have been without climate change, according to new analytic tools for distinguishing the climate "footprint" in extreme weather events. Fueled by ocean temperatures 2–4 degrees F above historic averages, the storm was larger (by 8–9%) and slower moving (allowing more rain intensity) than it would have been without the climate change bump (Reed, 2018).

In August 2017, Hurricane Harvey flooded Houston with up to 51 inches of rain in some areas (30 trillion gallons of water) (Schwartz, August 24, 2018), causing some 106 deaths and $125 billion in damages. Harvey's precipitation accumulations appear to have been more than 38% higher than they would have been without climate change effects (Risser and Wehner, December 12, 2017).

In the United States, 2017 was notable for its destructive hurricane season, with Irma and Maria piling atop Harvey. Updated casualty figures attributed 2,975 deaths in Puerto Rico to Maria, along with major impacts to infrastructure (e.g., nearly a year's delays in restoring electrical service island wide, estimated damage costs of $90 billion). New Orleans has yet to recover from 2005's Katrina (1,833 deaths, $160 billion in damages) (*The Economist*, 22 September 2018, pp. 54-55).

2018 saw extreme flooding events in Japan (200 dead), India (350 dead, 800,000 displaced), Southeast Asia (notable for the 12 teenaged soccer players rescued from their flooded cave in Thailand), and elsewhere.

While the impacts of tropical storms and flooding are hardly unknown in human history, their extent, intensity (wind strength), and moisture content (rainfall) have measurably increased as climate change effects have become more pronounced (Wikipedia, 2018, "Tropical Cyclones and Climate Change").

In 2018, Category 5-equivalent Typhoon Mangkut hit the Philippines with winds up to 125 mph and gusts over 200 mph,[16] doubling down on the destruction from last year's Typhoon Haima and from 2013's deadly Haiyan. ("Yolanda," as Haiyan was known, with sustained winds of 195 mph, left more than 7,000 people dead or missing and caused estimated damages of $14.5 billion). There is emerging consensus that such extreme storm events in the Pacific are becoming more intense and destructive, and that these changes are fueled by warming ocean temperatures.[17]

[16] BBC News, 15 September 2018.

[17] "… typhoons in the north-west Pacific had intensified by 12–15% on average since 1977. The proportion of the most violent storms — categories 4 and 5 — doubled and even tripled in some regions over that time and the intensification was most marked for those storms which hit land. … The intensity of a typhoon is measured by the maximum sustained wind speed, but the damage caused by its high winds, storm surges, intense rains and floods increases disproportionately, meaning a 15% rise in intensity leads to a 50% rise in destructive power" (Wei and Xie, September 5, 2016). And, "the strongest future storms will exceed the strength of any in the past" (Rahmstorf, Emanuel, Mann, et al., May 30, 2018).

OCEAN CONDITIONS

Then: According to the Oregon Climate Change Research Institute 2010 Assessment: "Substantial increases in water temperatures in the ocean are likely and will exceed natural variability. The ocean also absorbs carbon dioxide (CO2) from the atmosphere, which forms carbonic acid and is making waters corrosive to certain species. … The combination of these climate and near-shore ocean changes will exert stress on the communities of near-coastal and estuarine organisms."[18]

Now: The West Coast has already reached an acidification threshold and negative impacts are already evident, such as dissolved shells in pteropod[19] populations and impaired oyster hatchery operations. … 60 percent of the dissolved inorganic carbon in surface waters off Oregon's coast in 2013 is attributed to increasing greenhouse gas concentrations (Dalton et al., 2017).

Sixty percent of the dissolved inorganic carbon in surface waters off Oregon's coast in 2013 is attributed to increasing greenhouse gas concentrations.

Heat in Oregon's offshore waters is contributing to marine harmful algal blooms (HABs) adverse to the $70 million annual Oregon Dungeness crab catch (McCabe, Hickey, Kudela, et al., 2016), also impacts to salmon food species (Barth, Fram, Dever, et al., 2018).[20] "Ocean acidification … impairs the ability [of shellfish] to build shells" (OCCRI, 2017, p. 36). Scientists project that the West Coast "will face some of the earliest, most severe changes in ocean carbon chemistry [driven by climate change, including] intensification and expansion of low dissolved oxygen — or hypoxic — zones" (Chan, Boehm, Barth, et al., 2016). Oregon's commercial and recreational fisheries together amount to around $200 million annually (Oregon Department of Fish and Wildlife, 2017).

Elsewhere: The years 1982 to 2016 saw a doubling of the number of marine heat waves (exceeding the 99th percentile) globally, affecting phytoplankton (Frölicher, Fischer, and Gruber, 2018) that are the base of the ocean food chain and increasing the "Blob," a large area of persistent warm Pacific Ocean water present 2013–2016, reflecting wider abnormal ocean temperatures that depressed phytoplankton production, causing widespread declines in the ocean food web that, among other effects, led to death by starvation for thousands of California sea lion pups (Cavole, Demko, Diner, et al., 2016, http://dx.doi.org/10.5670/oceanog.2016.3).

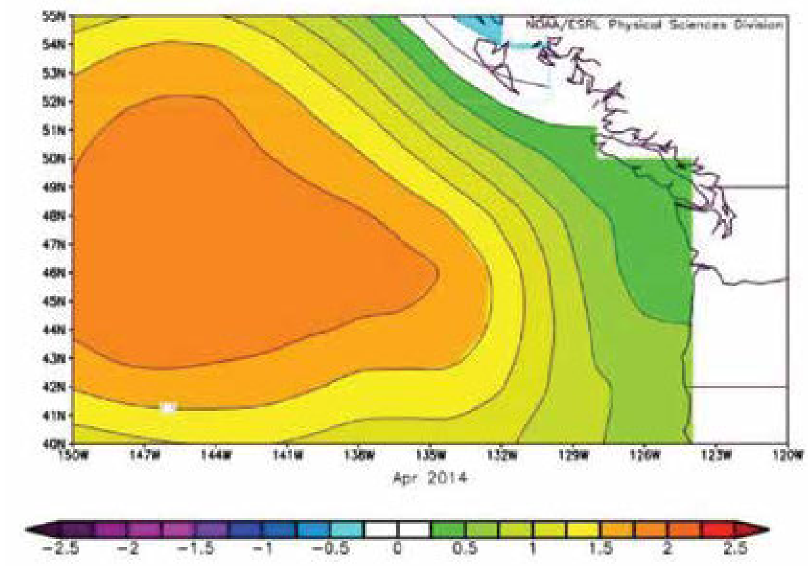
Kelp forests off the Pacific Coast have collapsed to less than 10% of their original density and range in just the last 10 years, the result of a food web disrupted by ocean warming, including effects of the "Blob." The red urchin and abalone commercial fisheries, collectively involving some $40 million in coastal business, are suffering (Pierre-Louis, October 22, 2018).

[18] See OCCRI, 2010, Legislative Summary, Executive Summary, and Chapter 6.

[19] Pteropods are small free-swimming mollusks that are a critical base species on which marine food webs, and the marine populations above, depend. (See *Third Climate Assessment*, 2017, chap. 4 — "Coastal Issues" — p. 37).

[20] Additional information via direct communication from Dr. Caren Braby, Oregon Department of Fish and Wildlife, October 2, 2018, on the value of Oregon Dungeness crab fishery.

Figure 4. The Blob (Pacific Ocean)



"The Blob is an anomalous body having sea surface temperature much above the normal (+2.5ºC), seen here in a graphic of April 2014 by the NOAA" (from Wikipedia article: "The Blob (Pacific Ocean)."

The phenomenon was detectable into the fall of 2018. It is thought to affect West Coast weather patterns as well as ocean food web nutrient levels by dampening upwelling of deep, cold, nutrient-rich ocean waters.

Source: Wikipedia, 2016, "The Blob (Pacific Ocean)," https://en.wikipedia.org/wiki/The_Blob_(Pacific_Ocean)

Infrastructure

Then: "Projected climate changes in precipitation rates and temperatures are likely to threaten the integrity of the built environment, including buildings, roads, highways and railroads, water and sewage systems, and energy facilities throughout Oregon" (OCCRI, 2010, p. 393).

Now: The Eagle Creek Fire interrupts commercial traffic on I-84; flooding occurs (e.g., Vernonia, 2007). Unseasonable warming in November 2006 melted ice and released a rock slide that closed OR 35 for >30 days. (OR 35 has a history of such washouts, more than 20 since 1907; five have occurred since 1998 [Wikipedia, "Oregon Route 35," 2018].)

Some 2,800 miles of roads in Oregon and Washington are in the 100-year floodplain; some highways may face increased inundation with 2 feet of sea-level rise (Dalton, Mote, and Snover [Eds.], 2013). An Oregon Department of Transportation 2012 analysis notes that "Oregon's coastal roadways already experience the effects of climate change. U.S. Highway 101 near the City of Seaside, Oregon, experiences habitual flooding problems causing road closures and delays multiple times every year." Impacts to coastal roadways will come, according to Oregon Department of Transportation, from "2–4 feet of sea-level by 2100 … Increases in wave heights … [and] inundation and erosion, [leading to slides] along the entire coastline" (Oregon Department of Transportation [ODOT], 2012, p. 16).

Summer 2018 heat in Portland forces MAX lines to slow down when temperatures exceed 95 degrees F, in turn slowing the overall commute.[22]

[21] Bureau of Reclamation, "Climate Change Initiative Briefing to NW Power Planning Council," July 13, 2011.

[22] See Njus, August 4, 2016, "Why do TriMet MAX and WES trains have to slow down in the heat?"

Less predictable river/reservoir flows make scheduling flood drawdowns and hydro generation more difficult,[21] while potential low summer stream flows put Oregon's irrigated agriculture sector at risk.

Elsewhere: The integrity of dikes and levees in Netherlands is threatened during the 2018 drought because of the scarcity of the fresh water flows necessary to offset sea water pressure (*Daily Express*, July 5, 2018). Elsewhere, Hurricanes Sandy (New York City subway flooding), Katrina (all New Orleans city services interrupted), and Maria (Puerto Rico electricity service failed and not fully restored for almost a year) illustrate the potential infrastructure impacts, always remembering that third-world infrastructure is already often unsteady and fragile, prone to interruption from lesser forces than those threatened by climate change, and far slower to recover (see Puerto Rico power system recovery).

"Nearly $51 million in tourism revenue was lost in Oregon [in 2017] because of wildfires," according to a study conducted by Travel Oregon

In 2017, the U.S. Government Accountability Office reported that direct federal government costs for responding to "extreme weather and fire events" were $350 billion more than in the prior decade (U.S. Government Accountability Office, 2017).[23] The report repeated the prediction in the *Third National Climate Assessment* that "the impacts and costs of extreme events — such as floods, drought, and other events — will increase in significance as what are considered rare events become more common and intense because of climate change."

ECONOMY

Then: The 2010 Oregon Climate Change Research Institute Report warned that "climate change poses economic risks to the state" (OCCRI, 2010, Legislative Summary).

Now: "Nearly $51 million in tourism revenue was lost in Oregon [in 2017] because of wildfires," according to a study conducted by Travel Oregon (Oregon Public Broadcasting, August 23, 2018). By the end of August 2018, the Oregon Shakespeare Festival in Ashland estimated that it had already lost 10% of its budgeted revenues, or $2 million, to smoke-driven performance cancellations or relocations (Flaccus, September 25, 2018). Costs for health care, fire fighting, commercial freight interruptions, reduced hydropower generation, drought effects on agriculture, and coping with other economic impacts of advancing climate change are increasingly apparent to Oregonians.

Since 1915, the western U.S. snowpack has declined by 21%, or 36 square kilometers (Dalton, Mote, and Snover, 2013, Executive Summary, p. 14) greater than the volume of water stored in the West's largest reservoir, Lake Mead, creating a challenge to western water managers. Irrigation, hydropower generation, navigation, recreation, and ecological sustainability are all put at risk. In recent years such as 2014–15, Oregon ski resorts have struggled to open (e.g., Mt. Ashland failed to open at all that year).

[23] Based on information from the Office of Management and Budget, FY 2017 Budget: "… including $205 billion for domestic disaster response and relief; $90 billion for crop and flood insurance; $34 billion for wildland fire management; and $28 billion for maintenance and repairs to federal facilities and federally managed lands, infrastructure, and waterways."

Oregon's forests provide Oregonians with "ecosystem services," the value of which can in many cases be quantified. Intact, sustainably functioning forest ecosystems provide the Pacific Northwest with $3.2 million per year in water purification, $5.5 million in erosion control (in the Willamette Valley alone), and $144 per household per year in cultural and aesthetic benefits (e.g., hiking, camping, and viewing). Climate change in Pacific Northwest forests could cost the region $650 million in recreation revenue losses by 2060 (Dalton, Mote, and Snover, 2013, Executive Summary, p. 14).

Some agricultural crops may benefit from added carbon dioxide supporting growth, but other crops (and farm earnings) stand to suffer from heat, insect predation, weed growth, reduced precipitation and irrigation water during summer months, excessive precipitation in winter months, reduced temperatures for fruit set, and impaired nutrient value of food crops.

An analysis of the costs associated with the public health effects of wildland smoke exposure estimated the "value" (cost) of long-term exposure, nationwide, at between $76 billion and $130 billion annually. Six states, including Oregon, were judged to be most affected (Fann, Alman, Broome, et al., 2018)

The Pacific Northwest seafood industries (including scallops, oysters, mussels, and crabs), which subject to ocean acidification and hypoxia, will be affected, as will commercial and recreational fishing (a $9.5 billion industry in the two states, with 84,000 jobs at stake). Ocean salmon, herring, mackerel, and other commercial finfish, dependent on food chain base species such as pteropods, whose shells are being damaged by ocean acidification, are likely to be adversely affected (OCCRI, 2017, chap. 4; Barth, Fram, Dever, et al., 2018).

Elsewhere: Extreme weather ("cold winter and baking summer") is projected to increase household food bills in the United Kingdom by 5% in 2018; harvest of European wheat and other grains could be down in 2018 by 5% (Davis, August 27, 2018).[24] A U.N. report on global hunger identifies "climate shocks, such as droughts and floods, as 'among the key drivers' for the rise [in global hunger] in 2017." That would be the third such year since 2015, after years of progress in reducing this affliction; (the U.N. report issued this year does not take account of 2018's weather extremes, but Oxfam GB warns that "a hotter world is proving to be a hungrier world") (Harvey and McVeigh, September 11, 2018).

Few third-world countries are positioned to fund both decarbonization of their energy sectors and sufficient adaptation and preparation strategies for expected public health, food supply, infrastructure, and other impacts.

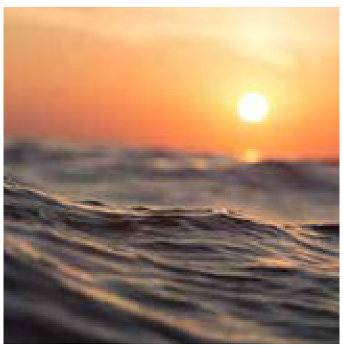
The Pacific Northwest seafood industries (including scallops, oysters, mussels, and crabs), which are subject to ocean acidification and hypoxia, will be affected, as will commercial and recreational fishing (a $9.5 billion industry in the two states, with 84,000 jobs at stake).

[24] Center for Economics and Business Research, reported in *Guardian Weekly*, August 27, 2018. Also of note: "… for every degree Celsius (about 1.8 °F) that temperatures increase, the world loses about 6% of its wheat crop." University of Florida professor of agriculture and biological engineering Senthold Asseng determined these findings through computer modeling. "Global food production needs to *grow* [italics added] by 60% by 2050 to keep up with population increases" (*Farm Journal*, 2018. Agweb).

There are ample additional examples of climate change effects locally and globally. From these we can infer three broad truths:

1. On a plain reading of the evidence, climate change is occurring in real time. Its effects are being felt, in Oregon and around the world, today and not in some distant and uncertain future. Discerning these effects no longer requires scientific instruments and models, only stepping outdoors to take in the heat and smoke.

2. Over the last three decades we have been repeatedly warned of higher deferred costs if we fail to intervene early, both to reduce emissions and to adapt to the effects of climate change. It is now later, and in many cases — not all — costs are occurring as predicted. The happy exception is that the costs of certain critical renewable resources and clean vehicle technologies have come down (but these would have come down earlier, with greater savings, if we'd forced the technologies earlier). Notwithstanding these examples of how to successfully deal with this challenge, we still drag our feet.



3. If we ended greenhouse gas emissions tomorrow, climate change effects would persist and worsen for decades to come. Cutting climate change off from its greenhouse gas fuel is like stopping a ship's engines: It does not stop the inertial forward motion but only allows it to gradually slow. Our children, and theirs, will be living for decades with the worsening consequences of our failure to take timely action when we knew we should. Bad as that is, further delay only makes it worse.

Oregon, and the nation, must also anticipate that climate change may not be linear. While average temperatures and other effects may take place predictably, their consequences may surprise and shock us with a kind of climatic "suddenness." *The Fourth National Climate Assessment Volume 1* (USGCRP, 2017) includes Chapter 15, "Potential Surprises, Compound Extremes and Tipping Elements." It contemplates multiple events reinforcing each other and compounding their effects, such as warm, wet winters followed by early and drier springs and summers; heavy rain on snow exacerbating flooding; or powerful ocean wind storms leveraging higher sea levels to create extreme tidal storm surges.

We have already seen some of these effects (e.g., Hurricanes Sandy, Harvey, and Florence). Other effects (e.g., release of frozen methane from melting permafrost) could have more far-reaching consequences.

And the Report acknowledges that "climate models … are more likely to underestimate than to overestimate the amount of long-term future change" (U.S. Global Change Research Program, 2017).

Even if they are not right about this, but more so if they are . . . we have only begun to sense the change that our children will be called upon to cope with.

Section 2:

Update on Oregon's Greenhouse Gas Emissions Inventories

In May 2018, the Oregon Department of Environmental Quality published a comprehensive report evaluating Oregon's greenhouse gas emissions (Oregon Department of Environmental Quality DEQ, 2018), using both "sector-based" and "consumption-based" accounting frameworks. This Oregon Global Warming Commission Report builds on a history of statewide inventory work:

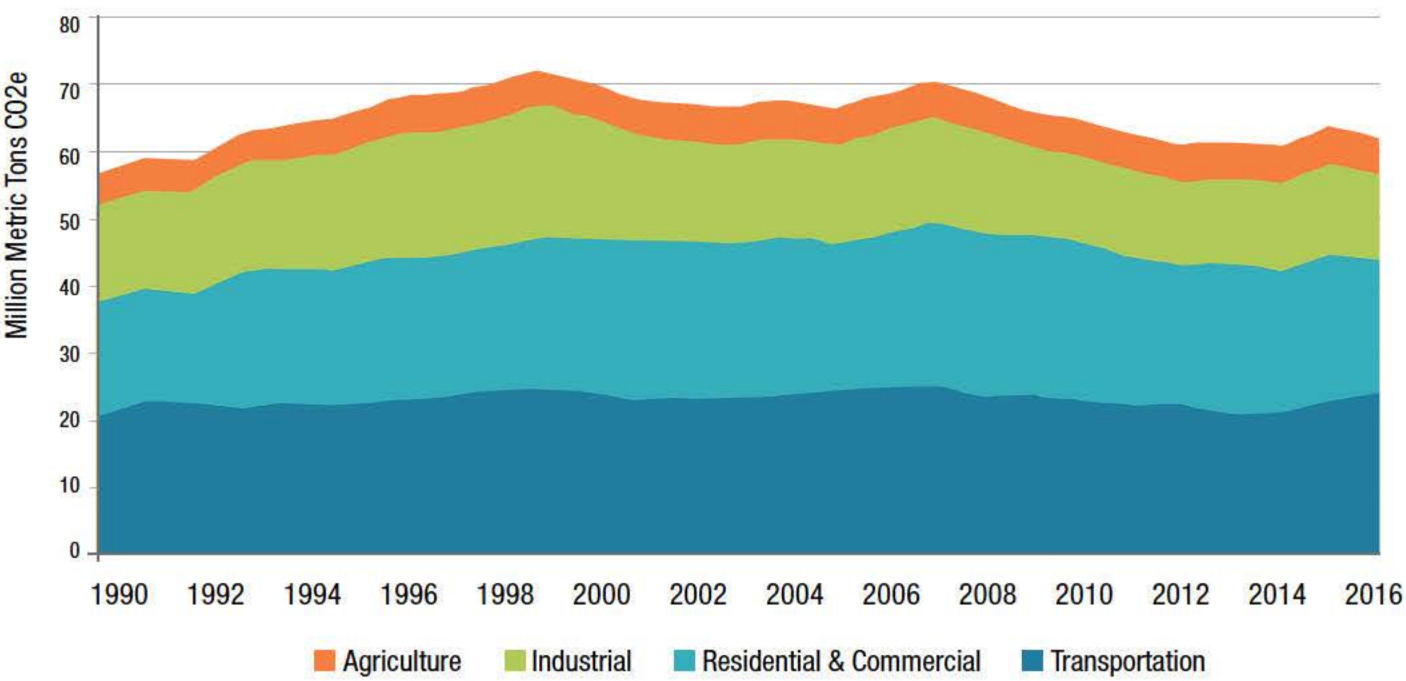
- Prior to 2011, Oregon's greenhouse gas inventory was limited to a single accounting framework (now called "sector-based") that included in-state emissions as well as emissions from generating electricity used in Oregon, regardless of where the generation occurred. Historically, this sector-based inventory was constructed in a "top-down" fashion, using an inventory tool published by the U.S. Environmental Protection Agency.
- In 2010, Oregon's largest emitters of GHGs began reporting their emissions to the Oregon DEQ as part of the mandatory greenhouse gas reporting program, allowing the DEQ to begin estimating most sector-based emissions using a "bottom-up" method.
- In 2011, DEQ published its first estimate of Oregon's emissions using an alternative, supplemental accounting framework: Oregon's consumption-based emissions inventory for 2005.
- In 2013, the Oregon Departments of Environmental Quality, Energy, and Transportation produced an integrated report that combined three inventories, using data up to 2010: (1) "in-boundary" emissions (now called "sector-based" emissions), which are those that occur within Oregon's borders plus emissions associated with the generation of electricity used in Oregon; (2) consumption-based emissions, which are those global emissions associated with satisfying Oregon's consumption of goods and services, including energy; and (3) expanded transportation sector emissions, which evaluated the full life-cycle emissions from fuel use by ground and commercial vehicles, freight movement of in-bound goods, and air passenger travel.
- In 2015, the *Oregon Global Warming Commission Biennial Report to the Legislature* included updates to these three inventories.
- In 2017, the *OGWC Biennial Report to the Legislature* included updates to the sector-based inventory.

Following is a summary of the results from the 2018 DEQ report. Appendix A provides a more detailed look at the underlying data. For more information and to download copies of the report, please see: https://www.oregon.gov/deq/FilterDocs/OregonGHGreport.pdf.

Sector-Based Inventory

Oregon's sector-based emissions from 1990 through 2016 are shown in Figure 5 and Table 1. The graph illustrates trends in emissions in this period within the key sectors, including emissions from the generation of electricity used in Oregon, regardless of where that electricity was generated. Statewide emissions declined from2007 through 2012 but have since increased. Sector-based emissions were 63 million metric tons of carbon dioxide equivalents (MTCO2e) in 2015, 62 million MTCO2e in 2016, and our preliminary estimate is ~64 million MTCO2e for 2017. Transportation continues to be Oregon's largest in-state contributor to emissions and accounted for 39% of the statewide sector-based total in 2016. In fact, transportation emissions have risen during each of the past three years. The second largest sector of emissions originates from the generation of electricity used in Oregon, with the residential sector creating the greatest demand. Emission trends in the electricity sector reflect both the impact associated with electricity demand and the influence of the availability of hydroelectricity, Oregon's largest source of zero-emitting energy.

Figure 5. Statewide sector-based greenhouse gas emissions: 1990-2016



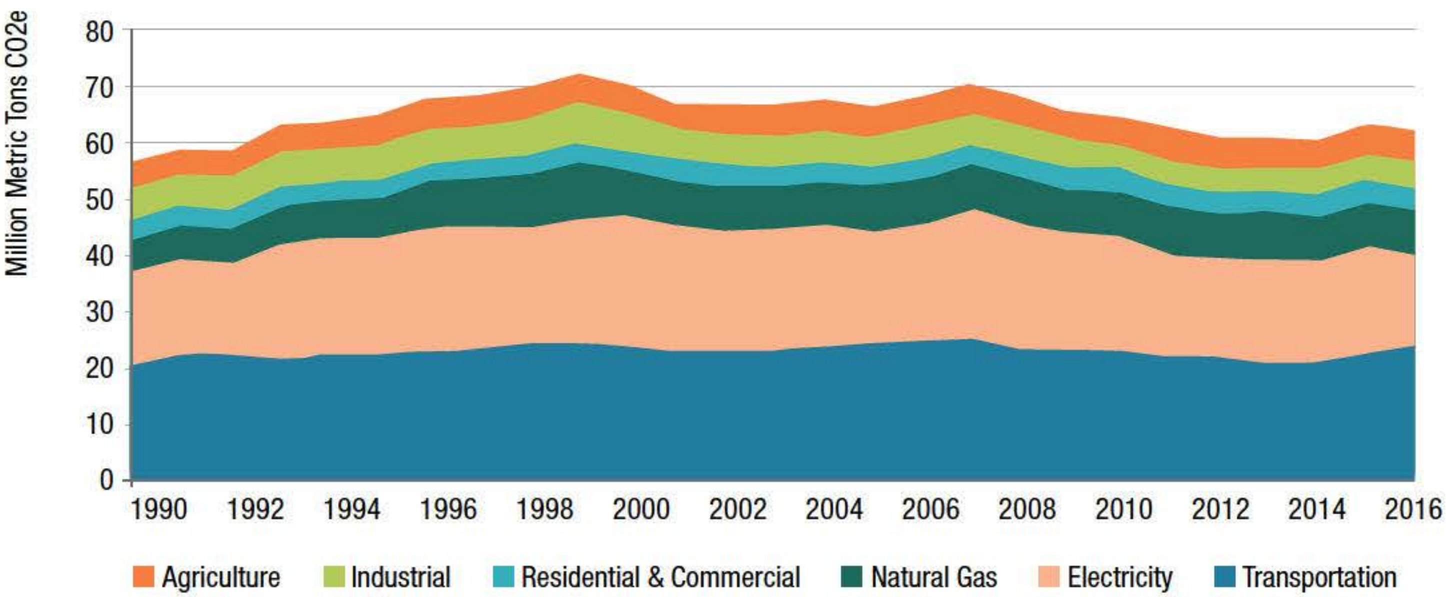
Source: DEQ, 2018

Table 1. Oregon emissions by sector: 1990-2017
(in million MTCO2e by 5-year increments + 8 most recent years)

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017
Transportation	21	23	24	25	23	22	22	21	21	23	24	25.7 (prelim)
Residential & Commercial	16	20	23	22	24	22	21	22	21	22	20	21.1 (prelim)
Industrial	14	17	18	14	12	12	12	12	12	13	12	12* (2016 data)
Agriculture	5	5	5	6	5	6	6	6	6	6	6	6* (2016 data)
Total	**56**	**65**	**70**	**66**	**64**	**62**	**61**	**61**	**60**	**63**	**62**	**64-65* (prelim)**

* These values are not yet available for 2017, but because emissions from Oregon's industrial and agriculture sectors do not generally vary greatly from year to year, we report a preliminary range for the state's total GHG emissions in 2017.

Figure 6. Sector-based emissions with electricity and natural gas aggregated for all sectors: 1990-2016



Source: DEQ, 2018. Note that this figure is identical to Figure 1 except that it shows electricity and natural gas usage taken out of the emissions of the other sectors and aggregated separately.

Table 2. Oregon sector-based emissions with an energy lens: 1990-2017 (in million MTCO2e by 5-year increments + 8 most recent years)

	1990	1995	2000	2005	'10	'11	'12	'13	'14	'15	'16	2017
Transportation	21	23	24	25	23	22	22	21	21	23	24	25.7 (prelim)
Electricity Use	17	21	23	20	20	18	17	18	18	19	16	17.1 (prelim)
Natural Gas Use	5	7	8	7	8	8	8	8	8	7	7	7* (2016 data)
Other Residential & Commercial[25]	3	3	4	4	4	4	4	4	4	4	4	4* (2016 data)
Other Industrial[26]	5	6	6	5	4	4	4	4	4	4	4	4* (2016 data)
Agriculture	5	5	5	6	5	5	6	6	6	6	6	6* (2016 data)
Total	**56**	**65**	**70**	**66**	**64**	**62**	**61**	**61**	**60**	**63**	**62**	**64-65* (prelim)**

Source: DEQ, 2018. A more detailed breakdown is provided in Appendix A.
* These values are not yet available for 2017, but because emissions associated with natural gas use, other residential and commercial, other industrial, and agriculture do not generally vary greatly from year to year, we report a preliminary range for the state's total GHG emissions in 2017.

Figure 6 and Table 2 present a different view of statewide emissions, breaking out and aggregating electricity and natural gas emissions from all sectors separately from the residential, commercial, and industrial sectors. When viewed this way, transportation is still Oregon's largest sector of emissions, followed by statewide electricity use and natural gas combustion. Emissions in the remaining sectors primarily include petroleum combustion (e.g., fuel oil for heating), waste and wastewater, and industrial process manufacturing.

More than half of the recent increased level of emissions is due to gasoline and diesel use (DEQ, 2018). Transportation emissions have grown as a share of Oregon's statewide GHG emissions total compared to emissions from electricity use. Specifically, transportation went from 35% of the statewide total in 2014 to 39% in 2016, while electricity

[25] This row presents the remaining GHG emissions after emissions from electricity and natural gas use are separated out. These are primarily associated with petroleum combustion (e.g., fuel oil for heating) and GHG emissions from waste and wastewater originating in the residential and commercial sectors.

[26] This row presents the remaining GHG emissions after emissions from electricity and natural gas use are separated out. These are composed primarily of emissions from petroleum combustion, industrial waste and wastewater, and industrial process manufacturing (e.g., production of cement, paper products, ammonia, urea, etc.).

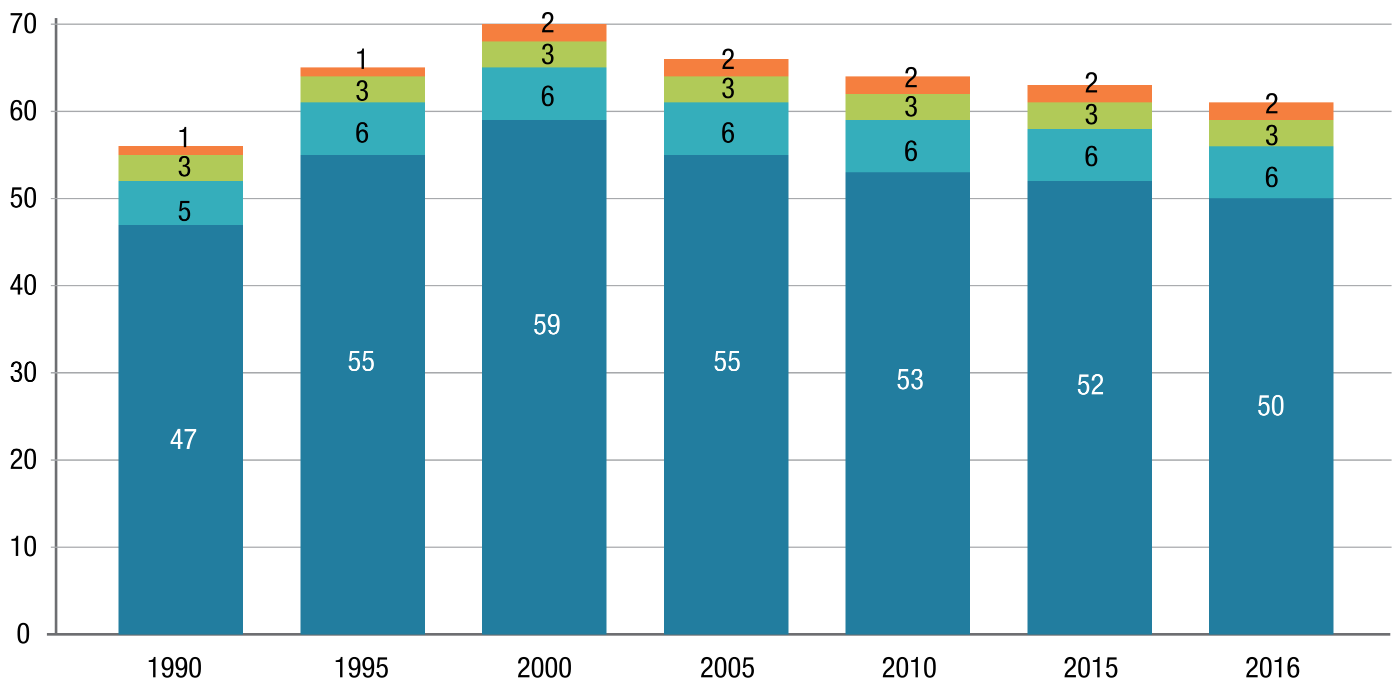
use emissions decreased from 30% to 26% of the state's total emissions, and all other sectors stayed relatively constant over the same period. Section 3 of this OGWC report will provide a deeper dive into transportation and electricity sector emissions and future projections.

Figure 7 shows the breakdown of Oregon's emissions by key greenhouse gases, including carbon dioxide, methane, nitrous oxide, and high global warming potential (HGWP) gases. Carbon dioxide makes up approximately 80% of statewide sector-based emissions and primarily originates from the combustion of fuels, including the generation of electricity. The second most abundant gas, methane, makes up approximately 10% of the statewide sector-based total. Methane emissions are primarily a result of agricultural activity but also originate from landfills and natural gas distribution.

Over time, the relative contributions from carbon dioxide, methane, and nitrous oxide have stayed relatively constant, while the share of HGWP gases has grown from 1% of statewide emissions in 1990 to 4% of emissions in 2016. Although HGWP gases are emitted in small quantities, their impact is significant due to their long atmospheric lifetimes and their ability to absorb energy, which is hundreds to thousands of times higher than carbon dioxide.[27]

Figure 8 compares Oregon's historical and projected GHG emissions to our statewide goals. Projected emissions are a forecast of Oregon's emissions assuming compliance with existing state policies, such as the Renewable Portfolio Standard and Clean Fuels program, and the continuation of certain federal standards like for fuel efficiency of cars and light-duty trucks (Section 4 of this report will describe why these assumptions may not hold true moving forward). The red dashed line in Figure 8 shows the trajectory of Oregon's projected emissions with these existing policies taken into account. This level is well above the state's goal of 51 million MTCO2e by 2020 and the Commission's adopted interim goal of 32.7 million MTCO2e by 2035, and it does not put Oregon on a path toward achieving its long-term goal of 14 million MTCO2e by 2050.

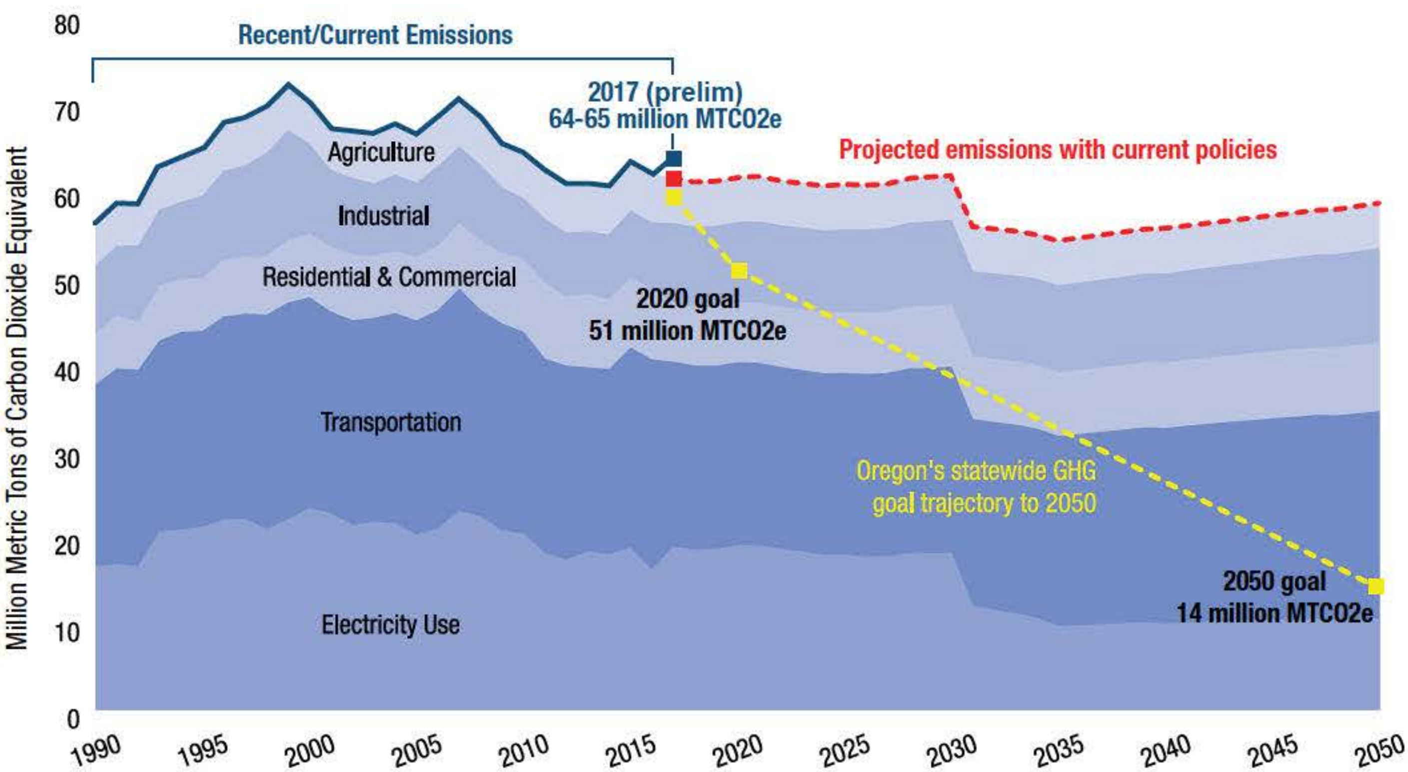
Figure 7. Statewide greenhouse gas emissions by gas over time



Source: DEQ, 2018

[27] DEQ uses 100-year global warming potentials from the *Fourth Assessment Report* of the Intergovernmental Panel on Climate Change (2007) to quantify greenhouse gas emissions in accordance with the most current accounting guidance from the United Nations Framework Convention on Climate Change.

Figure 8. Oregon past and projected greenhouse gas emissions compared to goals



Consumption-Based Inventory

Oregon also estimates its contribution to global greenhouse gas emissions using a consumption-based inventory. The consumption-based inventory estimates the global emissions resulting from consumption of goods and services (including energy) by Oregon consumers. Consistent with standards for national economic accounting, "consumers" include households and governments, as well as certain types of business expenditures (capital investment and inventory formation). Consumption-based emissions are calculated across the life cycle of items consumed. The consumption-based inventory supplements the sector-based inventory primarily by highlighting emissions resulting from the consumption of imported goods and services. Combined, the two inventories tell a more comprehensive story of how Oregon contributes to greenhouse gases and, by extension, to potential opportunities to reduce emissions.

Oregon's consumption-based greenhouse gas emissions in 2015 were 88.7 million MTCO2e, up from 79.6 million MTCO2e in 2005 and 80.2 million MTCO2e in 2010. Data from the consumption-based inventory also indicates that household demand is overwhelmingly the driver of consumption-based emissions, and that lower-income households on average consume less and generate fewer emissions (per household), while higher-income households on average generate more emissions.

Figure 9 illustrates how these and other emissions have changed between 2005 and 2015. The use of vehicles, production of food, and use of appliances (primarily for heating and cooling) contribute the most to these emissions, followed by emissions from provision of services, construction, and health care. Figure 10 shows that one category — vehicles and parts — represents fully 20% of all of Oregon's consumption-based emissions,

Figure 9. Consumption-based emissions by major category: 2005 – 2015

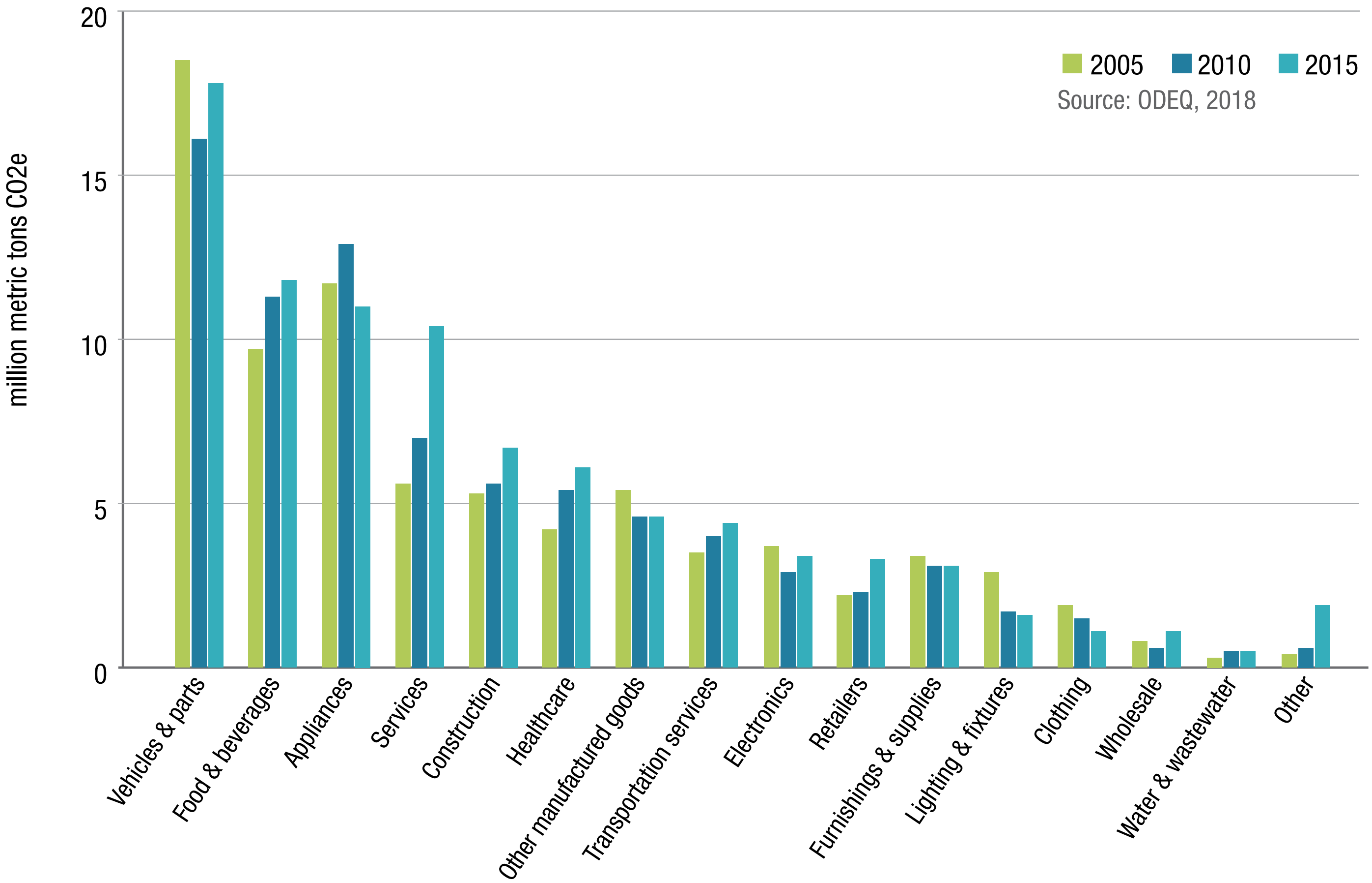
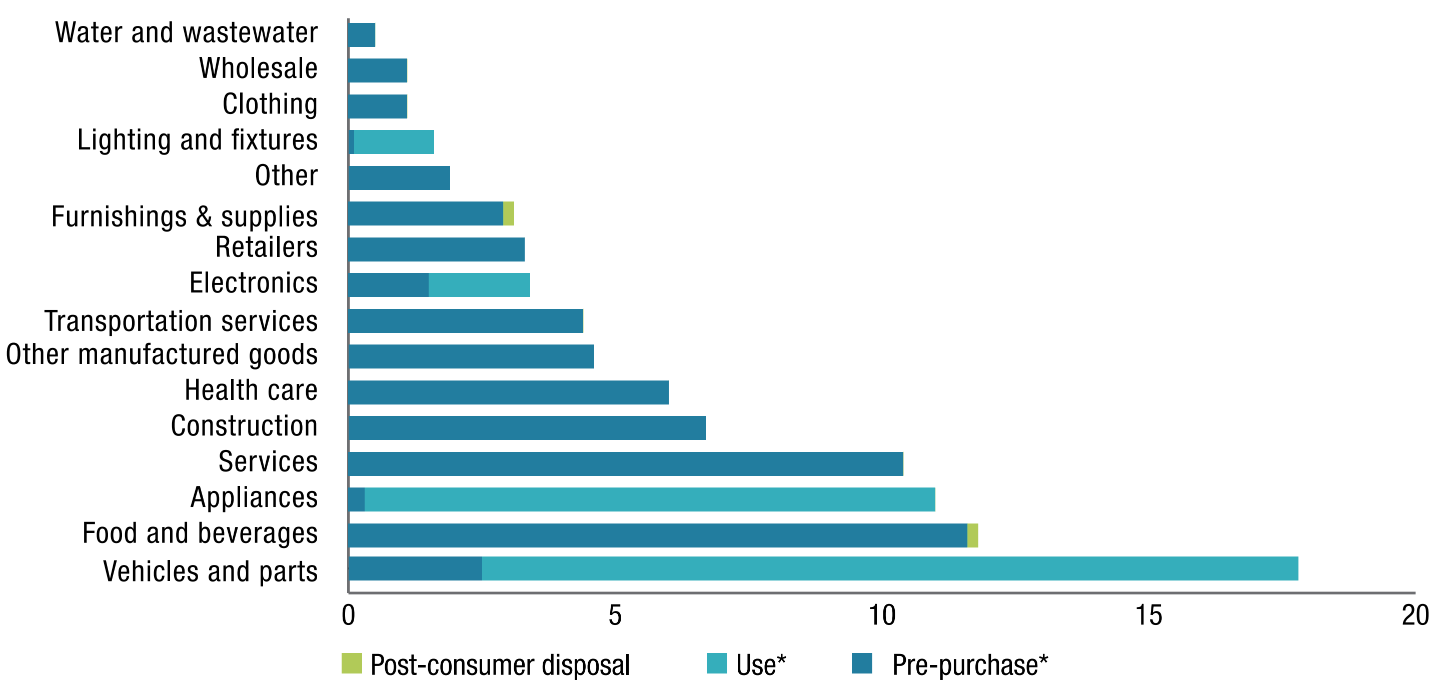


Figure 10. 2015 Oregon consumption-based greenhouse gas emissions, by category and life-cycle stage



"Pre-purchase" are all emissions that occur prior to final purchase, including production, supply chain, transport, retail and wholesale. "Use" refers to emissions resulting from the use of vehicles, appliances, electronics and lighting. Other categories (e.g., food and clothing) have use phase emissions that are accounted for elsewhere. For example, emissions from cooking and laundering are both assigned to the category of "appliances," which includes ranges and clothes dryers.

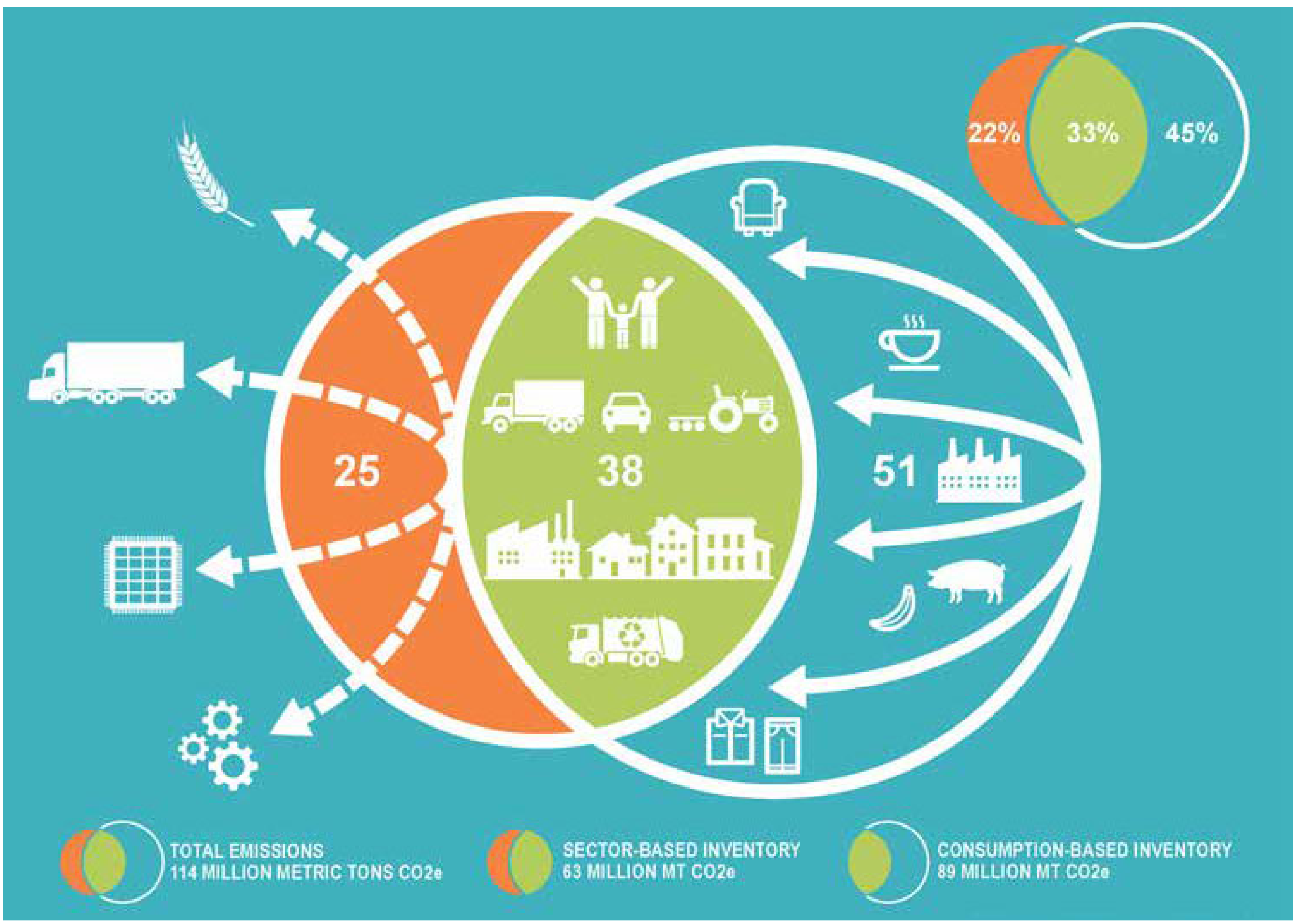
Source: DEQ, 2018

while the next highest category is food and beverages at 13% of the total. The figure also illustrates that the majority of emissions associated with vehicles and their parts are from vehicle use, while for food and beverages the majority of emissions are "pre-purchase" — i.e., associated with their production and sale. Nearly two-thirds of Oregon's consumption-based emissions are associated with just the five highest-emitting categories: vehicles, food and beverages, appliances, services, and construction.

Comparison

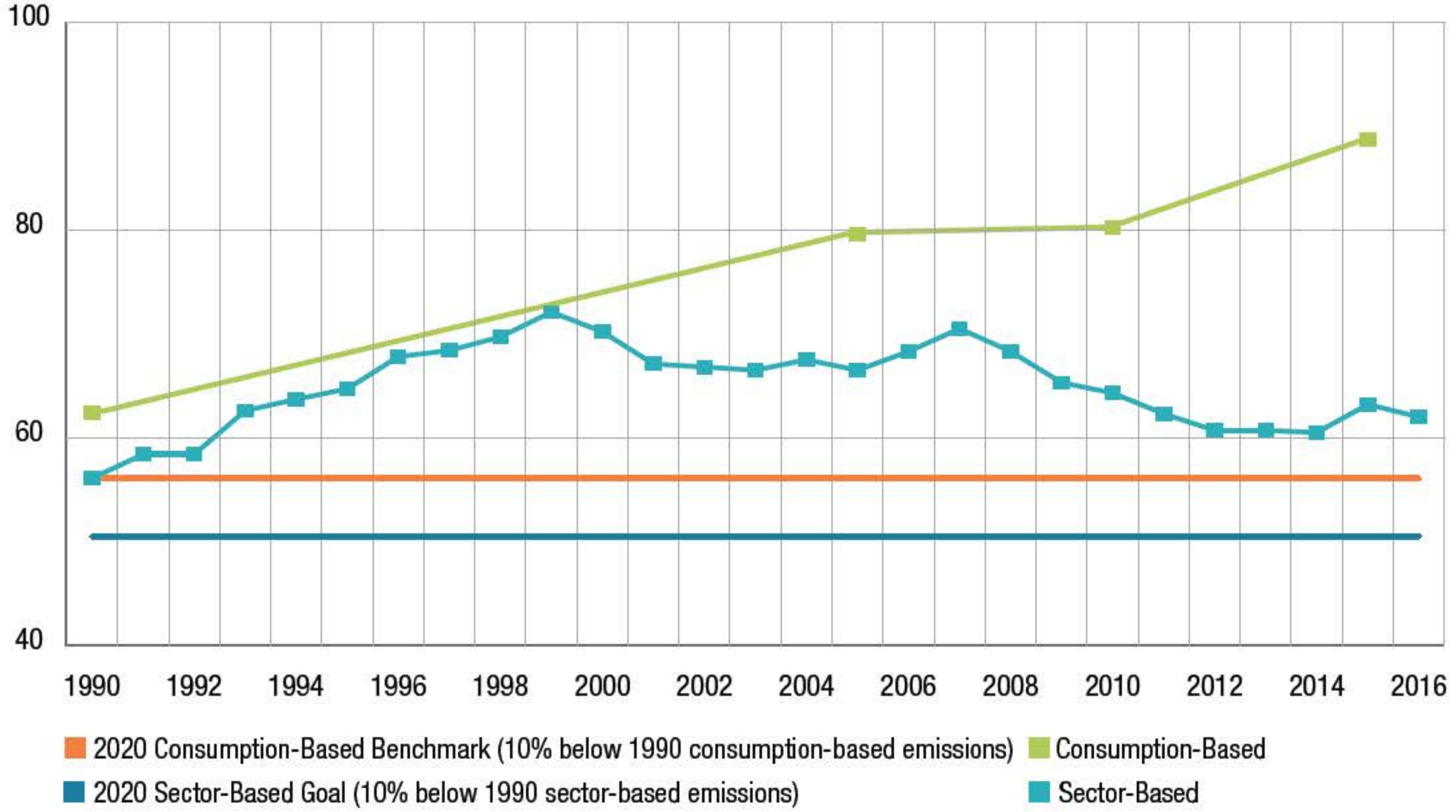
Figure 11 illustrates the relationship between the two inventories. Sector-based emissions for 2015 were approximately 63 million MTCO2e, while consumption-based emissions were approximately 89 million MTCO2e. The inventories share about 38 million MTCO2e in common. These shared emissions are from household and government use of energy and waste disposal, as well as commercial and industrial emissions associated with producing goods and services in Oregon that are consumed in Oregon, such as Oregonians' purchases of local ice cream or health care.

Figure 11. Comparison of Oregon's 2015 sector- and consumption-based greenhouse gas emissions expressed in millions of tons of CO2e



Source: DEQ, 2018. Note that the *left segment* shows emissions occurring in Oregon from making products and services that are exported. The *right segment* shows emissions occurring elsewhere in making products and services imported into Oregon. The *middle segment* shows emissions occurring in Oregon from making products and services in Oregon that are also used in Oregon.

Figure 12. Trends from Oregon's updated GHG inventories



Source: https://www.oregon.gov/deq/aq/programs/Pages/GHG-Oregon-Emissions.aspx

This overlap between the two inventories creates the potential for double counting, which is why the inventory totals are never simply added together.

Approximately 25 million MTCO2e of emissions in the sector-based inventory are distinct, and are associated with the in-state production of exported goods and services. These include Oregon's signature exports: foods, transportation equipment, semiconductors and electrical devices, and machinery. It also includes services that are "exported" to the extent that they are purchased by non-Oregonians, such as hotel stays and restaurant visits by tourists.

Oregon's imported emissions — at 51 million MTCO2e — are double those of our exports. These imported emissions are unique to the consumption-based inventory and include emissions associated with a wide variety of imported finished goods. It also includes additional out-of-state emissions that are not otherwise included in the sector-based inventory, such as out-of-state emissions associated with extracting and producing fossil fuels consumed by Oregonians and the out-of-state emissions embedded in the supply chains of many services and goods consumed by Oregonians, such as Chinese cement and steel.

After eliminating any overlap, the sum of Oregon's 2015 emissions demonstrates a carbon footprint of 114 million metric tons of CO2e — more than either inventory alone. Indeed, Oregon contributes to climate change in many different ways, and when viewed together, these distinct inventories provide a broader understanding of both our emissions and the opportunities to reduce them.

Additional Key Findings

Results from Oregon's updated inventories indicate that Oregon's contribution to global concentrations of greenhouse gases is not subsiding. The combustion of fossil fuel, whether occurring within Oregon or as a result of our consumption, is the key driver of greenhouse gas emissions. Figure 12 shows that Oregon is not on track to reduce statewide emissions 10 % below 1990 levels by 2020, in accordance with its goals. Rather, consumption-based emissions are rising, while sector-based emissions are not declining. The gap between the inventories has also grown over time. Consumption-based emissions were approximately 6 million MTCO2e higher than sector-based emissions in 1990. Fifteen years later, in 2005, that gap doubled (to 13 million MTCO2e), and 10 years later it doubled again (to 26 million MTCO2e in 2015). The Oregon Global Warming Commission will continue to rely on the research and analysis at DEQ and other state agencies to monitor and report on the course of current trends in Oregon's greenhouse gas emissions.

Emissions Intensity Data: A Different Way of Viewing Statewide GHG Emissions

Emissions intensity refers to the emissions of a given pollutant relative to a measurement of a specific activity or number of people. In past OGWC biennial reports, we have presented GHG emissions per capita and emissions per dollar of state gross domestic product (GDP). This helps provide insight about the effects of net population migration and economic activity on the state's absolute (total) emissions numbers. However *only total emissions count* when determining Oregon's contribution to either the forcing of climate change and its effects, or the abatement of climate change and effects.

Tables 3 through 6 present Oregon's per capita and per GDP emissions using both the sector-based and consumption-based emission inventories. Where data are available, we also present estimates of per capita emissions from other jurisdictions nationally and internationally. These are rough comparisons for scale only, since other GHG inventories are not always entirely comparable to Oregon's given differences in accounting methods for GHG emissions from the electricity sector (Oregon's is based on consumption regardless of where the electricity was produced, while other inventories can differ in how they account for electricity production emissions). While the emissions intesity data are a useful comparison to the absolute inventory data, it is important to note that solving the problem of climate change will require absolute reductions in GHGs, not only reductions in emissions per person or per unit of output. It is for this reason that GHG reduction goals and targets around the world – including ours – are expressed in absolute terms. Nonetheless, we endeavor to present these additional data points wherever possible.

The tables present the data and supporting sources for the GHG emissions intensity calculations for Oregon. For the other jurisdictions presented in Tables 4 and 5, GHG data came from those state or country GHG inventories and population data from the U.S. Census Bureau and Eurostat. Dashed boxes in all tables indicate years for which comparable data are not available.

Table 3. Data and supporting sources for emissions intensity calculations

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
Total sector-based GHG emissions (MMT)[1]	56.4	64.9	70.7	66.2	63.9	62.4	60.2	60.3	60.3	63.4	61.9
Total consumption-based GHG emissions (MMT)[1]	62.4	-	-	79.6	80.2	-	-	-	-	88.7	-
Population (millions)[2]	2.8	3.2	3.4	3.6	3.8	3.9	3.9	3.9	4.0	4.0	4.1
State GDP (millions of real 2009 dollars)[3]	92,850	114,805	130,992	153,771	190,371	198,298	192,598	188,806	190,626	199,682	207,367
Total	**56**	**65**	**70**	**66**	**64**	**62**	**61**	**61**	**60**	**63**	**62**

Sources:
1. Oregon GHG Inventory (www.oregon.gov/deq/aq/programs/Pages/GHG-Oregon-Emissions.aspx)
2. Portland State University Population Research Center (www.pdx.edu/prc/home)
3. U.S. Department of Commerce (https://www.bea.gov/data/gdp/gdp-state). Note that Oregon's GDP and emissions per GDP are expressed on the basis of real (inflation-adjusted) 2009 dollars. Because of changes in accounting standards at the U.S. Bureau of Economic Analysis, 1990 and 1995 data are only approximately comparable to data from later years. Data for 2000 and later years are expressed on the basis of chained 2009 dollars, while earlier years are expressed as real (inflation-adjusted) 2009 dollars, calculated using simple ratios of the consumer price index. Pre- and post-1997 economic data are not exactly comparable, but the inconsistency is expected to be fairly small.

Table 4. Oregon's per capita sector-based GHG emissions compared to other jurisdictions (million MT CO2e per person)

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
Oregon	19.7	20.3	20.5	18.3	16.8	16.1	15.6	15.5	15.3	15.7	15.2
California	-	-	-	-	12.0	11.8	11.8	11.7	11.5	11.3	10.9
Washington	18	-	-	-	14	14	14	14	-	-	-
European Union	12	11	11	11	10	9	9	9	8	9	8
United States	26	26	26	25	22	22	21	21	21	21	20

Table 5. Oregon's per capita consumption-based GHG emissions compared to other jurisdictions (million MT CO2e per person)

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
Oregon[28]	21.9	-	-	22	20.9	-	-	-	-	22.1	-
Minnesota[1]	-	-	-	-	-	-	24.7	-	-	-	-
United States[29]	25.0	25.9	29.0	29.2	25.6	25.0	24.2	24.5	24.3	23.6	-
United Kingdom[30]	15.7	15.6	16.4	16.7	14.4	13.5	13.7	13.5	13.0	12.5	-

Table 6. Oregon's per GDP greenhouse gas emissions (million MT CO2e per GDP, in millions of real 2009 dollars)

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
Sector-based emissions per GDP	605	564	536	432	338	314	315	322	317	316	298
Consumption-based emissions per GDP	672	-	-	518	421	-	-	-	-	444	-

[28] Oregon and Minnesota consumption-based emissions are estimated using a similar methodology and data sets and are relatively comparable. U.S. and U.K. consumption-based emissions are estimated using somewhat different methods and are not as comparable to Oregon.

[29] U.S. consumption-based emissions estimated from the U.S. national GHG inventory (U.S. EPA, 2018), multiplied by a ratio of consumption-to-territorial CO2 emissions for the U.S. estimated at www.worldmrio.com.

[30] U.K. consumption-based emissions estimated from the U.K. national GHG inventory (U.K. Department for Business, Energy, and Industrial Strategy, 2017), multiplied by a ratio of consumption-to-territorial CO2 emissions for the U.K. estimated at www.worldmrio.com.

Section 3:

A Closer Look at Oregon Utility Emissions

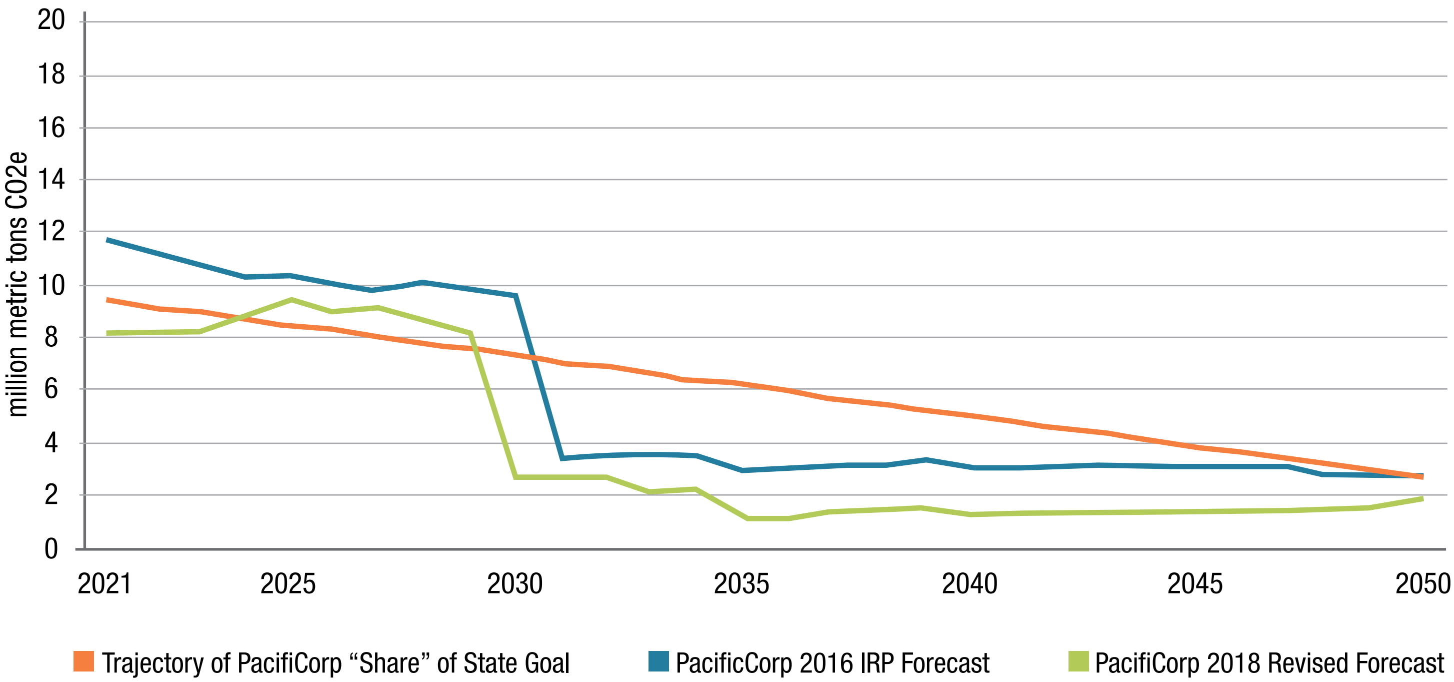
Electricity emissions in Oregon are largely a tale of the two largest investor-owned utilities, Portland General Electric (PGE) and PacifiCorp (called "PAC" in this report, also known as Pacific Power to customers in Oregon). The former serves customers only within the state of Oregon, while the latter has customers spread over six western states (we focus on the share of PAC's deliveries just to Oregon customers). PGE and PAC together serve about two-thirds of Oregon's utility customers. The other third is mostly served by Oregon's consumer-owned utilities, who are primarily supplied by the Bonneville Power Administration, which provides an electricity mix that is almost entirely hydroelectricity with a near-zero carbon content. A small subset of consumer-owned utilities generate or purchase additional electricity beyond what they receive from Bonneville Power Administration. Idaho Power Company serves approximately 18,000 people in far eastern Oregon (Baker, Harney, and Malheur Counties).

Both PGE and PAC have generating facilities within and outside Oregon's boundaries. PGE owns Oregon's only in-state coal facility (Boardman), numerous gas-fired facilities, and a share of the Colstrip coal plant in eastern Montana. PAC generates >60% of its power from coal facilities in several western states, but not in Oregon. For years in which the region's snowpack allows greater than average hydroelectric generation, both utilities will purchase lower-cost hydro and operate their thermal plants less, resulting in some unevenness of year-to-year carbon emissions and some difficulty in making comparisons.

Nevertheless, the story of PGE/PAC carbon emissions is largely one of how long the utilities' coal plants will continue to operate, and what will replace any terminated plants. It is also a story of a consistent commitment over the last four decades, driven by public policy and implemented by the utilities and others, to invest in energy efficiency before building new power plants. And it is becoming, as well, a story of renewable energy technologies that are not new but have gained new traction as their costs come down and carbon concerns grow.

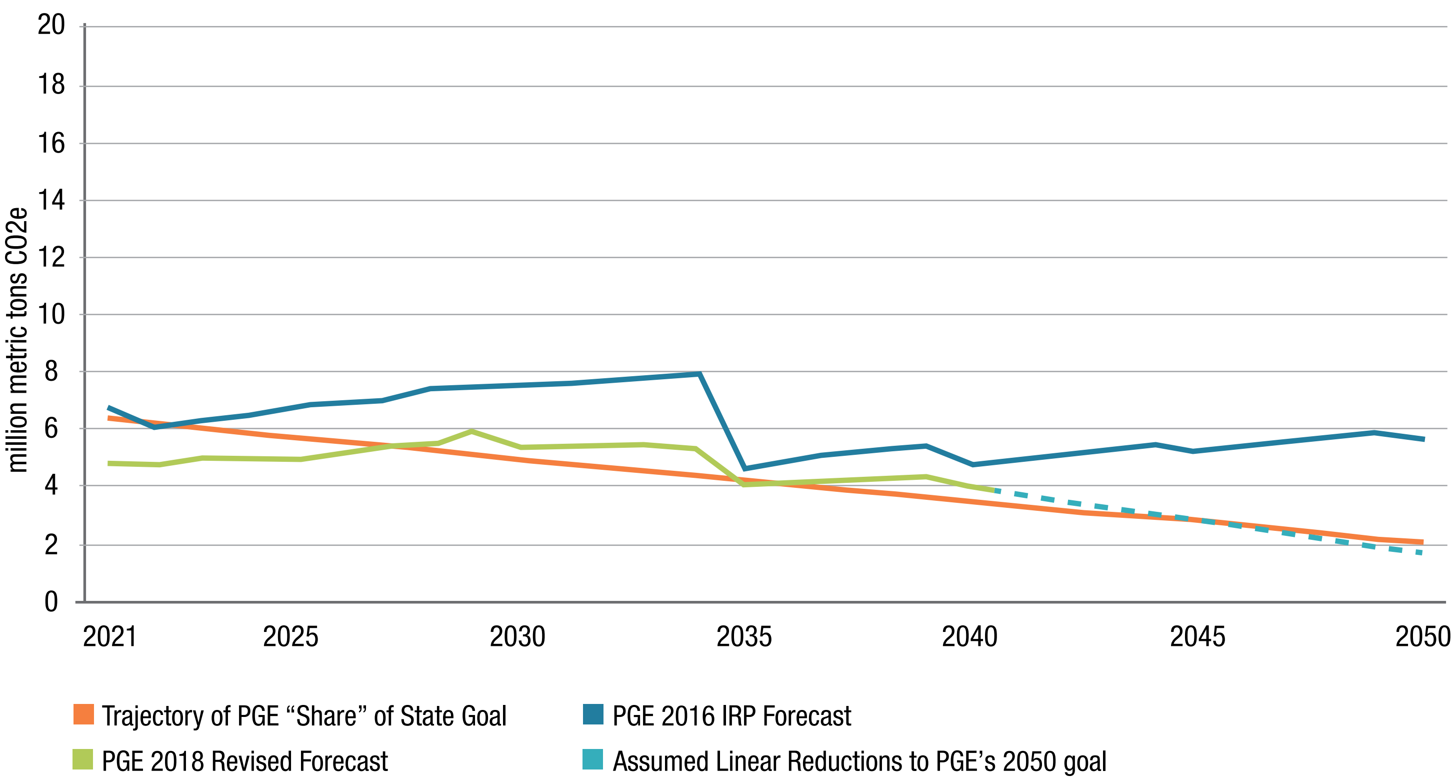
While greenhouse gas emissions from natural gas deliveries and onsite combustion have remained relatively stable in Oregon within a range of about 7–9 million metric tons since 2000 (or about 11–14% of total state emissions), the record looks better on a per customer basis. NW Natural, formerly Northwest Natural Gas Company, which supplies about two-thirds of gas deliveries in the state — mostly to residential and commercial heating loads — has itself seen a steady level of emissions but a per customer decline in usage (weather adjusted) of 19% since 2000.

Figure 13. Comparison of PacifiCorp forecasted emissions to OGWC proposed utility trajectory



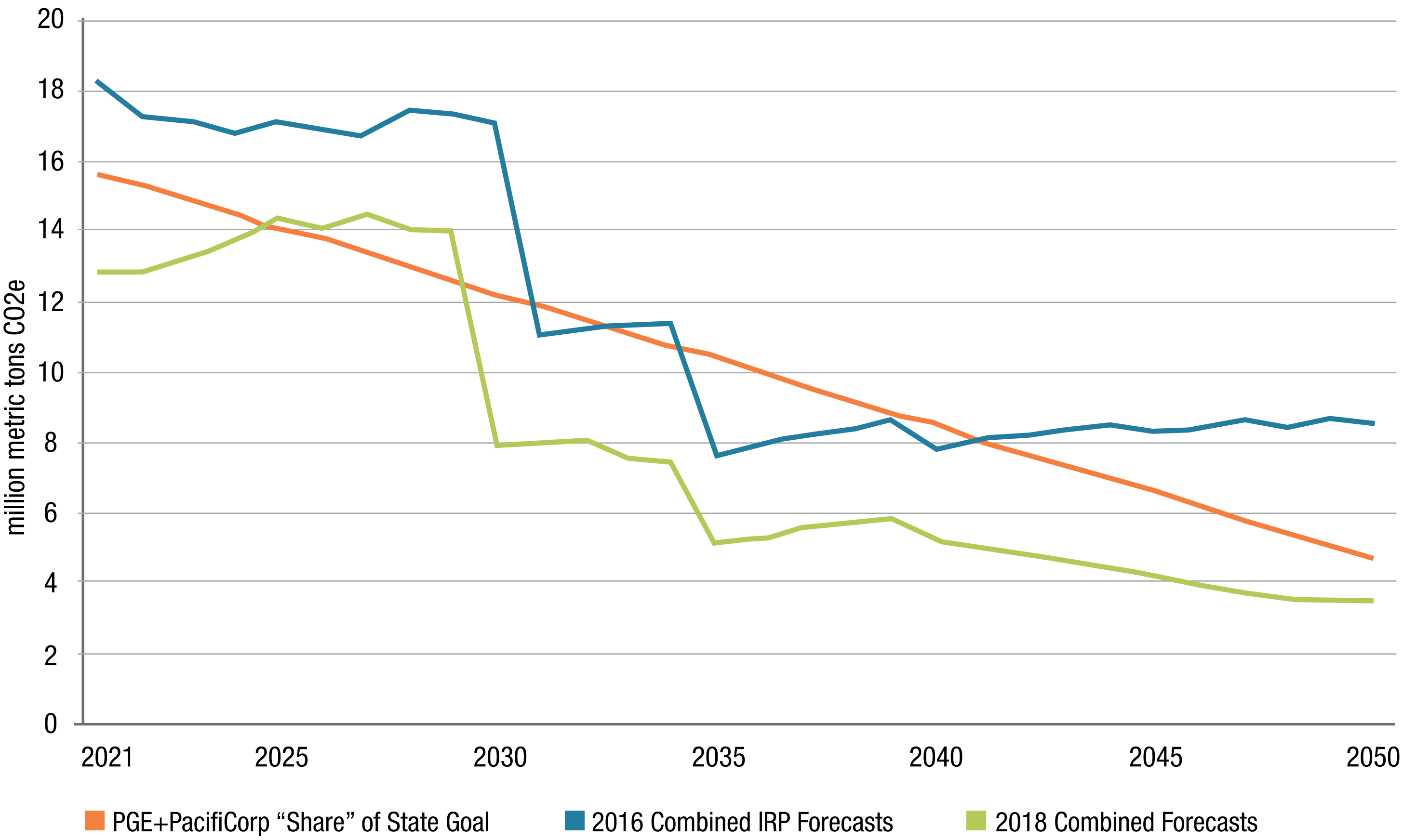
Source: OGWC staff analysis

Figure 14. Comparison of Portland General Electric forecasted emissions to OGWC proposed utility trajectory



Source: OGWC staff analysis

Figure 15. Comparison of combined Portland General Electric and PacifiCorp forecasted emissions to OGWC proposed utility trajectory



Source: OGWC staff analysis

A Tale of Two Years

In the year 2005, Oregon's largest electric utilities, PGE and PAC, emitted 22.72 million metric tons of CO2e, or 33% of the state's total.

By 2016 these emissions had dropped to 14.95 million metric tons (24% of total Oregon CO2e), of almost 30%. A large share of this reduction is associated with a 22% reduction in electricity generation, mostly associated with lower levels of energy generated for resale to industrial customers and other utilities. Because sales to industrial customers and for resale to other utilities are numbers that can bounce around, we can understand underlying trends best by focusing on residential customers and loads.

Both utilities have seen their numbers of residential customer accounts grow in this period by about 11%. But total kilowatt hours delivered to these customers have remained level, which should mean that each customer is using less. And, in fact, data from the Oregon Public Utility Commission show a reduction in kilowatt hours per customer of 9% (PGE) and 8% (PAC). So customers are using electricity more efficiently, notwithstanding that households are increasing their use of appliances and amenities that plug into the wall sockets (hence, "plug loads"). Increasing use of televisions, phones, computers, kitchen appliances, air conditioning, and other conveniences is being offset by increasingly efficient lighting, appliances, and heating/cooling electrical equipment.

But carbon reductions are not achieved by holding electrical loads steady. Either loads have to decrease, or carbon efficiencies in generating electricity have to gain traction. In addition, if there is to be a significant shift in vehicle fuels from gasoline and diesel to electricity, the sources of generated electricity become more important still.

The Carbon Chapter

While electricity deliveries have remained flat in the face of population growth and the spread of plug loads, electric utility carbon emissions have actually declined. PGE's carbon emissions in 2005 were 10.35 million metric tons; by 2016 they were down to 6.45 million metric tons.

PAC's emissions, for the share of its overall generation allocated to Oregon loads, dropped from 12.37 million metric tons in 2005 to 8.50 million metric tons in 2016.

The Oregon Department of Energy reports that from 2014 through 2016 the average kilowatt hour of electricity from PGE resulted in 0.896 pounds of carbon dioxide emissions. For PAC, the comparable figure was 1.552 pounds, reflecting the greater concentration of coal-fired generation in the PAC resource portfolio (ODOE, 2017).

While electricity deliveries have remained flat in the face of population growth and the spread of plug loads, electric utility carbon emissions have actually declined.

The reductions achieved early in the 2005–2016 period came from the utilities using their coal plants less heavily as reliance shifted to natural gas produced from new drilling and recovery techniques. The newest, most efficient gas power plants produce electricity at a carbon intensity roughly half that of coal, and their all-in costs (capital + operations) are challenging the operating costs of existing coal plants.

In the last eight to 10 years, the challenge to coal is coming increasingly from wind and solar renewable generation, where production costs have fallen even more dramatically than with gas. The most efficient new wind projects are competitive with new gas. While there are very modest carbon emissions embedded in fabricating wind and solar equipment, they will operate for 20 years or more at emissions per-kilowatt-hour levels that are effectively zero.

As these low-carbon alternative resources have become increasingly available and cost competitive, the economic logic for continuing to burn coal at often old and inefficient facilities — some from as far back as the 1950s and 1960s — becomes increasingly threadbare. When coal plants also come under pressure to meet other environmental emissions standards (e.g., for mercury and other heavy metals or for particulate matter), owners are faced with the choice to retrofit using costly emissions control equipment or to close the plants.

Thus PGE, in 2010, had to weigh a retrofit of its Boardman, Oregon, coal plant at a cost of half a billion dollars. Had it made this choice, that added investment would be at risk for the two decades or more it would take to recover the cost from ratepayers. Regulators, stakeholders, and PGE eventually found an alternative: Invest $50 million in equipment that would meet Clean Air Act emissions requirements for 10 years; then end coal combustion at the plant.

PGE's decision to pursue this alternative should result in the utility's overall carbon emissions dropping to below 6 million metric tons in 2021 from more than 10 million metric tons only 15 years earlier. It will then face additional choices, starting with the disposition of its share of Montana's Colstrip coal plant, and finding the right low-carbon path beyond that plant and onward to 2050.

It is notable that the prevailing PAC IRP proposes substantial wind and solar resource additions, along with new transmission to support the wind.

PAC has its own hard choices ahead, with >60% of its generation coal fired, mostly from aging power plants.[31] Oregon law requires it to end "coal-by-wire" deliveries of electricity to Oregon customers not later than 2030. Oregon and Washington regulators are directing the utility to review the cost and operating assumptions under which PAC is entitled to include those costs in bills to customers. PAC's 2017 Integrated Resource Plan, or IRP, projects that most of its coal fleet will be operating through 2036, when half the coal burning capacity will have closed. But it is also proposing, to five of the six states in which it operates, an accelerated depreciation schedule that would bring them in line with Oregon, which has all the plants fully depreciated not later than 2030.

According to Chad Teply, vice president of PAC, "This recommendation supports compliance with Oregon's Senate Bill 1547, and [anticipates] Washington energy policy developments and customer-driven demands" (Clearing Up, 2018). Some of these adjustments shorten depreciation schedules by nearly 20 years. While they do not commit the utility to coal plant termination by these dates, they would ensure that the company substantially recovers its capital investments if the plants are obliged to close earlier than now planned.

It is notable that the prevailing PAC IRP proposes substantial wind and solar resource additions, along with new transmission to support the wind. It includes, for the first time since IRPs were required, no new gas or coal through the 20-year planning horizon. But the schedule for terminating PAC's coal fleet remains uncertain.

Should Oregon's Legislature in 2019 adopt an economy-wide carbon cap, additional pressure will affect the continued operation of both utilities' out-of-state plants. The cap should also accelerate the transition of the state's vehicle fleet from gasoline and diesel to electric vehicles and other low-carbon options.

[31] Dave Johnston Unit 1, in Wyoming, was placed into service in 1959.

Looking Forward

Investor-owned electric utilities, regulated by the Oregon Public Utilities Commission, are required to do IRPs every two years. These plans weigh cost and operational choices, including existing and potential environmental regulation, to bring regulators a least-cost path forward that includes disposition of existing facilities and proposals for developing new ones. The plans include forecasts by each utility of a plausible carbon emissions trajectory. Making use of both historical emissions data and projections contained in each utility's update of its filed 2016 IRP (PacifiCorp, 2017 and 2018; Portland General Electric, 2016 and 2018), we can sketch out what would be a likely path for the state's utility emissions. Table 7 assumes that PGE's "decarbonization" commitment continues after 2040 to drive the utility's emissions downward.

Table 7. Utility forecasts of GHG emissions

Year	PGE (million metric tons)	PAC (million metric tons)
2005[32]	10.02	13.49
2016	6.39	8.41
2021	4.75	8.10
2031	5.31	2.60
2040	3.95	1.20
2050*	1.65*	1.90*

*2050 emissions levels represent post-IRP (2016 Update) emissions reduction goals, for each utility, of more than 85% below 2005 levels. Emissions projections beyond the 2016 IRP planning horizon are aspirational and dependent on technical and policy evolutions that are uncertain, but utility planning and resource strategies that align with state emissions goals should result in intermediate decision-making that will enable their achievement.[33]

The state's 2050 greenhouse gas reduction goal is "at least 75% below 1990 levels." In an earlier (2016) analysis, the Oregon Global Warming Commission proposed a roughly parallel calculation for these two electric utilities of at least 80% below 2005 levels.[34] By this measure, utility emissions in 2050 would be below the combined utilities' proportionate share goal of 4.5 million MTCO2e.

We can't say what these utilities' *share* of Oregon's emissions will be in 2031 and 2040. That depends on whether the state gains control of and succeeds in driving down its transportation emissions, which have risen in the last four years. We can say that Oregon's electric utilities are on a path that, if sustained, will deliver their proportional share — as this Commission calculates such a share — of Oregon's 2050 greenhouse gas reduction goal.

How has this measure of utility emissions reduction success come about to date and what is required to sustain it?

[32] Estimated baseline using a 5-year average (2003-2007).

[33] This forecast is primarily based on PGE's acknowledged 2016 IRP and 2016 IRP Update, which may differ from the emissions forecast resulting from PGE's next IRP. Consistent with PGE's 2016 IRP and 2016 IRP Update, this forecast:

- Incorporates PGE's December 2017 load forecast.
- Simulates dispatch and emissions from PGE's thermal resources in AURORA under the 2016 IRP Update Reference Case, which includes a federal carbon price that starts at $22/short ton CO2 beginning in 2022 and escalates to $90/short ton CO2 by 2040 (all in nominal dollars). To estimate the effects of carbon pricing in 2021 for this forecast, PGE assumed that thermal plant dispatch in 2021 is identical to forecasted thermal plant dispatch in 2022.

The forecast assumes that renewable portfolio standard (RPS) resources are procured incrementally over time to ensure physical compliance with PGE's RPS obligations. With the exception of a proxy resource representing the successful outcome of PGE's ongoing renewables, it does not include RPS-eligible resources in excess of PGE's RPS obligations unless they are already online. This simplifying assumption is applied in part because PGE did not receive acknowledgement of a specific glide path of future RPS procurement in the 2016 IRP. Market purchases are assumed to have a GHG emissions rate of 0.428 MTCO2e/megawatt hour, consistent with the California Air Resources Board's unspecified import emissions rate.

[34] The OGWC suggested this alternative to reflect the complication created by the closure of PGE's Trojan nuclear plant in the early 1990s. Since nuclear energy is effectively a zero-carbon emissions technology, PGE's Trojan closure resulted in higher mid-90s emissions from the replacement gas-fired generation PGE opted to develop. Selecting a 2005 average (2003–2007) as the utility baseline that steps around this anomalous action and outcome while upping the end goal to 80% below 2005 levels keeps a degree of rigor in the goal.

Energy Efficiency

First and foremost, Oregon's utilities have participated in and supported the state's commitment to energy efficiency.

While Oregon's electricity use per capita is about average nationally, this is qualified in several ways.

First, Oregon's electricity costs are on average a third to a half what these costs (especially during peak demand hours) are in states like California and Hawaii, which rank one and two for lowest kilowatt hours per capita. Those higher electricity costs create a strong economic incentive for consumers to conserve, while in Oregon we rely more on individual commitment, state and local incentives, and program outreach and support to achieve efficiency savings. PGE and PAC customer efficiency efforts are supported by technical staff and financing tools from the Energy Trust of Oregon, a nonprofit agency with the sole mission of providing these customers with access to efficiency and renewable energy technologies.

Larger house sizes and appliance loads, even if met with efficient heating/cooling and appliances, have acted against lowering electricity use.

Second, over decades, Oregon consumers have benefited from shared access to the region's low-cost hydroelectricity, encouraging disproportionate reliance on electricity for their lighting, heating/cooling, and appliances, while other regions were more reliant on other fuels, such as gas and heating oil. Half the homes in Oregon still heat with electricity, often using old low-efficiency resistance units.[35] In overall energy use (all sources), Oregon ranks 39th in residential energy use (U.S. Energy Information Administration, 2017).

Third, a cooler, wetter Oregon climate means more reliance on energy to keep homes and businesses warm in winter months, compared to California, Hawaii, and other states with warmer winters. This distinction is weakening as these warmer areas of the country ramp up their reliance on summer air conditioning.

Finally, larger house sizes and appliance loads, even if met with efficient heating/cooling and appliances, have acted against lowering electricity use.

These qualifying factors notwithstanding, Oregon consumers, with assists from utilities and the Energy Trust of Oregon, have driven their per household usage down over this period by almost 10%. The American Council for an Energy Efficient Economy annually ranks states by their energy efficiency accomplishments. Oregon and Washington are regularly ranked within the top 10, along with states whose power costs (and therefore economic incentives) are two or three times those in the Pacific Northwest.

That said, the state's energy and carbon goals both militate against resting on these laurels. Achieving the very aggressive carbon goals will require a redoubling of efforts to both identify technological efficiency advances and move them into the marketplace at cost-competitive levels.

[35] Oregon still meets 40% of its electricity demand from hydro, although most of this goes to consumer-owned utilities, while PGE and PAC rely more heavily still on gas- and coal-fired generation.

Renewable Energy

Oregon is used to relying on renewable electricity. Until the 1960s, most electric loads, of all utilities, were served from the region's extensive system of hydroelectric dams. Oregon was an early adopter (2007) of a utility renewable portfolio standard, which required electric utilities of a certain size (PGE, PAC, and certain customer-owned utilities) to be meeting 25% of their loads from *new* renewable generation by 2025. This new generation was added to the existing renewable hydroelectric base.

In 2016 the state, with support from PGE and PAC, increased the portfolio standard to 50% new renewables by 2040.

Both utilities were on compliance paths for meeting the earlier standard, and both have expressed their expectations of meeting the new standards in a manner that achieves both affordability and system reliability.

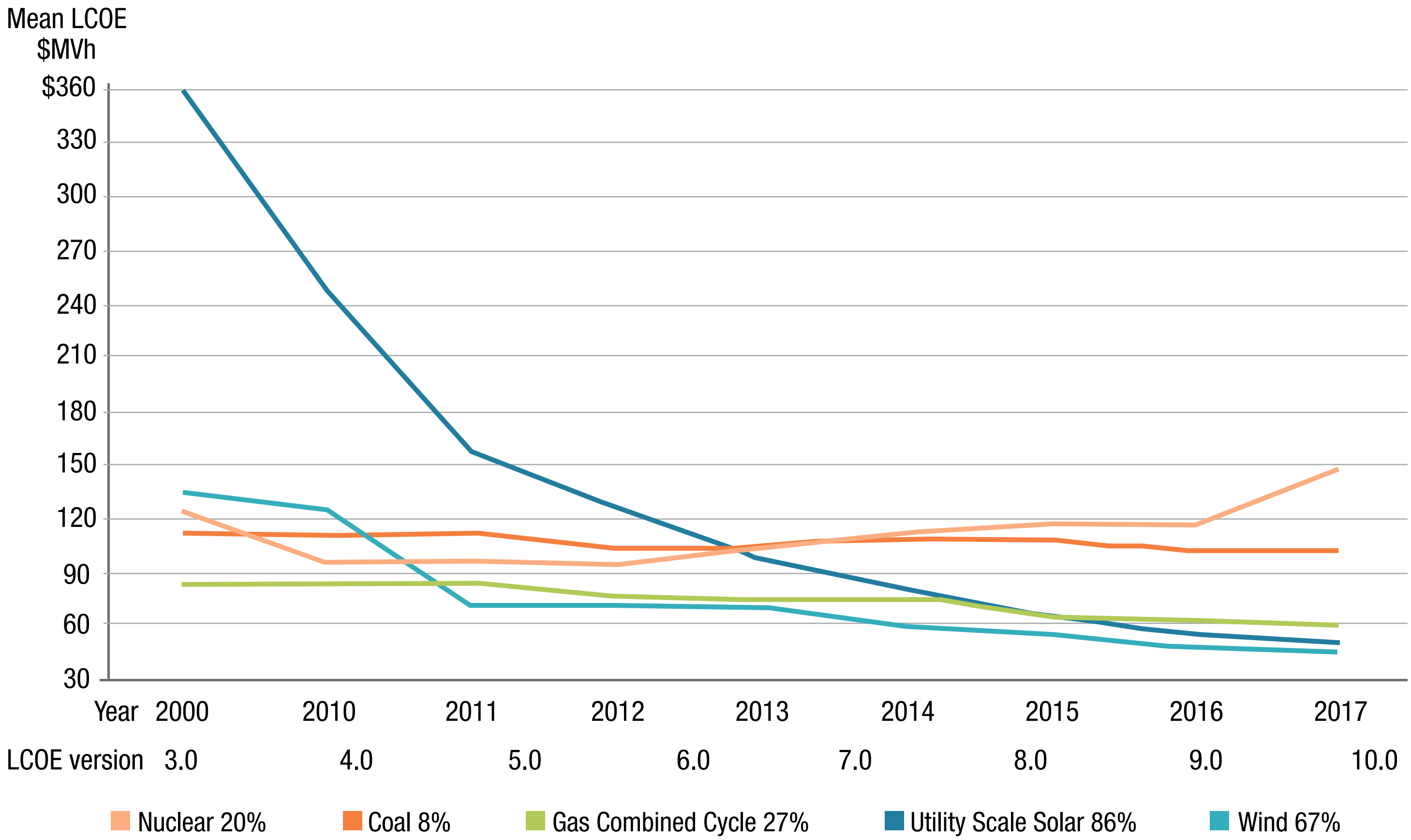
In 2016, Oregon was receiving almost 7% of its electric energy from new renewables, up from more than 1% only 10 years earlier. Both utilities were proposing significant new wind and solar facility investments in their 2016 Integrated Resource Plans.

Going forward, neither utility is proposing any significant new gas-fired generation. Both are proposing several hundred (PGE) to several thousand (PAC) megawatts of new wind and solar, anticipating the prospects that the two technologies continue to achieve significant new cost reductions, efficiency gains, and wider deployment. Figures 16 - 19 illustrate trends in falling costs of renewable electricity generation technologies and the projected shares these technologies will have in the global energy mix of the future.

Utilities, regulators, and technical staff express prudent concern about integrating the variable generating output of wind and solar into a grid that sets and attains very high reliability and power quality standards. To date, these criteria have been largely met by searching the grid for additional flexibility to achieve integration while respecting reliability standards. Wider energy imbalance markets have allowed the grids to have peaks and valleys as they find and offset themselves. Going forward, some observers believe these flexibilities will continue to be discovered in sufficient depth and breadth. Others argue that additional short- and intermediate-term electricity storage — batteries, pumped storage, underground compressed air, among other technologies — will be required. Much attention is going into these, especially short-term battery storage, where a $100/kilowatt hour threshold is posited as the target for new battery technologies.

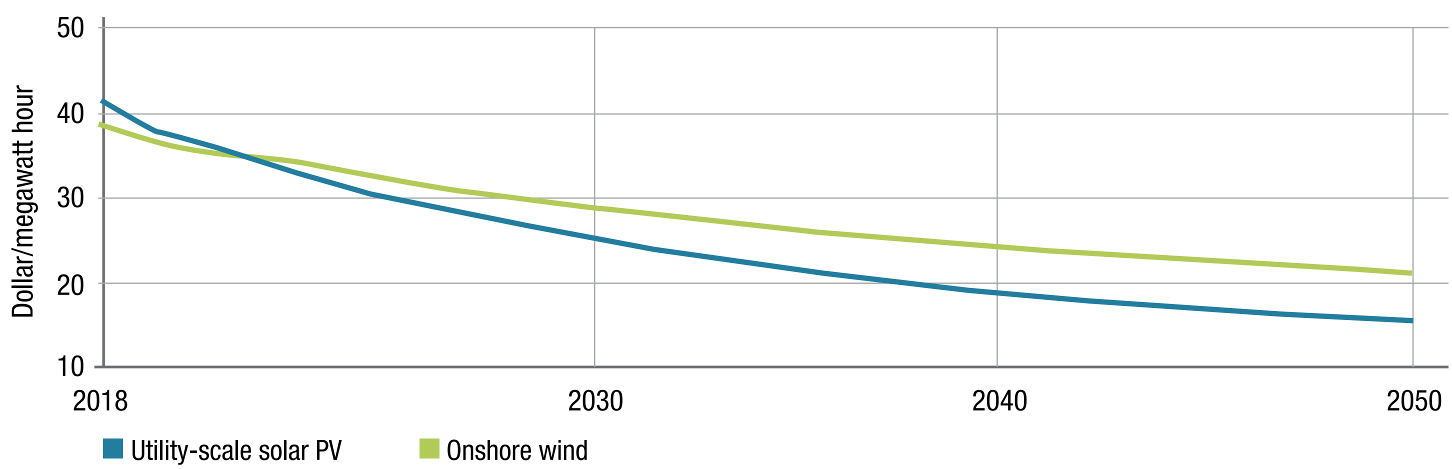
In 2016 the state, with support from PGE and PAC, increased the portfolio standard to 50% new renewables by 2040.

Figure 16. Trends in average levelized cost of energy (LCOE)[36] for selected generation technologies



Source: Lazard, 2017. Reflects average of unsubsidized high and low LCOE ranges from past reports, starting with LCOE version 3.0. Primarily reflects North American alternative energy landscape, but also broader/global cost declines.

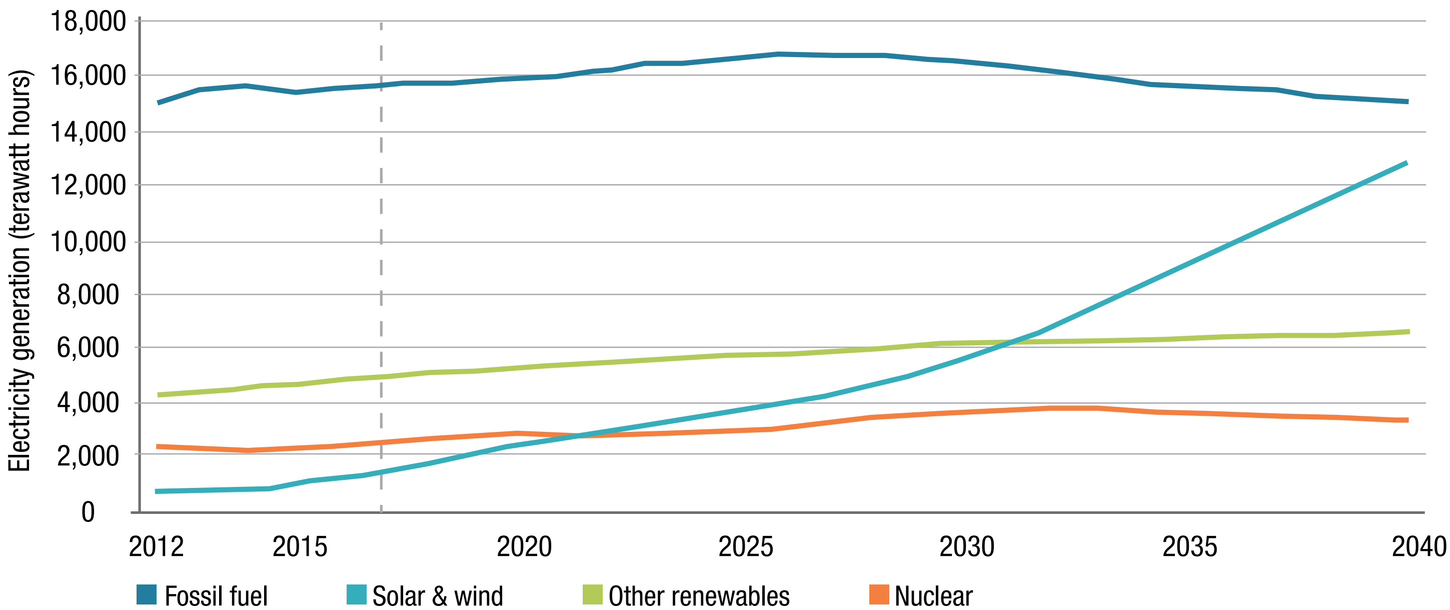
Figure 17. U.S. forceast of utility-scale solar and wind levelized costs



Source: Landberg and Hirtenstein, 2018, in Bloomberg New Energy Finance.

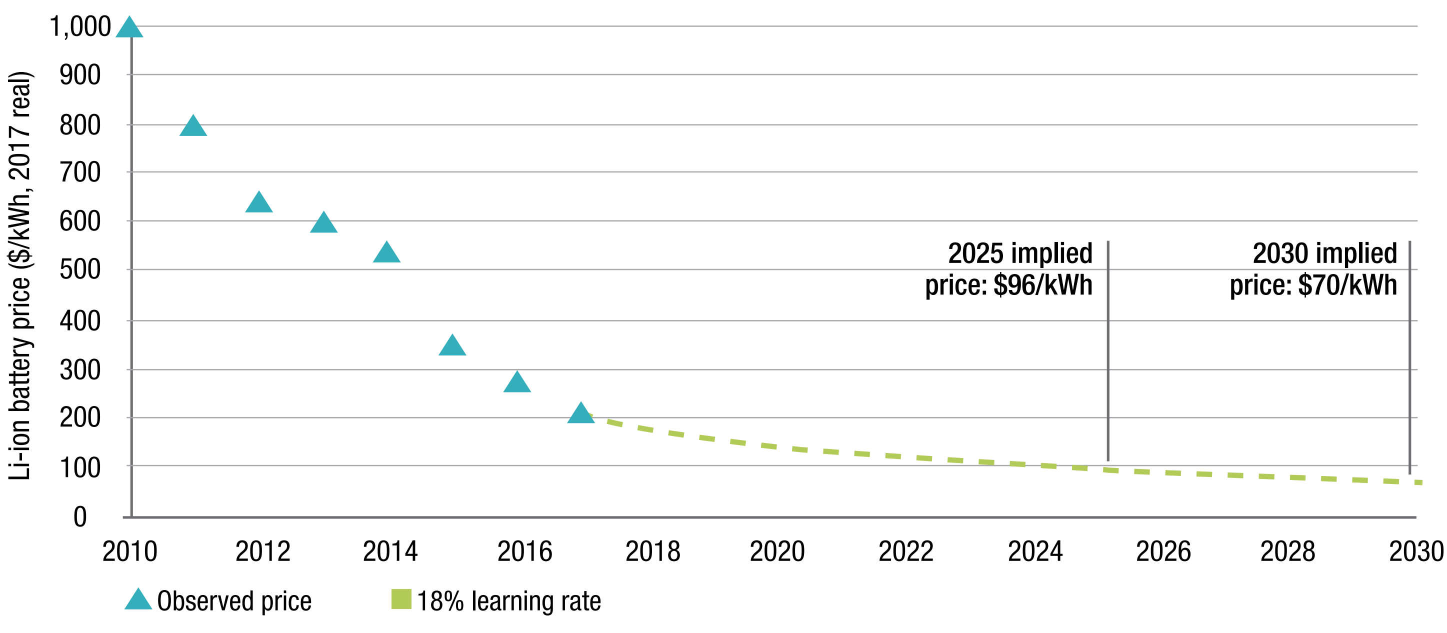
[36] LCOE calculations provide a convenient summary measure of the overall competitiveness of different generating technologies. It represents the per-megawatt-hour cost (in discounted real dollars) of building and operating a generating plant over its assumed lifetime. Calculating LCOE relies principally on information about capital costs, fuel costs, fixed and variable operations and maintenance (O&M) costs, financing costs, and an assumed utilization rate for each plant type. The importance of these factors varies among the technologies — for instance, solar and wind generation have no fuel costs and relatively small variable O&M costs, so their LCOE calculation changes in rough proportion to the estimated capital cost of generation capacity. For technologies with significant fuel cost, like coal, both fuel cost and overnight cost estimates significantly affect LCOE.

Figure 18. Historical and projected global electricity generation by technology



Source: Bloomberg *New Energy Finance*, 2017. In a 2018 analysis, Bloomberg projects that by 2050, the global electricity mix will be 63% renewables, 29% fossil fuels, and 7% nuclear (Landberg and Hirtenstein, 2018).

Figure 19. Lithium-ion battery price, historical and forecast



Source: Climate Home News Ltd., 2018.

Natural Gas

Homes and commercial establishments in the urban areas of Oregon and the Pacific Northwest are reliant on natural gas utilities to meet a substantial share of winter peaking needs for space and water heating, while many industrial processes use significant quantities of gas as well. Three gas utilities operate in Oregon: Avista Corporation, Cascade Natural Gas, and NW Natural (formerly called Northwest Natural Gas Company). Direct use of gas (in home furnaces and water heaters, for example) is a more efficient way to derive useful energy than burning the same gas in a power plant, but the combustion remains a significant source of greenhouse gas emissions.[37] From 2005 to 2016, GHG emissions from all gas users in Oregon have stayed relatively level, ranging from a low of 7.1 million metric tons of carbon dioxide equivalent in 2009 to a high of 8.2 million MTCO2e in 2013 and making up from 11 to 14% of Oregon's total annual GHG emissions.

NW Natural enlisted the services of the Energy Trust of Oregon to work with its customers on gas efficiency, weatherization, and other strategies that contribute to lowering GHG emissions.

NW Natural is the largest supplier of gas in Oregon, primarily serving residential and commercial customers.[38] According to the utility, NW Natural's emissions (expressed as CO_2 equivalents) were a little more than 3.5 million metric tons in 2017, or a little less than 6% of the state's total. NW Natural's GHG emissions can vary year by year — especially as winters are colder or warmer — but have remained roughly flat since 2000, while its customer numbers have increased significantly. As described earlier on a weather adjusted basis, NW Natural reports that its emissions per customer have declined 19% since 2000.

The first requirement for GHG reductions for both electricity and natural gas is energy efficiency, and NW Natural has demonstrated its commitment to this strategy. It voluntarily enlisted the services of the Energy Trust of Oregon to work with its customers on gas efficiency, weatherization, and other strategies that contribute to lowering GHG emissions.

NW Natural voluntarily agreed with its regulators to "decoupling" the amount of gas it supplies to customers from the returns the utility earns. This step removes the utility's profit incentive to encourage customers to use more gas, while still allowing it to earn a reasonable return for its product.

NW Natural has invested in modernizing its pipelines, replacing materials susceptible to leakage with coated steel and polyethylene. This reduces gas losses in transit, improves safety, and keeps "fugitive" methane, a powerful greenhouse gas, out of the atmosphere.

The Oregon Clean Fuels Program creates opportunities for producers of alternative fuels — such as electricity, natural gas, renewable natural gas, propane, and hydrogen — to voluntarily opt in and generate credits to trade in the program.

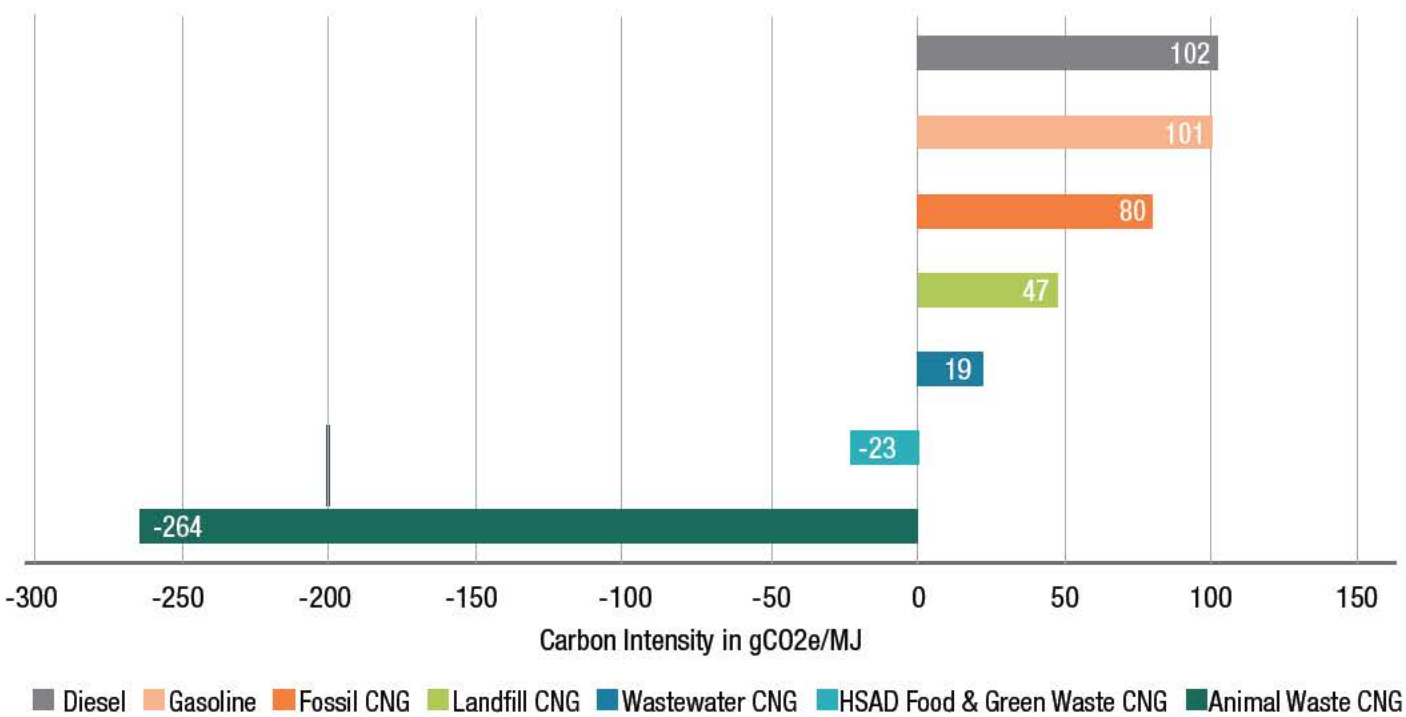
[37] 8.6 million metric tons CO2e in 2015, from inventory data tables published in the Oregon Global Warming Commission's Biennial Report to the Legislature, 2017, or about 14% of total state GHG emissions.

[38] Larger industrial users often buy their gas directly, then contract with NW Natural to transport it.

Specifically, the program allows producers to register fossil- and bio-based compressed natural gas, as well as fossil- and bio-based liquefied natural gas. Compressed natural gas has been advanced by NW Natural and other gas utilities as a lower-carbon transportation fuel compared to gasoline and diesel. There has been some resulting interest by fleets (trucks, buses), though widespread uptake has been hampered by the economic and logistical challenges of developing an efficient, extensive system of compression/distribution networks.

NW Natural has set itself a target of reducing its overall GHG emissions — not just emissions per customer — with a savings goal of 30% from 2015 levels by 2035. The primary strategies identified in their "low carbon pathway" include reducing the carbon intensity of their product, reducing and offsetting consumption, and replacing more carbon-intensive transportation fuels (NW Natural, 2018). Regarding the first and third strategies, NW Natural is pursuing some measure of fossil-based natural gas displacement with renewable natural gas (RNG) and potentially hydrogen (derived from water by electrolysis technologies). RNG is biogas[39] that has been processed to be interchangeable with conventional natural gas for the purpose of meeting pipeline quality standards or transportation fuel-grade requirements. Combustion of biogas and RNG still releases carbon dioxide to the atmosphere at the point of emission, but it displaces the more potent greenhouse gas effects of methane. On a life-cycle basis of analysis, the California and Oregon Low Carbon Fuels Programs consider certain forms of RNG to be net negative in terms of their GHG emissions impact (Figure 20).

Figure 20. Carbon intensity of approved RNG pathways used in California and Oregon Low Carbon Fuels Programs



Source: ODOE, 2018.[40]

[39] Biogas is a naturally forming gas that is generated from the decomposition of organic wastes or other organic materials in anaerobic environments or processes, such as gasification, pyrolysis, or other technologies that convert organic waste to gas in the absence of oxygen (ODOE, 2018). Biogas has a lower methane content and heating value than natural gas and contains many impurities. In some applications, it can be used directly, but in others it is considered an intermediate product that must undergo additional processing before use as fuel.

[40] https://www.oregon.gov/energy/Data-and-Reports/Documents/2018-RNG-Inventory-Report.pdf

The Oregon Department of Energy recently published the results of a detailed inventory of all potential sources of biogas and RNG available in Oregon (ODOE, 2018), which was requested by the State Legislature in SB 334 (2017). NW Natural served on the advisory committee for the inventory.

The inventory indicates that there is potential for a substantial amount of RNG to be produced in Oregon from a variety of biogas production pathways. The gross potential for RNG production when using anaerobic digestion technology is around 10 billion cubic feet of methane per year, which is about 4.6% of Oregon's total yearly use of natural gas. The gross potential for RNG production when using thermal gasification technology is nearly 40 billion cubic feet of methane per year, which is about 17.5% of Oregon's total yearly use of natural gas. The report estimated the following types of GHG benefits associated with these estimates of gross RNG potential:

NW Natural has made positive progress in this area in partnership with the city of Portland, where they are beginning to produce RNG from the city's Columbia Boulevard Wastewater Treatment Plant for pipeline injection, as well as a natural gas vehicle fueling station.

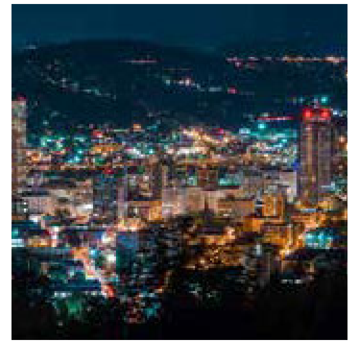
- RNG production prevents methane from sources like landfills and animal waste from being directly emitted to the atmosphere. The combustion of captured gas results primarily in carbon dioxide, a GHG that is at least 25 times less potent in the atmosphere than methane. If the volume of RNG that could be potentially captured and utilized in Oregon displaced fossil fuel natural gas for stationary combustion (e.g., heating, cooking, electricity generation, or industrial process heat), approximately 2 million MTCO2e would be prevented from entering the atmosphere.

- RNG used as an alternative to diesel fuel could produce significant GHG reductions. When used as an alternative for an equivalent amount of diesel fuel, the state's total RNG production potential from anaerobic digestion reduced net GHG emissions by almost 2.3 million MTCO2e. This is a 33% reduction in diesel fuel's total GHG contributions to the transportation sector, or a 9% reduction in the sector's total emissions of 24 million MTCO2e in 2016.

In order to realize these types of potential benefits, many barriers will need to be overcome, including financial, informational, market, policy, and regulatory (described in detail in the ODOE 2018 Report). NW Natural has made positive progress in this area in partnership with the city of Portland, where they are beginning to produce RNG from the city's Columbia Boulevard Wastewater Treatment Plant for pipeline injection, as well as a natural gas vehicle fueling station. However, more work is needed to enable the development of RNG at scale in Oregon.

NW Natural has chosen an aspirational and challenging — and necessary — path to lower GHG emissions, and now needs to identify and implement more specific ways and means for achieving that outcome.

Conclusion



With the discipline of state law that will displace coal generation and require new renewables, Oregon electric utilities are on an emissions reduction trajectory that is in general alignment with Oregon's overall emissions reduction goals. Without those same statutory incentives, NW Natural has set itself a comparably challenging GHG reduction goal. Oregon's ability to meet its overall emissions goals depends on locking in these utility reductions.

There remains, for the electric utilities, the considerable legacy of aging coal plants needing to be moved to retirement in a prudent but accelerated manner. Both PAC and PGE Integrated Resource Plans would have these facilities operating well into the 2030s (and in PAC's case, beyond). While shifting plant outputs to customers outside our state is an alternative Oregon cannot directly control, it must work with Washington and other allies to bring about earlier retirement.

Coal retirement will leave substantial gas generation in place, most of it today configured for operating to meet base-load customer requirements. To keep emissions going down, these plants will likely need to find a new vocation as integrating units that support increasing levels of variable (wind and solar) renewable generation. New gas plants are unlikely to be approved except in such an integrating role.

New wind and solar generation is clearly the mainstay of the new renewable electrical grid. These technologies may be joined in a decarbonized utility world by other renewable generating technologies (ocean, geothermal, biomass, etc.) and by biogas and hydrogen replacing fossil-derived gas in gas utility pipelines. Wind and solar, while more reliably predictable than many utility observers first thought, nevertheless will require some measure of storage support as they penetrate the grid at higher and higher levels. They also will require rethinking and some refiguring of the transmission grid and operations to optimize their system value.

At the same time, the ability of Oregon's gas suppliers to find, or fabricate, low-carbon versions of natural gas and package these with ongoing energy efficiency savings will determine whether gas remains a significant contributor to Oregon's energy banks.

Utilities are in for interesting times.

Section 4:
Projected GHG Emissions from the Transportation Sector

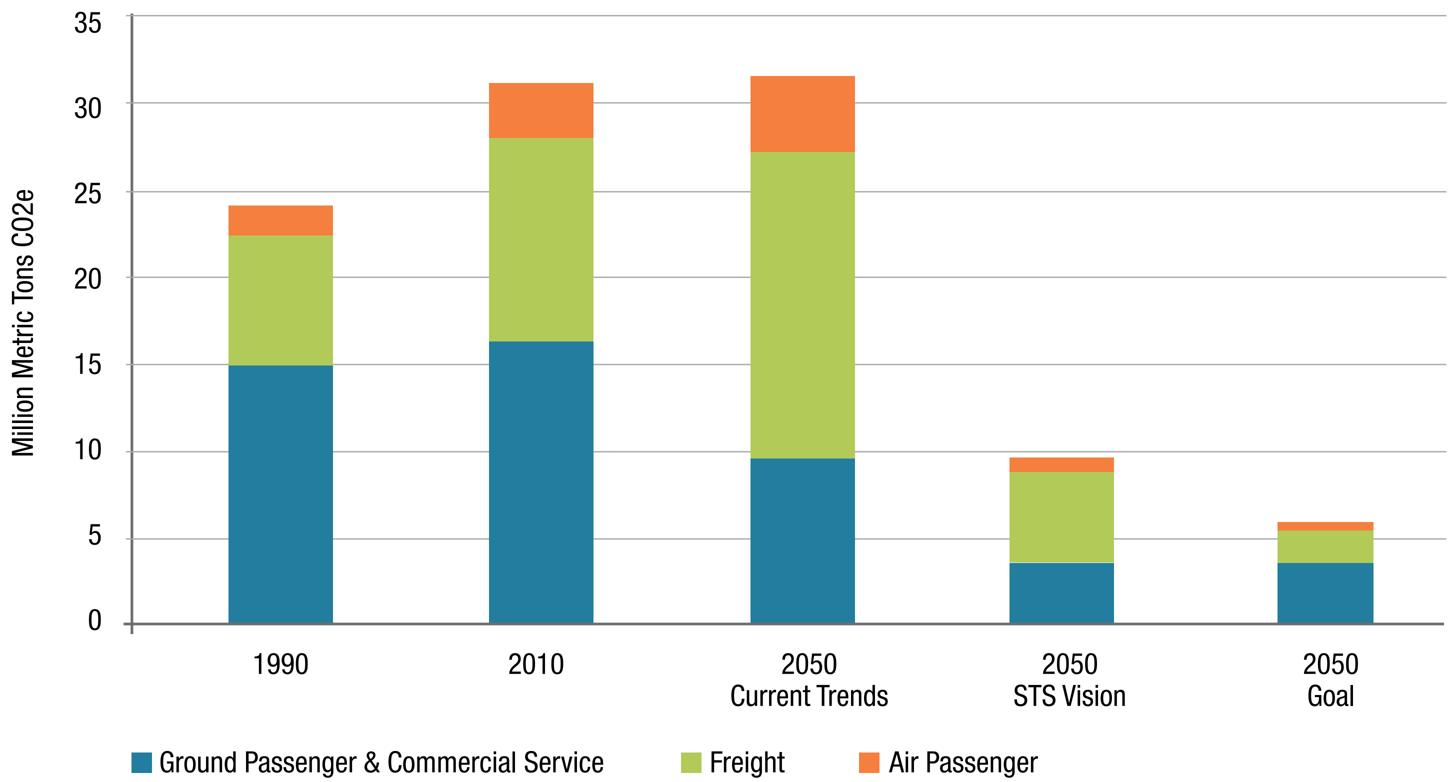
Multiple available data sources provide an understanding of where we think Oregon's transportation emissions are headed. These projections are based on our understanding of the factors affecting overall fossil-fuel consumption, such as vehicle miles traveled, projected vehicle fuel efficiencies, and population growth, which are in turn affected by factors such as economic cycles, global oil market dynamics, human migration and settlement trends, and individual purchasing patterns. Data on these types of factors and modeling capabilities to integrate them are continually being updated and refined. So although emissions projection results are necessarily snapshots in time, they still provide useful points of reference for policy tracking and evaluation.

In 2013, Oregon Department of Transportation modeled what would happen to GHG emissions from the transportation sector if all of the actions called for in their *Statewide Transportation Strategy* vision[41] were fully implemented. Specific details of the STS vision and their implementation status are discussed in this section. Figure 21 shows ODOT's projections compared to actual transportation emissions from 1990 and 2010, and presents the relative contribution of different transport modes to the emissions totals in each column. Under full STS implementation, depicted in the "2050 STS Vision" column, by 2050 transportation emissions would be reduced by 60% (to 9.7 million MTCO2e) compared to 1990 transportation sector emissions (24 million MTCO2e). The column "2050 Goal" shows that an additional reduction of 3.7 million MT would be needed by 2050 if the sector was asked to achieve a 75% total sector reduction (to 6 million MTCO2e) compared to its 1990 level for combined air, ground, and freight modes.

In 2018, ODOT published a Monitoring Report to document progress on implementing the STS since 2013. They identified a number of areas of short-term positive progress offset by other areas of stalled progress or negative trends, particularly in GHG emissions from light-duty or passenger vehicles. Figure 22 shows a projection of GHG reductions from light-duty vehicles attributable to current "plans and trends" (blue line), compared to an STS vision trajectory for light-duty vehicles that would result in a reduction of around 80% below 1990 levels. The blue line shows that, assuming a conservative level of implementation of the current suite of policies in combination with current market trends, passenger vehicle GHG emissions are expected to be reduced by about 15–20% below 1990 levels by 2050.

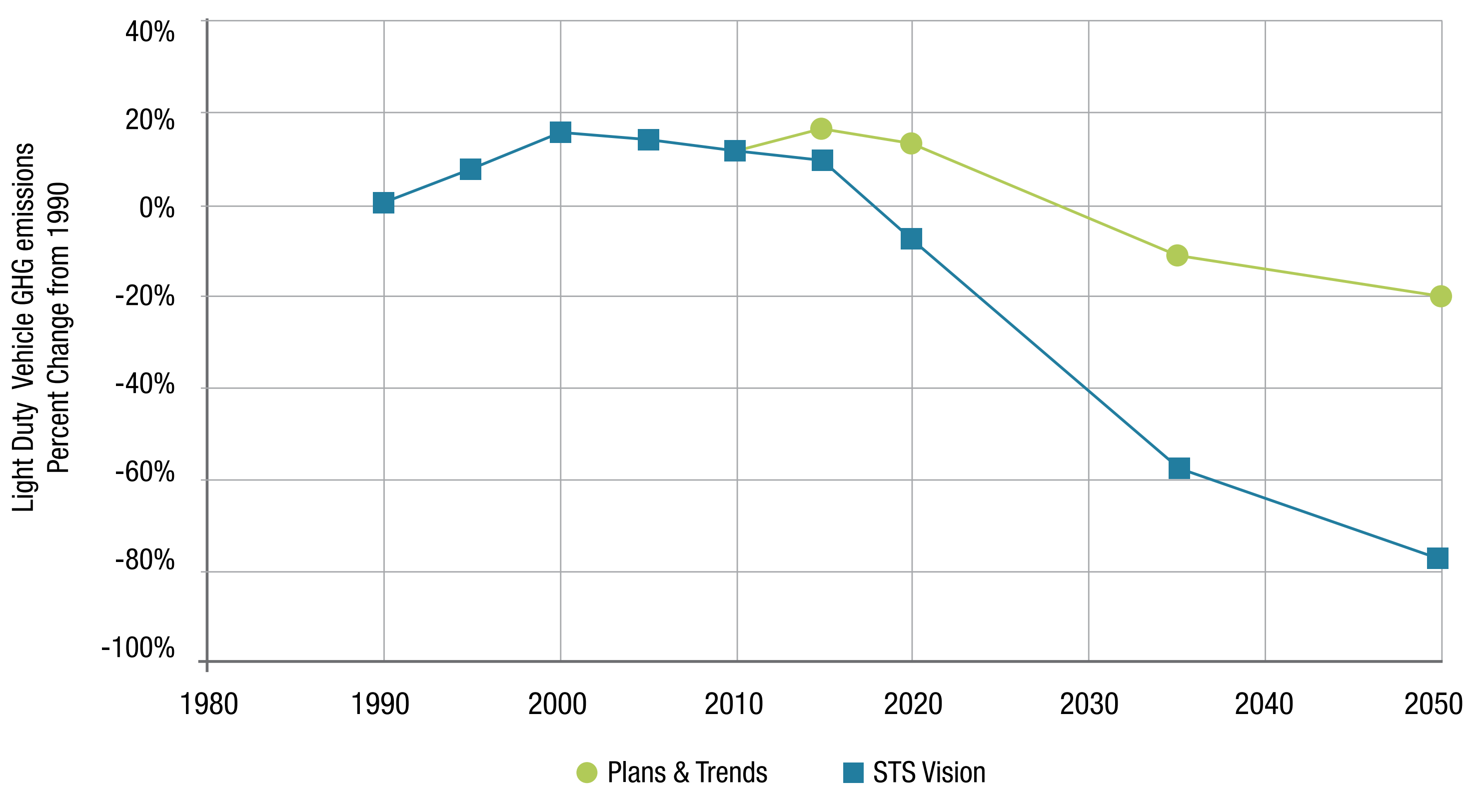
[41] The *Statewide Transportation Strategy* was developed by the Oregon Department of Transportation and supporting groups of stakeholders and technical experts, under direction from the 2010 Oregon Legislature in Senate Bill 1059 (Chapter 85, Oregon Laws 2010, Special Session). The STS sought to describe an integrated universe of actions that, taken together, could meet a proportional transportation share of Oregon's greenhouse gas reduction goals set by the 2007 Oregon Legislature.

Figure 21. Comparison of historic and projected transportation sector GHG emissions



Source: ODOT, 2013.

Figure 22. Projected light-duty GHG emissions of current plans and trends compared to the *Statewide Transportation Strategy* vision



Source: ODOT, 2018.

This projection is based on updated data about multiple drivers of fossil-fuel consumption and GHG emissions in the transportation sector. Policy/plan drivers include Oregon's Clean Fuels Program, public transportation funding from the 2017 Keep Oregon Moving Act, and improved systems operations. With regard to other changing Oregon trends that affect GHG emissions projections from light-duty vehicles, the 2018 Monitoring Report (ODOT, 2018, p. 19) states:

> In 2012, when the majority of work on the STS was completed, fuel prices were at an all-time high. In the six years since, prices have dropped and according to national sources are forecasted to stay low. In addition, Oregonians have held onto their vehicles longer than originally anticipated and have not transitioned to newer more fuel efficient or low/no-emission vehicles. The result is more internal combustion engines in the fleet that get fewer miles per gallon than was anticipated in the STS. Additionally, Oregon's population continues strong growth and incomes have recovered from the recession. As a result, lower gas prices coupled with higher incomes and post-recession increases in driving means that vehicle miles traveled (VMT) have increased in Oregon. … [Figure 22 shows] an uptick in emissions following the recession and projected reductions in the long term. In the long term it is assumed that vehicles get more efficient, which helps to bring the curve down. While the overall trend line is moving in the right direction, it falls short of the levels called for in the STS vision.

Is the Current State Framework for Reducing Transportation GHG Emissions Enough?

The STS development process was the first statewide planning effort targeting a single goal (GHG emissions reduction) and spanning the authority of multiple state agencies. The Oregon Transportation Commission chose to "accept" — a weaker option — rather than "adopt" the STS document outright when it was completed in 2013. In 2018, the STS was formally adopted by the Commission into the Oregon Transportation Plan, calling for a pursuit of strategies in the STS. Still, even an adopted STS is only advisory and has no force of law or programmatic consequences unless the Legislature chooses otherwise.

Six categories of strategies and 133 elements were identified and included in the STS. As summarized in the ODOT 2018 Monitoring Report, the categories for critical actions called for under the STS vision are as follows:

1. Vehicle and Engine Technology Advancements

Strategies in this category increase the operating efficiency of multiple transportation modes through a transition to more fuel-efficient vehicles, improvements in engine technologies, and other technological advancements. Sample elements include zero-emission vehicle programs, electric vehicle charging infrastructure, and fleet turnover to a greater proportion of electric or low-carbon fuel vehicles. Many of the elements in this category require legislative action, are under the authority of the Department of Environmental Quality, or are reliant on market forces to drive change. Multiple state agencies are supporting efforts to increase zero-emission vehicle adoption as a result of the Governor's Executive Order 17-21.[42]

2. Fuel Technology Advancements

This category contains improvements in vehicle efficiency and reductions in the carbon intensity of fuels and electricity used to power vehicles. Strategies in this category increase the operating efficiency of transportation modes through transitions to fuels that produce fewer GHG emissions or have lower life-cycle carbon intensity. Elements include Clean Fuels Standards and transitioning to low-carbon renewable fuels. Many of the elements in this category require federal programs or legislative action, or are under the authority of DEQ and ODOE, or are reliant on market forces to drive change.

3. Systems and Operations Performance

Strategies in this category address intelligent transportation systems, air traffic operational improvements, and other innovative approaches to improving the flow of traffic, reducing delays on transportation systems, and providing travelers with information that helps them drive more fuel efficiently or avoid significant delays. Strategies in this category improve the efficiency of the transportation system and operations through technology, infrastructure investment, and operations management. Elements include in-car displays that notify drivers of fuel efficiency as they travel; providing real-time information on crashes and delays; promoting vehicle-to-vehicle communications; and supporting autonomous vehicles. Many of these elements are under the authority of the private sector, ODOT, local jurisdictions, and Oregon Department of Aviation, or are reliant on market forces to drive change.

4. Transportation Options

This category contains strategies for providing infrastructure and options for public transportation and bicycle and pedestrian travel; enhancing transportation demand management programs; shifting to more efficient modes of goods movement; and providing alternatives to certain air passenger trips. This category encourages a shift to transportation modes that produce fewer emissions and provide for the more efficient movement of people and goods. Sample elements include providing park-and-ride facilities, promoting ride-matching services, adding biking and

[42] https://www.oregon.gov/gov/Documents/executive_orders/eo_17-21.pdf

walking infrastructure, enhancing passenger rail services, and achieving significant growth in public transportation service. Many of these elements are under the authority of ODOT, local jurisdictions, transit agencies, and Oregon Department of Aviation, or are reliant on market forces to drive change.

5. Efficient Land Use

Strategies in this category focus on infill and mixed-use development in urban areas to reduce demand for vehicle travel, expand non-auto travel mode choices for Oregonians, and enhance the effectiveness of public transportation and other modal options. This category promotes more efficient movement throughout the transportation system by supporting compact growth and development. This type of development pattern reduces the distances that people and goods must travel, and provides more opportunities for people to use zero- or low-energy transportation modes. Elements include supporting mixed-use development, limited expansion of urban growth boundaries, and development of urban consolidation centers for freight. Many of these elements are under the authority of Oregon Department of Land Conservation and Development and local jurisdictions, or are reliant on the market forces of housing costs, generational preferences, or job locations to drive change.

6. Pricing Funding and Markets

This category addresses the true costs of using the transportation system and pricing mechanisms for incentivizing less travel or travel on more energy-efficient modes. A “user pays true cost” approach ensures that less-efficient modes are responsible for the true cost of their impacts to the transportation system and the environment. Strategies in this category support a transition to more sustainable funding sources to maintain and operate the transportation system, pay for environmental costs, and provide market incentives for developing and implementing efficient ways to reduce emissions. Elements include transitioning to a user- or mileage-based fee, adding a carbon fee, promoting pay-as-you-drive insurance programs, and diversifying Oregon’s economy. Many of the elements in this category require legislative action.

The 2018 STS Monitoring Report assessed progress in each of these areas. ODOT found positive short-term progress in a number of categories, which are summarized below in rows marked with a dark blue circle.

Table 8. Summary of progress from ODOT 2018 STS Monitoring Report

Vehicle Tecnology	
Vehicle Mix	○
Fuel Efficiency (MPG)	◐
Battery Range	●
SUV/Light truck share	⊜
Vehicle Age	⊜
Fuel Technology	
Fuel Carbon Intensity	◐
Electric Carbon Intensity	●
Bus Fuels	⊜
Systems and Operations	
Intelligent Transportation Systems	◐
Managed Road Growth	●
Parking Coverage	●
Parking Price	⊜
Fuel Efficient Driving	⊜
Transportation Options	
Transit Service	◐
Bike	◐
Carshare	●
Demand Management Programs	●
Land Use	
Urban Growth Boundary Expansion	●
Mixed Use Areas	●

● on-track with or exceeding the STS vision;
◐ moving in the direction of the STS vision;
○ little to no progress towards the STS vision; or
⊜ moving away from the STS vision/trending in a negative direction.

For light-duty vehicles, although progress has been noted in several important areas, the projected 15 to 20% reduction is far short of what is needed to achieve the state's sustainable transportation and climate goals. Current efforts under the state's existing policy framework are occurring against a backdrop of relatively rapid and sometimes uncertain changes in the policy and economic/consumer landscape for successfully promoting alternatives to traditional fossil-fueled internal combustion engine passenger cars and trucks.

For light-duty vehicles, although progress has been noted in several important areas, the projected 15 to 20% reduction is far short of what is needed to achieve the state's sustainable transportation and climate goals.

In the passenger vehicle segment especially, ODOT's analysis indicates that effectiveness of efforts that support cleaner vehicles and fuels is most heavily reliant on consumer behavior. Fewer people than anticipated in the STS have transitioned to higher-miles-per-gallon cars or alternative fuel/lower-emission vehicles, including electric vehicles. Some of this is related to market factors — such as lower gasoline prices, higher up-front costs for alternative fuel vehicles, and certain operating aspects of electric vehicles on the market to date (like limited range, limited charging infrastructure, and slow charging times) — that will fluctuate or become less relevant over time as the market changes. Other consumer-related trends observed in Oregon that affect the state's efforts on behalf of cleaner vehicles and fuels include:

- Older vehicles on the road that get fewer miles per gallon: Average vehicle age on Oregon roadways has increased to at least 12 years old (with some estimates up to 13.5 years old).
- The share of larger vehicles (light trucks and SUVs) in the passenger vehicle fleet that get fewer miles per gallon has not decreased as expected, and this continues to be a very popular market segment for automobile consumers in Oregon.
- Lower gasoline prices since 2012, when the majority of work on the STS was completed.
- Resurging economy since 2012, when the majority of work on the STS was completed.
- Increases in Oregon's population and the number of people in the state traveling.

On the policy side, the timing of when current policies start to influence overall emissions trends is also an important consideration. In areas such as land use/urban design, emissions reduction effects will not be seen immediately but will be important in the intermediate and long-term future. And while ODOT is studying and preparing initial steps (e.g., submitting an application to the Federal Highway Administration) toward congestion pricing in the Portland area, the reality is that it will be a number of years before tolling would be implemented in the Portland area.

ODOT's 2018 STS Monitoring Report concluded that assumptions around certain legislative actions will need to hold true in order to get back on track with the STS vision. These include extended Federal Corporate Average Fuel Economy (CAFE) standards and extension of the Zero Emissions Vehicle Program (both discussed in the following section), as well as an extension of Oregon's Clean Fuels Program and the initiation of mechanism(s) for true-cost pricing. As will be discussed in the section on federal deregulation trends, sustained implementation of current policies is not always guaranteed.

Regarding fuels, the federal Renewable Fuel Standard,[43] the Oregon Renewable Fuels Standard,[44] and the Oregon Clean Fuels Program[45] have increased the amount of cleaner alternative fuels used in Oregon's transportation mix from less than 2% in 2005 to 7.4% in 2017 on an energy-equivalent basis (ODOE, 2018). The Oregon Clean Fuels Program is responsible for the introduction of new low-carbon fuels, including renewable natural gas from wastewater treatment plants and landfills, and renewable diesel sourced from a by-product of ethanol production. Some of these fuels are, or can be, produced in Oregon. The program is currently on track to meet its goal of reducing the carbon intensity of transportation fuels, though continued progress depends on factors including production and adoption rates for electric vehicles, biodiesel, and other alternative fuels.

Regarding true-cost pricing, those involved in the STS development process have recognized and emphasized the importance of sending a price signal about the impact of driving and thus incentivizing the adoption of other, less carbon-intensive, modal options. ODOT (2018) found that few of the fees called for in the STS have been imposed, although many are being considered, like congestion (value pricing), and per-mile (OReGO) charges. An economy-wide cap on greenhouse gas emissions, expected to be considered by the Oregon Legislature in 2019, would reinforce the message of these programmatic incentives to use cleaner vehicles and fuels.

ODOT (2018) indicated that continued and increased investments or work in the areas such as fuels and systems and operations are also needed to address light-duty vehicle emissions. ODOT identified a separate set of strategies to address some of the unique aspects of freight and heavy-duty vehicle emissions. Both sets of strategies will be needed to get the state on an effective pathway to achieving the STS vision and should be designed to be robust in the face of continuing changes in the policy and economic/consumer landscape.

The Oregon Clean Fuels Program is responsible for the introduction of new low-carbon fuels, including renewable natural gas from wastewater treatment plants and landfills, and renewable diesel sourced from a by-product of ethanol production.

[43] Congress passed the RFS program in 2005 and amended it in 2007 to increase the required amount of renewable fuels that must be included in the nation's fuel mix, as well as set requirements for the fuels' carbon content.

[44] The Oregon Renewable Fuels Standard passed in 2007 also sets standards for the amount of renewable, low-carbon fuels to be included in most transportation fuels sold in the state. The standard requires Oregon diesel fuel to contain 5% biodiesel and gasoline to contain 10% ethanol.

[45] The Oregon Clean Fuels Program was established by the State Legislature in 2009, with the goal of reducing GHG emissions from Oregon's transportation fuels by 10% over a 10-year period. The program sets the carbon intensity for individual fuels, creates annual baselines for regulated parties to meet, and establishes a market for clean fuels credits. The program has been fully operational since 2016.

Light-Duty Vehicle Emissions

Vehicles and fuels

Cleaner low- or no-emission vehicles and fuels. Cleaner vehicles and fuels are essential, representing 50–60% of the remaining gap between goals and implementation actions for light-duty vehicles in the STS. Immediate attention is needed to get cleaner vehicles on the road to reduce the carbon footprint of those who continue to drive.

- Today's vehicle mix includes more older, larger, and less fuel-efficient vehicles than when the STS was completed, and certainly more than what the STS envisions by 2020 and beyond. This, combined with no reductions in overall vehicle miles traveled, has led to increased emissions from transportation.
- A fleet shift to electric vehicles must be combined with a utilities shift to a decarbonized electricity supply for these vehicles.
- The electric vehicle industry must accelerate progress toward vehicles with less costly and more durable batteries, longer ranges between charges, and faster charging "fillups." State and local governments must work with the private sector to ensure that adequate charging infrastructure is available to meet the travel needs of Oregonians.

Public transportation

Promoting buses, light rail, passenger rail, and similar services. These types of strategies make up about 13–15% of the gap in implementation actions for light-duty vehicles in the STS. While continued investments in transportation options like biking and walking and public transportation are essential, mode shift is likely to be slow.

- Although recent funding from the 2017 Keep Oregon Moving Act helps progress in the direction of the STS, the levels envisioned in the STS call for exponentially more investment in transit service, along with converting bus fleets — public transit and school buses — to electricity as older buses are replaced.
- Continued investments and actions are needed to maintain gains in biking and walking and control of land uses. Investments in transportation options such as park-and-ride, vanpools, and other efforts to manage demand are also essential.

Systems and operations

Technologies that smooth traffic and help reduce idling. These types of strategies make up about 20–25% of the gap in implementation actions for light-duty vehicles in the STS.

- These types of investments are important because they reduce idling for vehicles on the road. The stop-start movement of traffic jams burns fuel at a higher rate than steady travel.
- Without such strategies, emissions are likely to continue to increase. These strategies will be most effective in the short term until significant vehicle turnover (to cleaner vehicles) occurs.

Freight Truck Emissions

Although cleaner trucks and fuels will need private sector commercialization, progress could be facilitated by public sector efforts in areas such as investments in electric truck charging stations.

Both the STS and the 2018 STS Monitoring Report acknowledge the challenges associated with reducing GHG emissions from freight transportation, mostly from heavy-duty trucks. For example, freight mode choice is primarily driven by the type of goods being shipped, which can limit opportunities for mode shift to other, less GHG emissions-intensive, forms of freight transport. The 2018 STS Monitoring Report identifies a number of ongoing ODOT actions that contribute to reducing medium- and heavy-duty truck GHG emissions. Their investments to reduce roadway congestion have emissions benefits in terms of reduced engine idling and reduced stops and starts, all of which help to minimize fuel consumption. Similarly, ODOT's Green Light truck preclearance system allows for weighing participating trucks at highway speeds using a combination of high-speed weigh-in-motion scales, transponders, and computer systems, which avoids stops and engine idling at weigh-in stations. The Connect Oregon program provides funding for projects supporting development of intermodal freight facilities to transfer goods between truck and rail (a less GHG emissions-intensive mode).

In addition to continuing and expanding implementation of current actions, more public and private sector efforts are needed to advance other freight truck emissions strategies. Both the STS and a recent review of the peer-reviewed literature on this topic (Oliveria et al., 2017) point to urban consolidation centers as a more efficient and less GHG emissions-intensive approach to freight deliveries to final destinations in urban areas (also referred to as "last mile" deliveries). These are distribution centers on the periphery of urban areas where large freight trucks can be unloaded, and then smaller commercial fleets can deliver the products within city centers. This keeps most heavy-duty trucks on main highways at higher, more fuel-efficient speeds. It also allows smaller commercial vehicles to chain trips to multiple businesses and thus reduce total vehicle miles traveled. The use of existing and emerging electric vehicle technologies in last mile deliveries can achieve additional emissions reduction benefits (Oliveria et al., 2017).

Other emerging strategies will depend on advancements in alternative fuels and autonomous vehicle technologies. These include:

Cleaner trucks and fuels

Less carbon-intensive trucks and fuels for both the medium- and heavy-duty fleet (e.g., Tong et al., 2015; Sen et al., 2017). Although cleaner trucks and fuels will need private sector commercialization, progress could be facilitated by public sector efforts in areas such as investments in electric truck charging stations.

Platooning

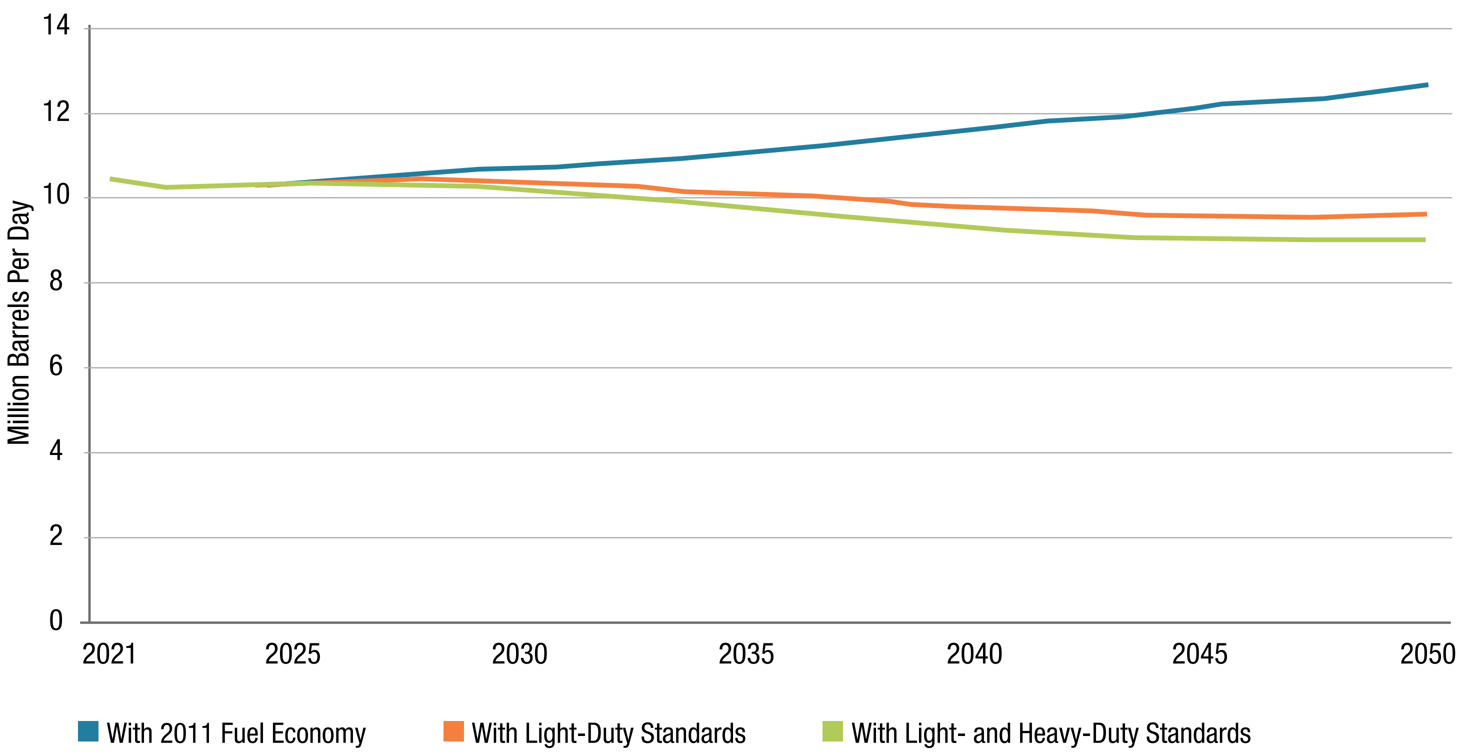
Automated trucks that allow drivers to travel closely behind another truck and thus reduce drag, improve fuel efficiency, and lead to overall emission reductions (e.g., Alam et al., 2015; Lammert et al., 2014). This strategy will also need private sector commercialization of products and technologies, though progress could be facilitated by public sector policies to allow platooning and testing of such fleets.

How Important are Federal Deregulation Trends for Meeting Oregon's Transportation Emissions Goals?

The Oregon Department of Transportation (2018) has stated that extended federal Corporate Average Fuel Economy standards and zero-emissions vehicles II requirements are needed for the STS vision to be realized. The CAFE standards are the primary pathway for reducing fuel use. Established by Congress in 1975, these standards set fuel efficiency goals that automobile manufacturers must achieve in the development of new vehicle models. Congress granted California a special waiver to allow the state to set its own, more stringent, standards to help better manage high levels of air pollution in its major cities. California's new goals, which covered both fuel efficiency and GHG emissions through 2025, were subsequently adopted by the federal government in 2009.

Oregon, along with 12 other states, signed on with California and agreed to follow their fuel efficiency standards. As the standards are updated, new targets are established for vehicle manufacturers to meet. However, on August 2, 2018, the EPA and National Highway Traffic Safety Administration submitted a proposed rule to freeze the standards to 2020 levels, making them less stringent on fuel efficiency and carbon emissions for years 2021 through 2026. The proposed rule would also revoke California's waiver and establish a single nationwide standard with weaker fuel economy goals than the current standard.

Figure 23. Car and truck fuel consumption with and without recent fuel economy standards



Source: American Council for an Energy-Efficiency Economy, 2013.

Fuel efficiency standards create benefits that continue throughout the lifetime of a vehicle, including decreasing petroleum consumption, saving money, and reducing harmful emissions. For example, if fuel efficiency standards had remained the same since 2011, rather than vehicles becoming more efficient based on CAFE standards set for 2016 and 2020, the U.S. would see increasing petroleum consumption. Figure 23 shows projected fuel consumption through 2035 for the 2011 standards (blue line) and the current efficiency standards (red and green lines). The standards are projected to save more than 3 million barrels a day by 2035, which is a key contributor to reducing GHG emissions.

The EPA/National Highway Traffic Safety Administration proposal to freeze the vehicle fuel efficiency standards also includes revoking California's authority to set rules for their Zero Emission Vehicle Program. Nine states, including Oregon, participate in the California ZEV Program, which requires most vehicle manufacturers to deliver a certain number of zero-emission vehicles, such as battery electric and fuel cell vehicles, plug-in hybrids, other hybrids, and gasoline vehicles with near-zero tailpipe emissions. This program is widely credited for the development of today's generation of electric cars on the market.

Conclusion

Oregon and the nation are off track in curbing vehicle greenhouse gas emissions and straying further away from the necessary pace every day. While electric vehicle sales are ramping up, new gasoline-fueled SUVs are entering the national fleet in far greater numbers. Even California, considered by many to be at the forefront of GHG reduction efforts, is seeing transportation emissions headed upward.

The federal government sets fuel economy standards and overall vehicle efficiency and emissions standards. Under the Trump administration the gains and directions set by previous administrations are now going in reverse. The states that have adopted California standards, including Oregon, are suing the administration, under the terms of the Clean Air Act, over its challenge to California's standards and our right to set our own climate-sensitive fuel economy standards.

Oregon and other states can enable progress on transportation emissions reduction with policies that incentivize low-carbon choices: electric vehicles, bicycle and pedestrian travel, and better urban design, to name a few. The states can reshape their electricity system to deliver clean, low-carbon electricity to a growing electric vehicle fleet. But states also face a difficult next several years trying to encourage sufficient market pull on manufacturers to maintain the necessary progress toward a clean vehicle fleet.

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Appendix

Appendix A. Oregon Greenhouse Gas Statewide Sector-based Inventory 1990-2015 and preliminary 2016 data

Emission estimates are based on the most current available data from Oregon's greenhouse gas reporting program and the U.S. EPA's State Inventory Tool.[1] All data are expressed in Million Metric Tons of Carbon Dioxide Equivalent (MMTCO2e) and use 100-year Global Warming Potentials from the IPCC's Fourth Assessment Report. High Global Warming Potential Gases (HGWP) include hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF6).

Total Oregon Gross GHG Emissions (With Emissions from the Use of Electricity) 1990-2003

1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
56	58	58	63	64	65	68	68	70	72	70	67	67	67

Total Oregon Gross GHG Emissions (With Emissions from the Use of Electricity) 2004-2016

2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	
68	66	68	70	68	65	64	62	61	61	60	63	62	

Emissions by Key Sectors 1990-2003

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Transportation	21.0	22.5	22.7	22.0	22.8	22.5	23.4	23.7	24.7	25.0	24.3	23.2	23.6	23.5
Electricity use (without transportation)	16.6	16.8	16.5	20.6	20.8	21.2	22.0	22.0	20.8	22.0	23.3	22.7	21.3	21.7
Natural gas use	5.0	5.6	5.5	6.3	6.3	6.5	8.0	8.2	8.9	9.7	7.7	7.3	7.4	6.9
Residential & Commercial	3.5	3.4	3.1	3.3	3.2	3.3	3.3	3.3	3.4	3.4	3.6	3.9	3.9	3.8
Industrial	5.2	5.1	5.7	5.6	5.5	5.8	5.5	5.6	6.3	6.8	6.3	5.1	5.1	4.8
Agriculture	4.9	4.9	4.9	4.9	5.2	5.5	5.6	5.6	5.5	5.2	4.9	4.9	5.5	5.8

Emissions by Key Sectors 2004-2016

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	
Transportation	24.2	24.7	25.2	25.6	23.8	23.8	23.3	22.4	22.4	21.2	21.4	23.0	24.2	
Electricity use (without transportation)	21.5	20.2	20.9	23.0	22.3	20.7	20.3	18.1	17.3	18.3	17.9	18.7	16.2	
Natural gas use	7.2	7.5	7.6	7.6	7.8	7.1	7.8	8.0	7.6	8.2	7.6	7.3	7.3	
Residential & Commercial	3.6	3.6	3.6	3.6	3.9	4.1	4.1	4.1	3.7	3.7	3.8	4.1	4.2	
Industrial	5.1	4.8	5.4	5.1	5.0	4.4	3.6	4.0	4.0	3.7	4.1	4.3	4.3	
Agriculture	5.9	5.7	5.6	5.5	5.5	5.1	5.3	5.7	5.7	5.6	5.6	5.7	5.7	

[1] The 2016 data utilizes 2016 emissions data reported to DEQ's Greenhouse Gas Reporting Program and 2015 modeled data from EPA's State Inventory Tool. It is considered to be preliminary and is subject to change. Please contact the Oregon DEQ Greenhouse Gas Reporting Program for the latest information and for the full data set at GHGReport@deq.state.or.us.

Transportation 1990-2003															
		1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
CO2	Motor Gasoline	11.610	11.782	11.705	12.112	12.372	12.400	12.801	12.208	13.114	13.257	13.061	12.957	13.133	13.004
	Distillate Fuel	4.533	4.849	4.935	4.661	4.876	4.572	4.902	5.069	4.889	5.495	5.523	5.144	5.509	5.370
	Jet Fuel, Kerosene	1.254	1.393	1.515	1.661	1.866	2.053	2.143	2.343	2.403	2.636	2.571	2.137	2.120	2.289
	Natural Gas	0.489	0.482	0.376	0.271	0.323	0.404	0.442	0.707	0.746	0.579	0.647	0.604	0.500	0.384
	Residual Fuel	1.723	2.665	2.697	1.758	1.808	1.489	1.415	1.509	1.706	1.119	0.588	0.548	0.565	0.710
	Lubricants	0.222	0.198	0.202	0.206	0.215	0.212	0.205	0.217	0.227	0.229	0.226	0.207	0.205	0.189
	Aviation Gasoline	0.042	0.044	0.045	0.038	0.054	0.050	0.067	0.061	0.052	0.056	0.048	0.079	0.054	0.047
	LPG	0.043	0.037	0.035	0.034	0.052	0.026	0.023	0.016	0.000	0.006	0.015	0.005	0.006	0.022
	Light Rail Electricity Use - Other	0.004	0.004	0.004	0.005	0.005	0.006	0.005	0.005	0.006	0.015	0.016	0.017	0.017	0.007
	Jet Fuel, Naphtha	0.082	0.113	0.098	0.072	0.004	0.003	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000
CH4	Passenger & Light Vehicles	0.095	0.088	0.092	0.094	0.089	0.085	0.080	0.079	0.076	0.071	0.066	0.062	0.053	0.049
	Non-Road Vehicles & Equipment	0.008	0.009	0.009	0.007	0.008	0.008	0.008	0.009	0.009	0.008	0.008	0.008	0.008	0.008
	Heavy-Duty Vehicles	0.007	0.007	0.007	0.007	0.007	0.006	0.006	0.006	0.005	0.005	0.005	0.004	0.004	0.003
	Natural Gas Distribution (sector share)	0.041	0.052	0.041	0.027	0.030	0.038	0.034	0.054	0.046	0.033	0.043	0.040	0.036	0.030
N2O	Passenger & Light Vehicles	0.758	0.760	0.849	0.924	0.922	0.936	0.934	0.977	0.985	0.971	0.935	0.862	0.773	0.711
	Non-Road Vehicles & Equipment	0.034	0.039	0.040	0.036	0.039	0.040	0.041	0.046	0.047	0.045	0.043	0.039	0.040	0.043
	Heavy-Duty Vehicles	0.019	0.020	0.022	0.023	0.024	0.025	0.026	0.029	0.031	0.032	0.031	0.026	0.027	0.027
HGWP	Refrigerants, A/C, Fire Protection Use	0.002	0.003	0.010	0.035	0.081	0.185	0.258	0.330	0.374	0.425	0.469	0.510	0.542	0.564
Transportation Sub-total		20.97	22.55	22.68	21.97	22.77	22.54	23.39	23.67	24.72	24.98	24.29	23.25	23.59	23.46

Transportation 2004-2016														
		2004	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
CO2	Motor Gasoline	13.055	13.197	13.350	13.257	12.361	12.380	12.111	11.657	11.636	11.108	11.281	12.489	13.197
	Distillate Fuel	6.103	6.358	6.691	6.902	6.523	6.463	6.726	6.636	6.723	6.339	6.513	6.505	6.873
	Jet Fuel, Kerosene	2.088	2.212	2.361	2.306	2.238	2.672	1.750	1.835	1.863	1.784	1.801	2.040	2.156
	Natural Gas	0.525	0.410	0.463	0.532	0.410	0.449	0.416	0.315	0.278	0.263	0.235	0.296	0.297
	Residual Fuel	0.801	0.878	0.689	1.018	0.693	0.358	0.728	0.428	0.379	0.269	0.046	0.120	0.127
	Lubricants	0.192	0.191	0.186	0.192	0.178	0.160	0.178	0.169	0.155	0.164	0.171	0.187	0.187
	Aviation Gasoline	0.044	0.050	0.071	0.070	0.065	0.047	0.048	0.045	0.044	0.033	0.030	0.037	0.039
	LPG	0.019	0.041	0.034	0.025	0.051	0.038	0.039	0.043	0.039	0.049	0.054	0.052	0.052
	Light Rail Electricity Use - Other	0.007	0.007	0.008	0.009	0.009	0.010	0.011	0.010	0.009	0.009	0.009	0.010	0.008
	Jet Fuel, Naphtha	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CH4	Passenger & Light Vehicles	0.045	0.041	0.038	0.034	0.030	0.028	0.026	0.024	0.023	0.021	0.021	0.024	0.025
	Non-Road Vehicles & Equipment	0.008	0.008	0.009	0.009	0.008	0.008	0.008	0.009	0.009	0.008	0.007	0.006	0.007
	Heavy-Duty Vehicles	0.003	0.003	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.002	0.002	0.002	0.003
	Natural Gas Distribution (sector share)	0.034	0.029	0.034	0.035	0.026	0.030	0.025	0.024	0.020	0.016	0.016	0.018	0.018
N2O	Passenger & Light Vehicles	0.648	0.577	0.518	0.442	0.370	0.310	0.273	0.228	0.200	0.159	0.147	0.147	0.155
	Non-Road Vehicles & Equipment	0.040	0.042	0.043	0.045	0.042	0.045	0.040	0.042	0.041	0.042	0.037	0.034	0.036
	Heavy-Duty Vehicles	0.027	0.024	0.013	0.012	0.012	0.016	0.014	0.011	0.011	0.009	0.009	0.009	0.010
HGWP	Refrigerants, A/C, Fire Protection Use	0.584	0.611	0.657	0.708	0.765	0.825	0.876	0.902	0.933	0.960	1.005	1.057	1.057
Transportation Sub-total		24.22	24.68	25.17	25.60	23.78	23.84	23.27	22.38	22.36	21.24	21.38	23.03	24.25

Residential and Commercial 1990-2003															
		1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
CO2	Residential Electricity Use	5.930	6.150	5.862	7.725	7.617	7.549	7.841	7.795	7.792	8.355	8.426	8.654	8.281	8.528
	Commercial Electricity Use	4.662	4.779	4.848	5.950	6.212	6.273	6.389	6.567	6.545	7.101	7.278	7.547	7.251	7.445
	Residential Natural Gas Combustion	1.269	1.440	1.273	1.644	1.601	1.555	1.840	1.813	1.917	2.169	2.117	2.089	2.114	1.993
	Commercial Natural Gas Combustion	1.110	1.221	1.078	1.328	1.275	1.242	1.417	1.419	1.448	1.604	1.564	1.522	1.508	1.395
	Commercial Petroleum Combustion	0.788	0.658	0.593	0.492	0.458	0.561	0.501	0.489	0.543	0.455	0.537	0.647	0.578	0.368
	Residential Petroleum Combustion	0.762	0.734	0.613	0.760	0.738	0.651	0.622	0.549	0.529	0.604	0.617	0.655	0.617	0.583
	Waste Incineration	0.076	0.076	0.073	0.078	0.079	0.078	0.084	0.090	0.094	0.098	0.085	0.086	0.087	0.088
	Residential Coal Combustion	0.001	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Commercial Coal Combustion	0.003	0.002	0.002	0.004	0.002	0.002	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000
CH4	Municipal Solid Waste Landfills	1.155	1.159	1.096	1.082	1.057	1.015	1.073	1.135	1.173	1.181	1.215	1.269	1.299	1.367
	Natural Gas Distribution (sector share)	0.200	0.288	0.258	0.294	0.267	0.263	0.251	0.245	0.209	0.215	0.243	0.236	0.263	0.266
	Municipal Wastewater	0.229	0.234	0.238	0.243	0.247	0.252	0.256	0.260	0.263	0.266	0.275	0.278	0.282	0.284
	Residential Combustion Byproducts	0.061	0.064	0.066	0.081	0.077	0.076	0.080	0.068	0.062	0.064	0.068	0.107	0.109	0.114
	Commercial Combustion Byproducts	0.019	0.019	0.017	0.021	0.014	0.014	0.015	0.015	0.014	0.015	0.016	0.023	0.023	0.023
	Waste Incineration	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
	Compost	0.004	0.004	0.004	0.012	0.016	0.016	0.020	0.022	0.022	0.018	0.024	0.025	0.032	0.031
N2O	Fertilization of Landscaped Areas	0.060	0.058	0.061	0.060	0.066	0.065	0.070	0.076	0.075	0.057	0.042	0.059	0.079	0.090
	Residential Combustion Byproducts	0.011	0.012	0.012	0.015	0.014	0.014	0.014	0.012	0.011	0.012	0.012	0.019	0.019	0.020
	Waste Incineration	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.010	0.010	0.010	0.010	0.010	0.011
	Compost	0.004	0.004	0.004	0.011	0.014	0.014	0.018	0.019	0.020	0.016	0.021	0.023	0.029	0.028
	Commercial Combustion Byproducts	0.005	0.005	0.004	0.004	0.003	0.004	0.004	0.004	0.004	0.003	0.004	0.005	0.005	0.005
	Municipal Wastewater	0.084	0.086	0.088	0.090	0.093	0.094	0.097	0.097	0.099	0.102	0.105	0.105	0.107	0.109
HGWP	Refrigerants, Aerosols, Fire Protection Use	0.001	0.002	0.007	0.024	0.057	0.129	0.181	0.231	0.262	0.298	0.328	0.357	0.379	0.395
Residential & Commercial Sub-total		16.45	17.01	16.21	19.93	19.92	19.88	20.78	20.92	21.09	22.65	22.99	23.72	23.08	23.14

Residential and Commercial 1990-2003		2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
CO2	Residential Electricity Use	8.492	7.986	8.264	9.140	9.031	8.624	8.324	7.460	7.005	7.412	7.056	7.244	6.255
	Commercial Electricity Use	7.391	6.697	7.004	7.636	7.400	6.958	6.828	6.049	5.871	6.167	6.079	6.353	5.485
	Residential Natural Gas Combustion	2.062	2.188	2.255	2.350	2.450	2.439	2.584	2.827	2.565	2.856	2.502	2.326	2.332
	Commercial Natural Gas Combustion	1.403	1.519	1.530	1.590	1.655	1.618	1.725	1.841	1.705	1.888	1.724	1.611	1.615
	Commercial Petroleum Combustion	0.346	0.343	0.323	0.292	0.375	0.429	0.417	0.330	0.238	0.195	0.221	0.564	0.596
	Residential Petroleum Combustion	0.440	0.461	0.424	0.361	0.441	0.442	0.349	0.342	0.287	0.288	0.269	0.257	0.272
	Waste Incineration	0.086	0.086	0.088	0.089	0.091	0.092	0.096	0.090	0.098	0.099	0.104	0.100	0.100
	Residential Coal Combustion	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Commercial Coal Combustion	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CH4	Municipal Solid Waste Landfills	1.395	1.382	1.341	1.412	1.534	1.543	1.575	1.571	1.343	1.373	1.405	1.449	1.449
	Natural Gas Distribution (sector share)	0.225	0.261	0.282	0.262	0.260	0.274	0.262	0.360	0.312	0.298	0.288	0.243	0.245
	Municipal Wastewater	0.286	0.290	0.294	0.299	0.303	0.306	0.307	0.310	0.312	0.314	0.318	0.322	0.322
	Residential Combustion Byproducts	0.116	0.077	0.069	0.076	0.084	0.120	0.106	0.109	0.101	0.138	0.139	0.105	0.104
	Commercial Combustion Byproducts	0.023	0.016	0.015	0.016	0.017	0.021	0.021	0.021	0.018	0.020	0.021	0.023	0.022
	Waste Incineration	0.004	0.004	0.004	0.004	0.004	0.004	0.003	0.003	0.003	0.003	0.003	0.003	0.003
	Compost	0.037	0.035	0.034	0.040	0.036	0.039	0.041	0.040	0.043	0.041	0.050	0.045	0.045
N2O	Fertilization of Landscaped Areas	0.087	0.077	0.075	0.081	0.072	0.064	0.077	0.082	0.083	0.087	0.087	0.087	0.087
	Residential Combustion Byproducts	0.020	0.014	0.012	0.013	0.015	0.020	0.018	0.018	0.017	0.023	0.023	0.018	0.017
	Waste Incineration	0.011	0.011	0.011	0.011	0.011	0.011	0.009	0.009	0.009	0.009	0.009	0.009	0.009
	Compost	0.033	0.031	0.030	0.036	0.032	0.035	0.037	0.035	0.038	0.037	0.045	0.040	0.040
	Commercial Combustion Byproducts	0.004	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.005	0.005
	Municipal Wastewater	0.111	0.110	0.113	0.113	0.113	0.114	0.114	0.118	0.119	0.120	0.121	0.123	0.123
HGWP	Refrigerants, Aerosols, Fire Protection Use	0.409	0.428	0.460	0.495	0.536	0.578	0.613	0.631	0.653	0.672	0.703	0.740	0.740
Residential & Commercial Sub-total		22.98	22.02	22.63	24.32	24.46	23.74	23.51	22.25	20.82	22.04	21.17	21.67	19.87

Industrial 1990-2003		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
CO2	Industrial Electricity Use	5.976	5.898	5.831	6.946	6.974	7.329	7.724	7.657	6.508	6.527	7.567	6.469	5.801	5.751
	Natural Gas Combustion	2.603	2.956	3.163	3.286	3.405	3.739	4.751	4.925	5.583	5.918	4.066	3.709	3.737	3.524
	Petroleum Combustion	2.620	2.374	2.824	2.634	2.398	2.504	2.028	1.972	2.503	3.035	2.598	1.844	2.011	1.524
	Cement Manufacture	0.216	0.139	0.173	0.193	0.214	0.207	0.359	0.379	0.397	0.457	0.445	0.428	0.429	0.370
	Coal Combustion	0.137	0.180	0.221	0.214	0.272	0.270	0.185	0.188	0.072	0.000	0.000	0.000	0.104	0.139
	Ammonia Production	0.069	0.068	0.071	0.065	0.068	0.071	0.072	0.070	0.071	0.072	0.067	0.047	0.058	0.047
	Urea Consumption	0.008	0.008	0.008	0.008	0.009	0.009	0.010	0.010	0.011	0.009	0.007	0.010	0.017	0.019
	Waste Incineration	0.065	0.065	0.065	0.060	0.064	0.105	0.047	0.028	0.025	0.015	0.019	0.013	0.009	0.009
	Iron & Steel Production	0.704	0.704	0.704	0.704	0.704	0.704	0.704	0.811	0.747	0.640	0.750	0.573	0.440	0.429
	Soda Ash Production & Consumption	0.031	0.030	0.030	0.031	0.031	0.032	0.032	0.033	0.033	0.032	0.032	0.032	0.033	0.032
	Limestone and Dolomite Use	0.009	0.009	0.009	0.009	0.007	0.011	0.005	0.011	0.011	0.013	0.008	0.006	0.008	0.005
	Lime Manufacture	0.085	0.108	0.125	0.140	0.147	0.157	0.172	0.156	0.171	0.160	0.145	0.098	0.074	0.077
	Pulp & Paper including wastewater	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186
CH4	Natural Gas Distribution & Production	0.257	0.392	0.438	0.423	0.455	0.456	0.481	0.477	0.530	0.496	0.521	0.542	0.496	0.598
	Industrial Landfills	0.070	0.071	0.073	0.074	0.077	0.081	0.086	0.092	0.097	0.102	0.109	0.114	0.118	0.124
	Combustion Byproducts	0.032	0.031	0.025	0.022	0.023	0.023	0.027	0.029	0.025	0.023	0.025	0.024	0.020	0.016
	Food Processing Wastewater	0.012	0.011	0.011	0.011	0.012	0.012	0.012	0.012	0.012	0.012	0.009	0.008	0.008	0.008
	Waste Incineration	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.003	0.003	0.003	0.004	0.004	0.005
N2O	Combustion Byproducts	0.053	0.050	0.041	0.036	0.038	0.038	0.044	0.046	0.041	0.037	0.040	0.038	0.033	0.025
	Waste Incineration	0.002	0.002	0.002	0.002	0.002	0.002	0.004	0.004	0.005	0.005	0.005	0.006	0.006	0.007
	Nitric Acid Production	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
HGWP	Semiconductor Manufacturing	0.357	0.357	0.357	0.446	0.490	0.619	0.688	0.727	0.963	1.057	0.957	0.735	0.821	0.922
	Refrigerant, Foam, Solvent, Aerosol Use	0.000	0.001	0.003	0.010	0.024	0.055	0.078	0.099	0.112	0.128	0.141	0.153	0.163	0.169
	Aluminum Production	0.313	0.316	0.307	0.281	0.250	0.256	0.270	0.272	0.279	0.280	0.272	0.191	0.084	0.084
Industrial Sub-total		13.81	13.96	14.67	15.78	15.85	16.87	17.97	18.19	18.39	19.21	17.97	15.23	14.66	14.07

Industrial 2004-2016														
		2004	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
CO2	Industrial Electricity Use	5.639	5.523	5.657	6.188	5.872	5.122	5.173	4.593	4.460	4.682	4.796	5.135	4.434
	Natural Gas Combustion	3.757	3.749	3.781	3.704	3.674	3.062	3.453	3.380	3.333	3.471	3.365	3.361	3.369
	Petroleum Combustion	1.675	1.432	1.575	1.372	1.486	1.381	1.319	1.643	1.573	1.377	1.410	1.619	1.711
	Cement Manufacture	0.422	0.443	0.454	0.451	0.320	0.314	0.455	0.461	0.452	0.490	0.694	0.713	0.571
	Coal Combustion	0.131	0.019	0.248	0.216	0.157	0.180	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Ammonia Production	0.057	0.056	0.062	0.061	0.057	0.058	0.113	0.130	0.115	0.129	0.130	0.101	0.110
	Urea Consumption	0.016	0.015	0.016	0.017	0.015	0.013	0.016	0.017	0.016	0.017	0.017	0.017	0.017
	Waste Incineration	0.010	0.012	0.012	0.012	0.016	0.018	0.019	0.022	0.009	0.013	0.006	0.004	0.004
	Iron & Steel Production	0.429	0.340	0.364	0.369	0.365	0.234	0.030	0.031	0.030	0.035	0.033	0.038	0.027
	Soda Ash Production & Consumption	0.032	0.032	0.031	0.031	0.029	0.026	0.027	0.026	0.026	0.026	0.027	0.026	0.026
	Limestone and Dolomite Use	0.007	0.009	0.006	0.000	0.000	0.000	0.000	0.000	0.014	0.015	0.018	0.018	0.018
	Lime Manufacture	0.097	0.095	0.083	0.072	0.060	0.050	0.051	0.052	0.052	0.054	0.055	0.055	0.055
	Pulp & Paper including wastewater	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.192	0.180	0.138	0.139	0.140	0.133
CH4	Natural Gas Distribution & Production	0.560	0.603	0.589	0.621	0.640	0.613	0.643	0.550	0.603	0.627	0.607	0.655	0.659
	Industrial Landfills	0.128	0.134	0.140	0.145	0.151	0.156	0.161	0.166	0.171	0.176	0.181	0.184	0.184
	Combustion Byproducts	0.022	0.021	0.023	0.023	0.020	0.019	0.019	0.019	0.023	0.025	0.025	0.028	0.025
	Food Processing Wastewater	0.008	0.008	0.008	0.009	0.008	0.009	0.008	0.009	0.009	0.009	0.009	0.009	0.009
	Waste Incineration	0.005	0.006	0.007	0.006	0.005	0.004	0.004	0.004	0.004	0.004	0.004	0.005	0.005
N2O	Combustion Byproducts	0.035	0.034	0.036	0.037	0.032	0.031	0.031	0.031	0.038	0.041	0.040	0.045	0.040
	Waste Incineration	0.008	0.009	0.011	0.009	0.008	0.006	0.006	0.006	0.006	0.006	0.006	0.008	0.008
	Nitric Acid Production	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
HGWP	Semiconductor Manufacturing	1.001	1.064	1.297	1.299	1.222	0.902	0.356	0.548	0.588	0.449	0.608	0.540	0.571
	Refrigerant, Foam, Solvent, Aerosol Use	0.175	0.183	0.197	0.212	0.230	0.248	0.145	0.101	0.126	0.114	0.106	0.126	0.125
	Aluminum Production	0.087	0.087	0.087	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Industrial Sub-total		14.49	14.06	14.87	15.04	14.56	12.63	12.22	11.98	11.83	11.90	12.28	12.83	12.10

Agriculture 1990-2003

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
CO2	Urea Fertilization	0.063	0.062	0.063	0.065	0.071	0.072	0.074	0.079	0.085	0.070	0.053	0.080	0.129	0.144
	Liming of Agricultural Soils	0.029	0.025	0.027	0.029	0.031	0.033	0.035	0.038	0.040	0.042	0.044	0.038	0.033	0.034
CH4	Enteric Fermentation	2.582	2.604	2.609	2.603	2.781	2.936	3.014	2.996	2.922	2.926	2.819	2.661	2.769	2.787
	Manure Management	0.298	0.301	0.309	0.296	0.316	0.319	0.314	0.315	0.320	0.339	0.353	0.363	0.429	0.486
	Agricultural Residue Burning	0.007	0.006	0.006	0.008	0.007	0.007	0.008	0.007	0.007	0.004	0.007	0.004	0.004	0.006
N20	Agricultural Soil Management	1.795	1.765	1.710	1.804	1.802	1.944	2.026	2.016	1.998	1.707	1.487	1.618	1.963	2.217
	Manure Management	0.135	0.135	0.135	0.121	0.141	0.149	0.137	0.137	0.146	0.151	0.159	0.166	0.170	0.172
	Agricultural Residue Burning	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.001	0.002	0.001	0.001	0.002
Agriculture Sub-total		4.91	4.90	4.86	4.93	5.15	5.46	5.61	5.59	5.52	5.24	4.92	4.93	5.50	5.85

Agriculture 2004-2016

		2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	
CO2	Urea Fertilization	0.120	0.117	0.122	0.128	0.113	0.098	0.121	0.130	0.129	0.134	0.134	0.134	0.134	
	Liming of Agricultural Soils	0.039	0.043	0.041	0.040	0.037	0.030	0.027	0.035	0.039	0.050	0.048	0.058	0.058	
CH4	Enteric Fermentation	2.946	2.971	2.936	2.751	2.878	2.703	2.681	2.803	2.816	2.718	2.684	2.711	2.711	
	Manure Management	0.481	0.491	0.490	0.481	0.494	0.511	0.501	0.544	0.568	0.568	0.594	0.586	0.586	
	Agricultural Residue Burning	0.006	0.005	0.006	0.007	0.006	0.006	0.007	0.009	0.007	0.006	0.005	0.005	0.005	
N20	Agricultural Soil Management	2.084	1.914	1.886	1.968	1.819	1.634	1.839	1.997	2.003	1.946	2.009	2.012	2.012	
	Manure Management	0.180	0.156	0.162	0.158	0.155	0.145	0.145	0.143	0.146	0.143	0.147	0.147	0.147	
	Agricultural Residue Burning	0.002	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.001	0.001	0.001	
Agriculture Sub-total		4.91	4.90	4.86	4.93	5.15	5.46	5.61	5.59	5.52	5.24	4.92	4.93	5.50	

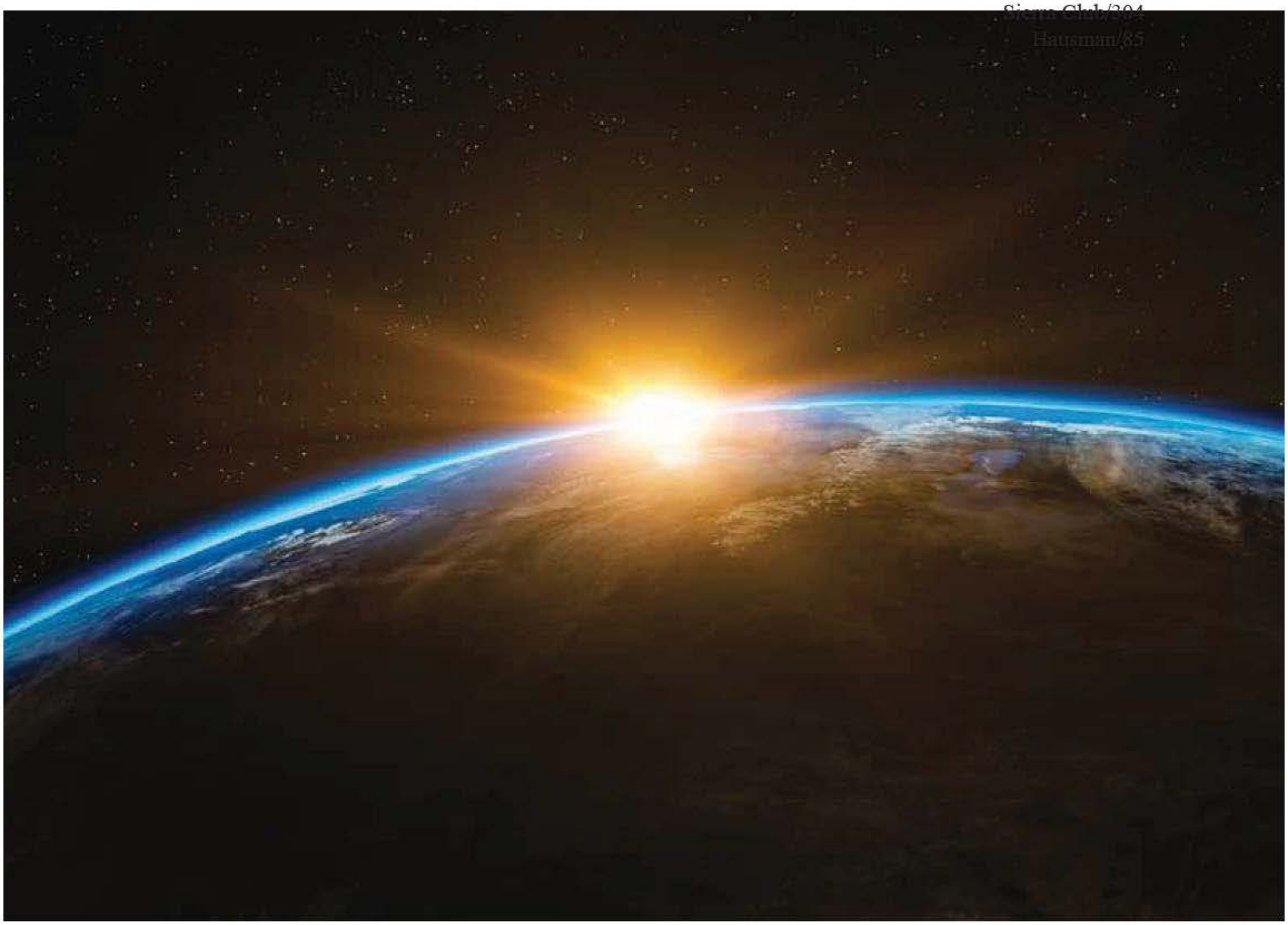
ADJUSTMENT TO DERIVE PRODUCTION-BASED GROSS INVENTORY
(In-state direct emissions only — Uses in-state electricity generation emissions instead of emissions associated with the use of electricity within Oregon.)

In-State Electric Power Generation 1990-2003

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
CO2	OR Power Plant Natural Gas Combustion	0.402	0.623	0.792	0.928	1.436	1.046	1.425	1.303	2.859	2.678	3.749	4.470	3.013	4.031
	OR Power Plant Coal Combustion	1.369	2.978	3.713	3.359	4.014	1.674	1.769	1.389	3.308	3.539	3.548	3.976	3.358	3.977
	OR Power Plant Petroleum Combustion	0.024	0.010	0.008	0.024	0.005	0.005	0.004	0.010	0.025	0.007	0.045	0.078	0.006	0.043
CH4	OR Power Plant Combustion Byproducts	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.004	0.006	0.005	0.006	0.006	0.005	0.006
N2O	OR Power Plant Combustion Byproducts	0.013	0.019	0.022	0.021	0.024	0.014	0.015	0.013	0.023	0.023	0.024	0.027	0.022	0.027
HGWP	Transmission and Distribution Systems	0.366	0.350	0.343	0.334	0.309	0.282	0.265	0.241	0.191	0.195	0.187	0.163	0.143	0.128
In-State Electric Power Generation Sub-total		2.179	3.984	4.883	4.668	5.793	3.027	3.483	2.959	6.412	6.446	7.559	8.721	6.547	8.212
Remove Total of Electricity Use Emissions		(16.57)	(16.83)	(16.55)	(20.63)	(20.81)	(21.16)	(21.96)	(22.02)	(20.85)	(22.00)	(23.29)	(22.69)	(21.35)	(21.73)
Gross GhG Emissions, Production Basis		42	46	47	47	49	47	49	49	55	57	54	53	52	53

In-State Electric Power Generation 2004-2016

		2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	
CO2	OR Power Plant Natural Gas Combustion	4.804	4.762	4.087	5.564	6.315	5.894	6.045	3.310	4.497	5.645	4.997	6.353	6.087	
	OR Power Plant Coal Combustion	3.214	3.247	2.221	3.955	3.642	2.862	4.045	3.323	2.650	3.648	3.102	2.296	1.825	
	OR Power Plant Petroleum Combustion	0.017	0.040	0.005	0.004	0.009	0.002	0.002	0.005	0.005	0.005	0.008	0.005	0.004	
CH4	OR Power Plant Combustion Byproducts	0.003	0.008	0.007	0.007	0.006	0.006	0.016	0.012	0.010	0.015	0.013	0.011	0.010	
N2O	OR Power Plant Combustion Byproducts	0.018	0.025	0.020	0.028	0.024	0.021	0.026	0.020	0.018	0.024	0.022	0.018	0.016	
HGWP	Transmission and Distribution Systems	0.117	0.105	0.091	0.081	0.080	0.079	0.072	0.075	0.061	0.059	0.061	0.052	0.052	
In-State Electric Power Generation Sub-total		8.172	8.187	6.431	9.638	10.076	8.865	10.207	6.745	7.240	9.396	8.203	8.735	7.995	
Remove Total of Electricity Use Emissions		(21.53)	(20.21)	(20.93)	(22.97)	(22.31)	(20.71)	(20.34)	(18.11)	(17.35)	(18.27)	(17.94)	(18.74)	(16.18)	
Gross GhG Emissions, Production Basis		54	54	54	57	56	53	54	51	51	52	51	53	54	



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Docket No. UE 374
Exhibit Sierra Club/305
Witness: Ezra Hausman

PUBLIC UTILITY COMMISSION OF OREGON

UE 374

SIERRA CLUB EXHIBIT 305

Exhibits Accompanying the Opening Testimony of Ezra D. Hausman, Ph.D.

Selected Public Data Responses

Exhibit Sierra Club/305

Selected Public Responses to Sierra Club Data Requests

1. PacifiCorp Response to Sierra Club Data Request 5.1

2 PacifiCorp Response to Sierra Club Data Request 5.3

3. PacifiCorp Response to Sierra Club Data Request 6.1

UE 374/PacifiCorp
May 28, 2020
Sierra Club Data Request 5.1

Sierra Club Data Request 5.1

Please provide any updated load forecasts prepared by or for PacifiCorp or Pacific Power since the Company filed its 2019 IRP. Please include load forecasts for Pacific Power's Oregon service territory, Pacific Power overall, and for PacifiCorp overall.

Response to Sierra Club Data Request 5.1

PacifiCorp has not completed a load forecast since PacifiCorp's 2019 Integrated Resource Plan was filed (docket LC 70 on October 18, 2019).

Pacific Power is the trade name for PacifiCorp and is not a separate legal entity.

UE 374/PacifiCorp
May 28, 2020
Sierra Club Data Request 5.3

Sierra Club Data Request 5.3

Please provide all notes, reports, memoranda, and presentations provided to the Pacific Power and/or PacifiCorp Board of Directors discussing:

(a) The impact of coronavirus and the resulting economic impacts on the Company's expected load and energy sales;

(b) The impact of coronavirus and the resulting economic impacts on the need for new resources over the next several (1-5) years;

(c) The impact of coronavirus and the resulting economic impacts on the Company in general;

(d) Changes in expectations for new resource capital costs and economics since the Company filed its 2019 IRP.

Response to Sierra Club Data Request 5.3

No notes, reports, memoranda or presentations have been provided to the PacifiCorp Board of Directors discussing the matters noted in subparts (a) through (d).

Pacific Power is the trade name for PacifiCorp and is not a separate legal entity.

UE 374/PacifiCorp
June 3, 2020
Sierra Club Data Request 6.1

Sierra Club Data Request 6.1

According to PacifiCorp witness Etta Lockey (pp. 16-17), "the Exit Date for Jim Bridger Units 2-4 represents a trade-off between the potential for continued NPC benefits associated with including the units in rates through the operational lives identified in the 2019 IRP, and the certainty of decommissioning and remediation liability of Jim Bridger Units 2-4, commensurate with Oregon's current allocation."

a. Please provide any analysis and workpapers prepared by or for the Company relating or referring to the "trade-off" described by Ms. Lockey. Please provide such workpapers in their native electronic format with formulas intact.
b. Please provide any reports or presentations based on or describing such analyses and their results, as well as meeting minutes from any meeting of the Board of Directors at which they were presented or discussed.
c. Did PacifiCorp analyze, or cause to have analyzed, any analogous "trade-offs" concerning an earlier (e.g., 2025) exit order than those shown in Table 1 of Ms. Lockey's testimony for any of the following units:
    i. Colstrip units 3 and 4
    ii. Dave Johnston Units 1-4
    iii. Hunter Units 1-3
    iv. Huntington Units 1 and 2
    v. Wyodak

If the answer to "c" above is yes, please provide all such analyses and workpapers, along with any reports, presentations, and board minutes describing the analyses and results.

Response to Sierra Club Data Request 6.1

PacifiCorp objects to this data request to the extent it requests information that is privileged, including privileged material from negotiations leading to the 2020 PacifiCorp Inter-jurisdictional Allocation Protocol (2020 Protocol). The Oregon Exit Date for Jim Bridger Units 2-4 and all other coal units was a negotiated outcome as part of the 2020 Protocol. Please refer to UM 1050 for the approval of the 2020 Protocol. There is no further analysis to provide.