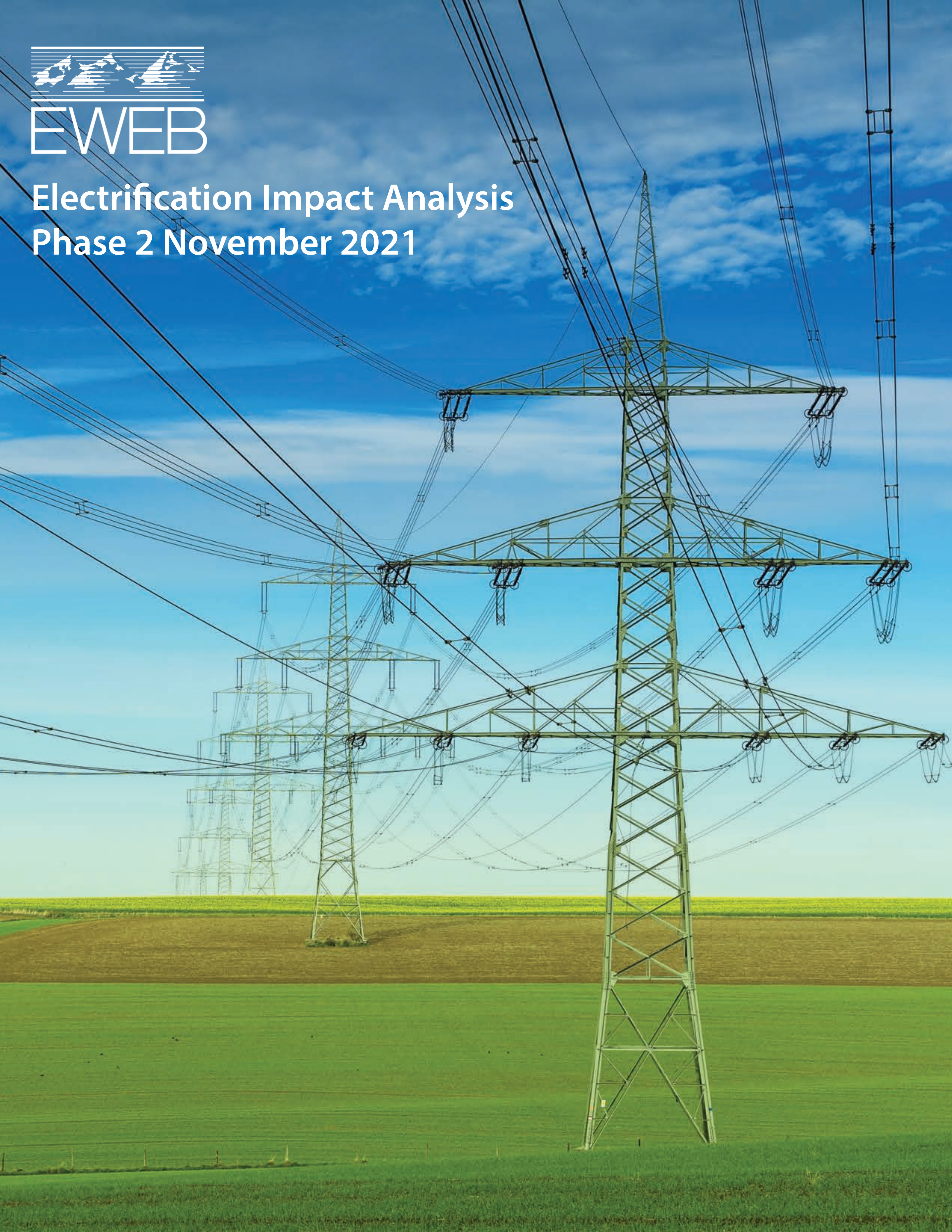
EWEB

Electrification Impact Analysis
Phase 2 November 2021



EWEB

Readers:

In early 2020, EWEB's management and Commissioners agreed to develop a better understanding of the impacts of electrification on EWEB's future planning efforts. I am pleased to present our second analysis of the potential impacts of electrification, this time including economic factors affecting decisions to convert to electricity.

EWEB's first report, published in November 2020, focused on the potential impacts of electrification without analyzing the costs to customers choosing to electrify. The attached second report seeks to build on that initial analysis and context by considering the economics of electrification from multiple perspectives.

In both studies, the analysis of the transportation sector focuses on light-duty vehicle electrification, while the building sector analysis focuses on the electrification of space and water heating technologies for existing residential and small commercial buildings.

These reports reflect our ongoing assessment of evolving electricity consumption patterns that will help guide decisions and investments associated with electricity generation, delivery infrastructure, utility rate design, and customer program development. These studies do not advocate a position, or necessarily fully align with other agency targets or assumptions but attempt to inform and prepare EWEB for a range of different future conditions.

Prior to 2028, EWEB will need to reassemble an electric supply portfolio for the long-term economic, environmental, and social benefit of our community. These electricity supply decisions can be improved by effectively aligning time-of-use consumption, distributed generation, demand response, and efficiency programs with the increasingly dynamic future of clean energy resources and evolving storage technologies.

Consistent with the values of our customer-owners, EWEB will need to align our electricity supply portfolio with the evolving energy needs of our community, considering the potential effects of climate change, economics, technology, customer behavior, industry variations, and policy changes. All of these factors, including the likelihood, degree, and pace of electrification, will be used as planning criteria in EWEB's Integrated Resource Plan (IRP), scheduled to begin in early 2022 for completion in early 2023.

Thank you for your interest.

Frank Lawson
Eugene Water & Electric Board
CEO & General Manager

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1 ABSTRACT

In early 2020, EWEB's management and Commissioners agreed to develop a better understanding of the impacts of electrification on EWEB's future planning efforts. The likelihood, degree, and pace of Electrification, or the conversion of fuel-based consumption to electricity, will be used as planning criteria in EWEB's Integrated (Electricity) Resource Plan, scheduled for completion in early 2023.

Phase 1 of the Electrification Impact Analysis Report focused on potential changes to electricity consumption patterns and environmental impacts from electrification of passenger vehicles, as well as residential and small commercial water and space heating. While the Phase 1 study relied on assumed low, medium, or high levels of electrification, the adoption rate of electrification was uncertain because the analysis was done without considering costs. Phase 2 seeks to build on the analysis and context established in Phase 1 by considering the economics of electrification from multiple perspectives, and therefore providing a better understanding of the likelihood of electrification and EWEB's opportunities to engage with customers and develop programs. This study utilizes benefit/cost analysis to understand the financial benefits of electrification and explores key variables which will influence customer choices over the next 20 years.

2 EXECUTIVE SUMMARY

In early 2020, EWEB initiated a study of the impacts of widespread electrification in our community to understand various electrification scenarios and assess potential impacts to power supply, demand, local infrastructure, and community greenhouse gas (GHG) emissions.

Phase 1 of the study, completed in Oct. 2020, focused on potential changes to demand and consumption patterns, generation needs, and environmental impacts from electrification of small vehicles, water and space heating. Phase 2 of the Electrification Impact Analysis Report seeks to build on the analysis and context presented in Phase 1 by considering the economics of electrification.

For Phase 2, EWEB analyzed economic value from the perspective of the Customer/Participant, EWEB Ratepayers, and Society as a whole.

Like Phase 1, analysis of the transportation sector focuses on light-duty vehicle electrification. The building sector analysis focuses on space and water heating technologies for existing buildings using natural gas which can be electrified using heat pumps.

To perform this economic analysis, EWEB worked with Energy and Environmental Economics (E3). Using this financial analysis, EWEB can better understand customer choices, key variables impacting the likelihood of transportation and building electrification and impacts under a Base Case (expected future) and Aggressive Carbon Reduction (ACR) scenario.

This analysis can help EWEB refine forecasting of future electricity demand, inform Integrated Resource Planning efforts, and highlight opportunities to engage with customers around the topics of power supply, carbon reductions, consumer behaviors, and electrification impacts.

2.1 ELECTRIC AND NATURAL GAS SUPPLY DECARBONIZATION

Both the electricity and natural gas sector are anticipated to decarbonize over the next 30 years due to regulatory influences, coal plant retirements, buildout of renewable resources (primarily wind and solar), the increasing use of Renewable Natural Gas (RNG) and the potential of methanized hydrogen. The costs to decarbonize electricity and natural gas can, in turn, impact consumer prices and thus influence the pace of electrification.

Whereas the rate impact in the electric sector is expected to be moderate, increasing RNG content will put strong upward rate pressure on natural gas providers. In The Challenge of Retail Gas in California's Low Carbon Future study by E3[1], the analysis indicated that California electric rates could increase 20-40% by 2050, depending on the scenario, where natural gas rates could increase by 300% over the same period.

In EWEB's Phase 2 study, the increasing use of RNG and resulting upward costs of natural gas improve the financial benefits of electrification of space and water heating improve over time.

[1] "*The Challenge of Retail Gas in California's Low Carbon Future*", authored by E3 and University of California, Irvine, Advanced Power and Energy Program Engineering Laboratory Facility for the California Energy Commission, April 2020, CEC-500-2019-055-F.

2.2 KEY FINDINGS

2.2.1 Transportation

Electrification of light-duty vehicles creates value (marginal benefit/marginal cost) from all perspectives (Customer/Participant, EWEB Ratepayer, Society) in both the Base Case and ACR scenario, indicating electrification is likely and beneficial.

While federal and state incentives help provide benefits to EV purchases today, the benefits of owning an EV are expected to dramatically improve by 2030, even as incentives expire or are eliminated.

Economic analysis indicates that EV adoption will rapidly increase after 2030, with nearly 85% of all vehicles on the road being electric by 2040. Based on the benefits to customers, the phase 2 economic analysis shows an accelerated adoption of EV's greater than the "high adoption" assumption modeled in the phase 1 study.

EVs provide benefits for owners, ratepayers, and society:

- All battery electric vehicles, regardless of size or vehicle type, are expected to become cheaper than conventional cars before 2030.
- EWEB ratepayers benefit through the increased sales of electricity realized by EV charging, the proceeds of which could be used to cover the fixed costs of the utility, reduce rates, pay for distribution infrastructure investments, or fund additional incentives for EV adoption.
- By 2040, Eugene's total carbon emissions could be reduced by 38% due to EV adoption.

Phase 2 of the study estimates a lower coincident peak of EV charging (1 kW per EV) compared to Phase 1 of the study due to increased levels of off-peak workplace and public charging in the future. The electric peak impact, while still significant, can be mitigated with managed or diversified charging behavior.

EWEB can encourage diversified charging behavior by increasing the availability of public and workplace charging infrastructure and utilizing dynamic energy price signals (like time-of-use rates) to encourage vehicle charging to shift to non-peak times. In the near term, EWEB's engagement and collaboration with electric vehicle owners and the City of Eugene to shift charging times to non-peak hours of the day when carbon benefits are highest, and costs are lowest, will be beneficial to the impact and rate of electrification.

2.2.2 Buildings

The benefit/cost analysis of electrification of space and water heating is influenced by multiple factors, primarily building type and technology choices.

Water Heating

Even without incentives, water heating electrification has economic benefits for all three electrification perspectives by 2030. The aggregate carbon reduction benefits are small compared to other end-uses, due to relatively low energy consumption of water heaters, but so is the electric system peak impact.

For Single Family Dwellings (SFD), electrification of water heating is expected to have financial benefits in 2030 as heat pump water heaters become more cost competitive with natural gas water heaters over time.

Space Heating

The economics and impacts of space heating electrification is more complex and uncertain. Removing other variables (mandates, incentives, equity, personal choice), substantial single-family dwelling electrification of space heating is unlikely under the Base Case scenario given lack of economic benefit created for the Customer/Participant.

From this value perspective, for a residential property, electrifying with standard performance heat pump or dual-fuel heat pump technology creates the most economic value for both the participant and society. However, the standard heat pump has the most electric system peak impact, which may be more difficult to mitigate given its correlation to EWEB's existing system peaks.

For both scenarios studied, multifamily dwellings (MFD) have lower energy consumption than SFD, which makes it more difficult for the Customer/Participant to recover the upfront costs of electrifying through annual energy savings. All the space heating electrification measures studied were a net cost to the Customer/Participant, making electrification of MFD space heating unlikely.

Small office electrification was also found to be unlikely due to EWEB's commercial rate structure which includes a demand charge on peak energy use. This demand pricing signal may currently be acting as a deterrent to electrification for commercial customers.

2.2.3 Cumulative Impacts of Electrifying Transportation and Buildings

Overall, the study finds that the pace of customer-driven electrification, if based on economic value alone, will be slow in the next decade with EV adoption appearing to be the most likely and impactful form of electrification based on the large conversion potential (number of cars).

The following tables and charts summarize the cumulative electrification findings and highlight the differences between the Base Case and the Aggressive Carbon Reduction (ACR) scenarios. The cumulative energy impacts are relative to EWEB's existing system loads and existing peak demand periods. The percentage increase is based on EWEB's existing system average load of 270 aMW and a 1-in-10 peak of 510 MW, which is a common planning standard for electric utilities.

2040 - Base Case					
Electrification Measure	% Electrified	Average Energy Increase (aMW)	% Increase	1-in-10 Peak Increase (MW)	% Increase
Electric Vehicle - Managed	85%	57	21%	77	15%
Electric Vehicle - Unmanaged	85%	57	21%	131	26%
Heat Pump Water Heater	50%	1	0.3%	1.5	0.3%
Standard Performance Heat Pump	< 2%	Without significant incentives or mandates, impactful space heating electrification is unlikely if driven by participant economics (consumer choice).			
Cold Climate Heat Pump	< 2%				
Dual Fuel Heat Pump	< 2%				

2040 - Aggressive Carbon Reduction					
Electrification Measure	% Electrified	Average Energy Increase (aMW)	% Increase	1-in-10 Peak Increase (MW)	% Increase
Electric Vehicle - Managed	95%	63	24%	85	17%
Electric Vehicle - Unmanaged	95%	63	24%	145	28%
Heat Pump Water Heater	85%	2	1%	3	1%
Standard Performance Heat Pump*	50%	8	3%	33-61	6-12%
Cold Climate Heat Pump*	50%	4	2%	17-31	3-6%
Dual Fuel Heat Pump*	50%	6	2%	Minimal	Minimal

*Space heating energy impacts shown assume 100% of space heating electrifcation assuming a single technology to illustrate that space heating technology choice matters. In reality, customers will choose a mix of the 3 different space heating technologies. Peak impacts are presented in ranges due to uncertainty regarding coincident load of units. Utilizing AMI data in the future, EWEB could better estimate the coincident load of these space heating technologies.

As mentioned in Phase 1, electrification is just one of the pillars of decarbonization. Although separate from the benefits of electrification, staff provided an estimate of the potential carbon reduction benefits of RNG based on the Eugene Climate Action Plan's 2017 carbon inventory for additional context.

Annual Carbon Reductions	2040					
	Base Case			Aggressive Carbon Reduction Scenario		
Carbon Reduction Measures	% Electrified	MTCO2e Reduced	% Carbon Reduction	% Electrified	MTCO2e Reduced	% Carbon Reduction
Vehicle Electrification	85%	(390,000)	-38%	95%	(432,000)	-43%
Water Heating Electrification	50%	(5,700)	-1%	85%	(6,500)	-1%
Space Heating Electrification	0%	-	0%	50%	(16,000)	-2%
Residential RNG Benefits*		(19,600)	-2%		(45,100)	-4%
Commercial & Industrial RNG Benefits*		(45,300)	-4%		(104,400)	-10%
Total Annual Carbon Reductions		(460,600)	-45%		(604,000)	-60%
Total 2017 Carbon Emissions (City of Eugene CAP 2.0)		1,013,600	100%		1,013,600	100%
*The Base Case assumes a blend of 23% RNG by 2040 and the Aggressive Carbon Reduction scenario assumes a blend of 53% RNG by 2040. The estimated carbon reduction benefits of increased carbon-free RNG are shown in addition to the benefits of building electrification for context.						

2.3 EWEB's Electrification Opportunities

Electrification measures can be most beneficial when they reduce carbon emissions while maintaining reliability and affordability.

Measures that add to existing system peaks may create reliability risks because they could, (1) increase utilization (reduce available capacity) of EWEB's existing local distribution network, and (2) increase reliance on the regional electric grid, where decarbonization efforts are impacting the availability of existing transmission and generation capacity. To manage the reliability risk, additional distribution, transmission, and generation assets potentially need to be procured at a cost to EWEB, which represents a risk to future customer affordability.

Economics are another factor influencing the benefits of various electrification measures. Technologies that do not produce economic benefits show lower likelihood of consumer-driven adoption and may require more resources to influence customer choices. Therefore, maintaining affordable/competitive electricity rates will have a favorable impact on electrification.

To the extent that electrification provides financial benefits to participants, EWEB programs will need to consider access to these benefits and equity among customers. Exclusion of multifamily housing incentives, for example, may inadvertently exclude low and moderate income (LMI) communities from the benefits.

The Electrification Scorecard below was developed by staff to provide high level context for the different electrification measures studied in Phase 2.

Electrification Scorecard	Carbon Reduced	Base Case 2030			1-in-10 Peak Adder	Peak Management Potential	EWEB Engagement Opportunities
		EWEB Participant	EWEB Ratepayer	Society			
Electric Vehicle	🍃🍃🍃	🟢	🟢	🟢	⚡⚡⚡	🩹🩹🩹	Encourage managed charging to avoid peak, increase public and workplace charging opportunities.
Heat Pump Water Heater	🍃	🟢	🟢	🟢	⚡	🩹🩹	Consider existing energy efficiency incentive program's influence on electrification of water heating.
SFD - Standard Heat Pump	🍃🍃	🟡	🟢	🟢	⚡⚡⚡	🩹	Participant benefits are neutral, making electrification unlikely. Possible incentive opportunity.
SFD - Cold Climate Heat Pump	🍃🍃🍃	🔴	🟢	🔴	⚡⚡	🩹🩹	Participant benefits are lacking, making electrification unlikely. Possible incentive opportunity.
SFD - Dual Fuel Heat Pump	🍃🍃	🟡	🟢	🟢	⚡	🩹🩹🩹	Participant benefits are neutral, making electrification unlikely. Possible incentive opportunity.
Multi-Family Dwelling Space Heat	🍃	🔴	🟢	🔴	⚡	🩹🩹	Participant benefits are lacking, making electrification unlikely. Possible incentive opportunity.
Small Office Space Heat	🍃🍃	🔴	🟢	🟢	⚡⚡	🩹🩹	Participant benefits are lacking, making electrification unlikely. Consider rate design changes for commercial electrificaiton.

Electrification Scorecard	Carbon Reduced	Aggressive Carbon Reduction 2030			1-in-10 Peak Adder	Peak Management Potential	EWEB Engagement Opportunities
		EWEB Participant	EWEB Ratepayer	Society			
Electric Vehicle	🍃🍃🍃	🟢	🟢	🟢	⚡⚡⚡	🩹🩹🩹	Encourage managed charging to avoid peak, increase public and workplace charging opportunities.
Heat Pump Water Heater	🍃	🟢	🟢	🟢	⚡	🩹🩹	Consider existing energy efficiency incentive program's influence on electrification of water heating.
SFD - Standard Heat Pump	🍃🍃	🟢	🟢	🟢	⚡⚡⚡	🩹	Influence customer space heating technology choices to mitigate peak impacts.
SFD - Cold Climate Heat Pump	🍃🍃🍃	🟢	🟢	🟢	⚡⚡	🩹🩹	Influence customer space heating technology choices to mitigate peak impacts.
SFD - Dual Fuel Heat Pump	🍃🍃	🟢	🟢	🟢	⚡	🩹🩹🩹	Influence customer space heating technology choices to mitigate peak impacts.
Multi-Family Dwelling Space Heat	🍃	🔴	🟢	🔴	⚡	🩹🩹	Participant benefits are lacking, making electrification unlikely. Possible incentive opportunity.
Small Office Space Heat	🍃🍃	🔴	🟢	🟢	⚡⚡	🩹🩹	Participant benefits are lacking, making electrification unlikely. Consider rate design changes for commercial electrificaiton.

3 PHASE 2 ELECTRIFICATION IMPACT ANALYSIS SCOPE

Phase 2 of the electrification study seeks to build on the analysis and context presented in Phase 1 by considering the financial costs and benefits of electrification. Similar to Phase 1, analysis of the transportation sector focuses on light-duty vehicle electrification. The building sector analysis focuses on space and water heating technologies for existing buildings using natural gas which can be electrified with heat pumps. To perform this economic analysis, EWEB worked with Energy and Environmental Economics (E3) to develop in-house tools for modeling benefits and costs of electrifying.

Consumer choices are influenced by forces largely beyond the control of EWEB, such as state or federal tax policies and technological innovation. EWEB programs and pricing can influence consumer technology decisions. This analysis lays out a framework that may inform potential EWEB programs by end-use. For example, incentive levels that leave the utility/customers indifferent (held harmless) while providing financial benefit to program participants can help drive consumer adoption. For some end uses, educational campaigns without additional incentives may influence customer choices where the value proposition is already clear. This analytical framework can indicate how potential incentives could change over time, as economics change. This is intended to be information only and not a recommendation or call to action. It should be emphasized that this economic analysis is foundational and informs other work streams such as future integrated resource plans.

3.1 OUTSIDE OF SCOPE

Non-economic decision making is outside the scope of this study. Consumer choice has multiple drivers, like convenience or aesthetics, but economics are nearly always a primary consideration. Thus, economics is the basis of our quantitative analysis. While we do not disregard qualitative impacts to customer choice (e.g. customer desire for carbon reduction), these factors can be difficult to model and often require alternate forms of analytical methods.

Carbon emissions associated with upstream production of energy are outside the scope of this study. These upstream emissions do have impacts on the climate (like methane gas leaks from natural gas production and distribution[2] or the lifecycle of solar panel manufacturing and disposal). Other organizations like the National Renewable Energy Laboratory (NREL) have done studies on life cycle carbon emissions across electricity generation technologies which readers may find helpful[3]. For the purposes of economic analysis, staff focused on the carbon emissions with the direct use of electricity or fossil-based fuels for the specific end-uses analyzed.

For the transportation sector, this study focuses on electrification of light-duty vehicles only. According to the City of Eugene's 2017 Greenhouse Gas Inventory[4], approximately 33% of the transportation sector emissions come from diesel and the remaining come from gasoline. Diesel is more commonly used in mid-size pickups (over 6,500 lbs) and freight trucking. Reduction of emissions of this portion of the transportation sector is outside of this study's scope.

For the building sector, the space and water heating equipment for the residential sector overlaps with the small office segment of commercial sector. Hence, our study of the economics of electrification can be more broadly

[2] Northwest Power and Conservation Council has published staff recommendations for upstream methane emission assumptions related to the 2021 Power Plan here: https://www.nwcouncil.org/energy/energy-advisory-committees/natural-gas-advisory-committee

[3] https://www.nrel.gov/analysis/life-cycle-assessment.html

[4] City of Eugene Climate Action Plan 2.0 – Appendix 6 2017 GHG Inventory.

applied to small offices or other commercial properties with energy equipment similar to residential homes. Space and water heating end-uses for larger commercial and industrial segments represent a smaller proportion of total energy consumption (estimated to be 33% and 7% for commercial and industrial[5], respectively). Electrification of space and water heating end-uses for large commercial and industrial segments is more complex and site-specific and is outside the scope of this economic analysis.

4 KEY CONTEXT: ROLE OF ECONOMICS IN ELECTRIFICATION

HIGHLIGHTS

- While some consumers will choose to electrify for environmentally altruistic reasons, significant electrification will either be driven by policy mandate or economic benefit to the consumer.
- For Phase 2 of the electrification study, EWEB used benefit-cost modeling for targeted electrification measures to better understand the economic value from the perspective of the consumer (participant), EWEB ratepayers, and society as a whole.
- Understanding and aligning the economic interests of participants, ratepayers, and society can inform future electrification programs, utility rate designs, and financial incentives.
- Maintaining affordable electric rates is crucial to preserving the economic benefits and offsetting the upfront cost of electrification investment.

Phase 2 of the electrification study utilizes benefit-cost analysis to better understand the customers' financial considerations when choosing to electrify. The benefit-cost analysis considers the total lifecycle of targeted electrification measures, and then presents those findings on a discounted cash flow basis. Since most customers do not consider discounted cash flows when making purchasing decisions, EWEB also translates discounted cashflows into simple payback periods (upfront costs divided by annual savings) to better estimate the likelihood a consumer may choose to electrify. These are standard tools for estimating consumer adoption of new technologies. **While some consumers will choose to electrify regardless of financial impact, it is likely that widespread electrification will only occur if there is either: 1) a financial benefit to the consumer to voluntarily choose to electrify, or 2) a policy driven mandate that requires consumer electrification.**

The cost-effectiveness of electrifying can differ depending on one's frame of reference. The consumer or "participant" is the EWEB customer who chooses to electrify, and ultimately determine which transportation, space, and/or water heating technology will be implemented. However, those participant choices have specific impacts on EWEB ratepayers and society in general. Thus, the benefit-cost analysis is presented from multiple perspectives:

- **EWEB Participant:** Do benefits outweigh costs for an EWEB customer adopting a new technology?
- **EWEB Ratepayer:** Do benefits outweigh costs for a nonparticipant EWEB ratepayer?
- **Society:** Do benefits outweigh costs for a resident of the community?

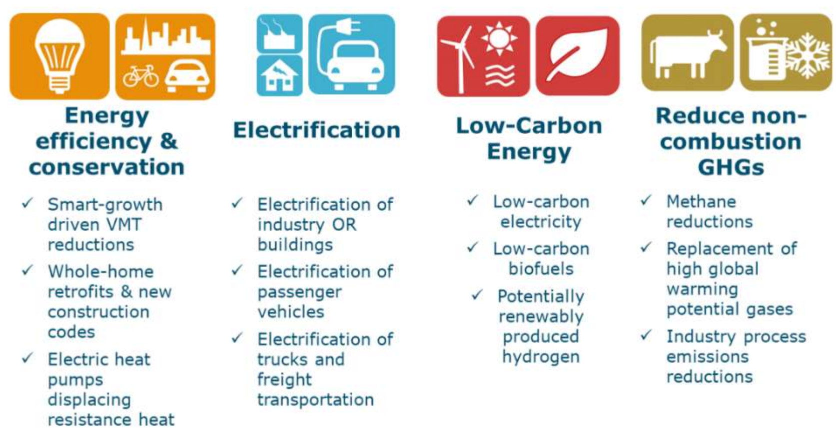
Analyzing benefits and costs from multiple perspectives helps the utility understand to what extent value can be exchanged between EWEB ratepayers and participants. For example, EWEB's level 2 charger rebate is an exchange of value from EWEB ratepayers who fund the incentive to participants who receive the rebate. The participant clearly benefits in the form of a financial rebate. Value is also passed along to EWEB ratepayers in the form of additional revenue collected from the electric vehicle charging over time, and society will benefit from the emissions reductions associated with the electric vehicle. But does the benefit to society outweigh the

[5] Per CADMUS end-use model

incremental cost to the participant to purchase the technology? Is there a way to compensate the participant for the benefit created for society? EWEB has significant influence over the exchange of value between ratepayers and program participants (through electric rates and incentives). By quantifying the benefits from multiple perspectives, EWEB can understand the financial benefits of electrification for ratepayers while being mindful of costs to participants and ratepayers. This information can inform future electrification programs, rate design, and electrification incentives.

The goal of the Society perspective is to provide context for the participant who pays for the upfront equipment costs, the supply chain that provides energy to the equipment and the benefit of avoided emissions (based on the assumed social cost of carbon). It can be useful to understand the efficiency of electrification for society to get the benefits of reduced carbon emissions. If the society perspective is a net cost for an electrification measure, it indicates that the financial investment of electrification is greater than the financial benefit of carbon reduction. This is not meant to imply that carbon reduction is not valuable, but instead to distinguish the financial efficiency of the identified electrification opportunities.

4.1 AFFORDABILITY



As discussed in Phase 1 of EWEB's electrification study, electrification is just one pillar of a larger decarbonization strategy[6]. The greening of the electric grid plays an important role in decarbonization as well, and the Northwest electric sector is legislated to become cleaner. However, it is possible that increasing electric rates could become a deterrent to electrification. To date, encouraging building and transportation electrification as a critical pillar of successful, economy-wide decarbonization has focused on incentives rather than legislative mandate. Absent such mandates to electrify, an attractive economic proposition is necessary to induce businesses and individuals to choose electrified technology over a fossil fuel-based alternative on a widespread basis. This includes ensuring that electricity remains competitively priced.

4.2 ENVIRONMENTAL IMPACTS AND EQUITY

As identified in the City of Eugene CAP 2.0, national research and local experience show that the impacts of climate change tend to disproportionately impact marginalized communities, including indigenous peoples, communities of color, low and moderate income (LMI) communities, the elderly, and people experiencing disabilities. As we explore potentials for electrification and who is impacted by such decisions, we must consider how electrification might address or exacerbate social disparities. For example, Seattle City Light (SCL) City Light actively engaged with communities most impacted by environmental inequities and racial, social and economic burdens to prioritize transportation electrification investments. As a result of this engagement, SCL placed higher prioritization on electrification of public assets (like public transit, commercial, non-profit & government

[6] https://www.ethree.com/wp-content/uploads/2018/11/E3_Pacific_Northwest_Pathways_to_2050.pdf

fleets) before personal mobility electrification (cars, bikes, scooters, etc.). A key factor for this priority was to direct the environmental benefits of electrification (reduced air and noise pollution) to where the impacts are greatest. As EWEB works to engage customers around electrification, it will be important to consider the impacts on LMI populations as well as those experiencing racial and environmental inequities. EWEB will need to think about how to ensure the environmental benefits of electrification flow to marginalized communities while at the same time, avoiding program costs that could impact affordability of electricity for our LMI customers.

5 KEY CONTEXT: EMERGENT TRENDS IN ELECTRIFICATION

HIGHLIGHTS

- State and federal policies are encouraging increased EV adoption and reduction in the use of carbon emitting fuels.
- Vehicle manufacturers are offering more electric vehicles and committing to increase electric vehicles' percent of new car sales.

5.1 REGULATORY TRENDS

Over the last several months, political support for decarbonization has increased, especially in the west. As a result, several new regulatory policies and related efforts have been introduced or passed since Phase 1 of EWEB's electrification study, all of which seem to be accelerators of carbon reduction and electrification. For example:

- In September of 2020, Governor Newsom of California signed Executive Order N-79-20 which aims to phase out the sale of gasoline-powered vehicles by 2035.
- In May of 2021, Oregon passed SB 333, a bill that directs state agencies to study the potential of, and benefits to Oregon from renewable hydrogen. Additionally, the Oregon legislature passed HB 2021, a 100% clean energy standard which would require Oregon's largest investor-owned utilities to reduce greenhouse gas emissions by 100 percent, below baseline levels, by 2040. Interim goals are 80 percent emissions reduction by 2030 and 90 percent reduction by 2035. Finally, as proposed HB 2021 would include a new gas generation siting ban in Oregon.
- Also in May of 2021, Washington's legislature passed a ban on the sale of gasoline-powered vehicles starting in 2030. The bill was subsequently vetoed by Governor Inslee because the legislation was tied to a separate road usage fee change[7].
- Nationally, the Biden administration has been working to advance the adoption of electric vehicles (EVs) and deploy additional charging infrastructure across the country[8].
- Some cities are updating building codes to reduce greenhouse gas emissions and, in some cases, restricting the use of natural gas. For example, in February 2021, Seattle updated commercial and large multifamily building codes to eliminate gas from most water heating and space heating systems.

[7] https://www.seattletimes.com/seattle-news/politics/inslee-vetoes-2030-target-for-electric-cars-set-by-washington-legislature/

[8] https://www.whitehouse.gov/briefing-room/statements-releases/2021/04/22/fact-sheet-biden-administration-advances-electric-vehicle-charging-infrastructure/

- Seattle's code changes apply to new construction and major renovations, or when space and water heating systems are being replaced[9].

5.2 Vehicle Manufacturer Trends

The electric vehicle market continues to see a rapid evolution as more Original Equipment Manufacturers (OEMs) are committing to increased or even 100% electric offerings within the next 15 years. According to the International Energy Agency, 18 of the 20 largest OEMs, which combined accounted for almost 90% of all worldwide new car registrations in 2020, have announced intentions to increase the number of available models and boost production of electric light-duty vehicles (LDVs)[10]. In addition, the OEMs are beginning to expand their EV lineup into larger vehicles like SUVs and Crossovers. A prominent example of this expanded offering is the Ford F150 Lightning, which is an electric version of the bestselling pickup truck in the U.S. It should be noted that these commitments by OEMs have not yet been realized and that EV sales accounted for only 1-3% of new car sales in 2020.

Below is a summary of vehicle makers' EV offerings and commitments:

Original equipment manufacturer	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
BMW Group			25		15-25%					10
BAIC Group	2				1.3					50%
Changan Automobile (Group)					33					
Daimler		10			25%					50%
Dongfeng Motor Co	1	30%	1		1				1	1
FAW					40%					60%
Ford		40				100%*				
GM Group			22		30	1				1
Honda										40%T
Hyundai-Kia					1					
					29					
Mazda		1								5%
Renault-Nissan		20								
		20%								
Maruti Suzuki	1									1.5
SAIC					30%					30
Stellantis					38%*					70%*
					31%**					35%**
Toyota Group	1				15					>1
Volkswagen					20%					70%*
			1		3				26	50%**
					75					
Volvo (Geely Group)	1	1	1	1	50%					100%*

% of sales electric
Annual sales (million)
New EV models (number)
Cumulative sales (million)

* European market only
** Chinese and US markets only
T Includes both EVs and FCEVs

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In 2020, 559 new electric vehicles were registered within EWEB's service territory. This represents a 42% increase in the number of EVs in 2019. While we do not have exact data regarding total car sales within the service territory, this is estimated to be less than 5% of the new vehicles sold in 2020.

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9 https://www.seattle.gov/environment/climate-change/buildings-and-energy/seattle-energy-code
10 IEA (2021), Global EV Outlook 2021, IEA, Paris https://www.iea.org/reports/global-ev-outlook-2021
11 https://www.iea.org/reports/global-ev-outlook-2021/trends-and-developments-in-electric-vehicle-markets

6 KEY CONTEXT: ELECTRIC AND NATURAL GAS SUPPLY DECARBONIZATION

HIGHLIGHTS

- Increasing the blend of Renewable Natural Gas (RNG) is a likely pathway to decarbonizing the natural gas sector.
- The supply of RNG sources is limited and much more expensive compared to fossil fuel natural gas. Thus, increasing RNG content will put strong upward rate pressure on natural gas providers.
- The electricity supply in the Pacific Northwest already has low carbon content and the upward rate pressure from continued decarbonization is expected to be lower compared to natural gas.

6.1 RENEWABLE NATURAL GAS (RNG) IN NATURAL GAS SUPPLY

To meet decarbonization goals, existing fossil-based natural gas will need to reduce its associated carbon emissions. The carbon reduction benefits of building electrification are relative to the carbon content of direct use natural gas. An increase in RNG would reduce the comparative carbon reduction benefits of electrification, however there would also be financial impacts to increasing the blend of RNG in the natural gas supply. This section highlights findings from "The Challenge of Retail Gas in California's Low Carbon Future," authored by E3 and University of California, Irvine[12]. It should be noted that the study's results are based on total US supply and are not specific to the northwest. However, given common industry and western energy market trends, the results of this study could be considered indicative for the northwest region.

To meet the deep decarbonization climate goal of 80% reduction by 2050[13], the carbon content of fossil-based natural gas will need to be proportionally reduced by 80%. To achieve this goal, natural gas use will have to be significantly reduced and/or replaced with RNG.

RNG is broadly defined as:

1. **Biomethane** – produced from anaerobic digestion of biomass waste or gasification of biomass waste
2. **Hydrogen gas** – sometimes called "green hydrogen" which is carbon neutral. This could be produced from electrolysis using renewable electricity which might otherwise be wasted.
3. **Methane** – produced synthetically from climate neutral sources of carbon and hydrogen

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[12] "*The Challenge of Retail Gas in California's Low Carbon Future*," authored by E3 and University of California, Irvine., Advanced Power and Energy Program Engineering Laboratory Facility for the California Energy Commission, April 2020, CEC-500-2019-055-F.

[13] Deep decarbonization can have different definitions depending on the study, but typically means reducing 1990 GHG emission levels by at least 80% by 2050. This metric is a common multi-sector goal used in the US.

Figure A - Categories of Renewable Natural Gas that could be use within existing distribution infrastructure

Waste biogas	Gasification of biomass	Hydrogen	Synthetic Natural Gas
Sources: Municipal waste, manure	**Sources:** Agriculture and forest residues	**Sources:** Electrolysis + zero-carbon electricity, or steam methane reformation with carbon capture and sequestration*	**Sources:** Renewable hydrogen + CO2 from biowaste (bi-product of biofuel production) or direct air capture
Constraints: Very limited supply	**Constraints:** Limited supply and competing uses for biofuels	**Constraints:** Limited pipeline blends (7% by energy, 20% by volume) without costly infrastructure upgrades**	**Constraints:** Limited commercialization, low round-trip efficiency

***This analysis did not model SMR + CCS for hydrogen production.**
****This analysis did not evaluate conversion of the gas system to 100 percent hydrogen, which would require replacement of end-use devices and gas pipeline upgrades.**

Source: E3

6.2 RNG SUPPLY CURVE

All RNG sources can be scaled to increase volumetric production, however, all sources are far more expensive compared to existing fossil fuel natural gas. Further, the least expensive source (biomethane) is limited in availability, so the model assumes that more expensive RNG sources will be required. The graph below shows two anticipated supply curves (cost vs. volume) for four RNG technologies.

Figure B - California Renewable Natural Gas Technical Potential Supply Curve in 2050, assuming all biomass is directed to Renewable Natural Gas[14]

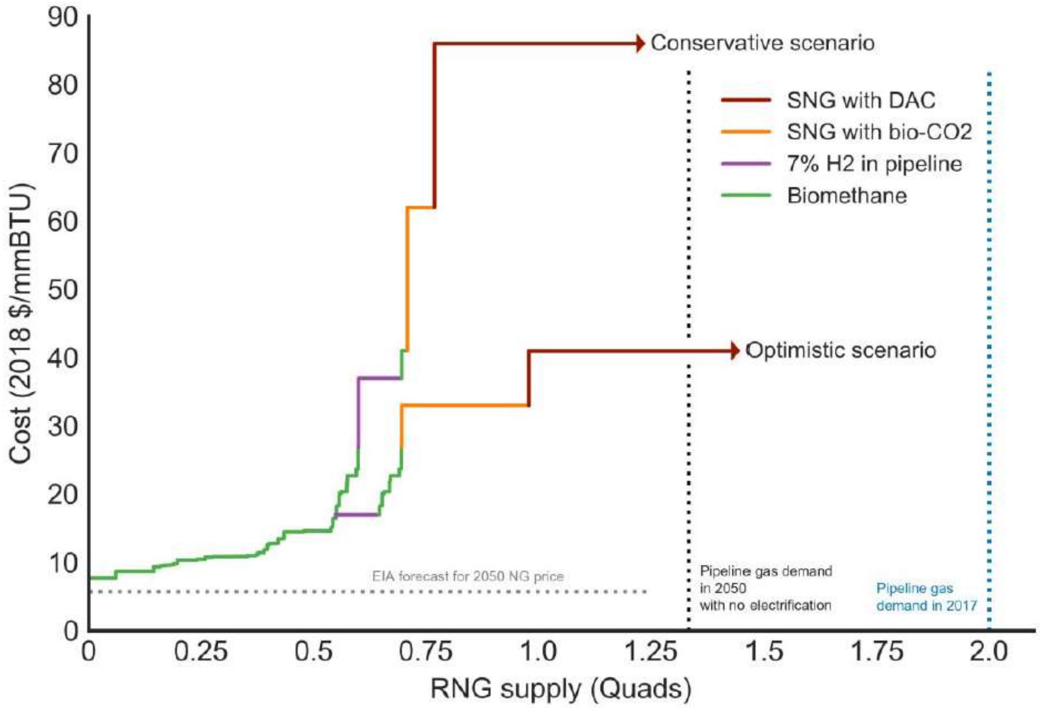

Figure B, above, illustrates the limited supply of renewable natural gas and the increasing cost of supplying greater quantities of RNG. In the optimistic scenario, synthetic natural gas with direct air capture technology (labeled SNG with DAC above) at $41/MMBtu would be the marginal resource to fully decarbonize the gas system in 2050. This optimistic scenario is approximatly 8 times greater than the estimated cost of fossil fuel natural gas in 2050 (shown as a blue dotted line). The conservative RNC supply scenario shows that by 2050 the marginal cost of RNG will be approximately 18x higher than the cost of fossil fuel natural gas.

6.3 Economic Impacts for Natural Gas Providers

It is anticipated that higher levels of RNG in the natural gas system will increase retail natural gas rates. Higher retail rates provide an economic response to reduce consumption, resulting in lower volume sales for the gas provider. Customer classes (industrial, commercial or residential) are impacted differently due to cost causation principles incorporated in rate designs. The residential customer class requires significant distribution piping systems to serve relatively small individual loads compared to large commercial and industrial loads that tend to be centralized (lower distribution costs) with large loads (higher consumption costs).

In "The Challenge of Retail Gas in California's Low Carbon Future" study [15], the key impacts of decarbonization for natural gas providers are:

1. Assumed higher commodity prices in the future as higher levels of RNG are needed and the low-cost sources of RNG are depleted.

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[14] Pipeline gas demand in 2017 was 2 quadrillion BTU (quads), including electricity generation. This demand could decline to 1.3 quads in a scenario with high energy efficiency and renewable electricity generation by 2050. CEC-500-2019-055-F.

[15] https://www.energy.ca.gov/sites/default/files/2021-06/CEC-500-2019-055-F.pdf

2. Substantial rate increases compared to today (300% by 2050) due to higher supply costs and lost customer sales (assuming high building electrification future). It is anticipated that the residential segment could see increases of 600% by 2050 compared to today due to high distribution costs, whereas industrial and transportation segments are not as greatly impacted.
3. Anticipated lower volume sales because of increased natural gas rates

Figure C below illustrates how natural gas retail rates could increase dramatically. Both internal and external factors combine to create a cycle of upward rate pressure. Overtime, a growing pool of natural gas system costs are spread over a declining customer base, which in turn increases costs to these customers.

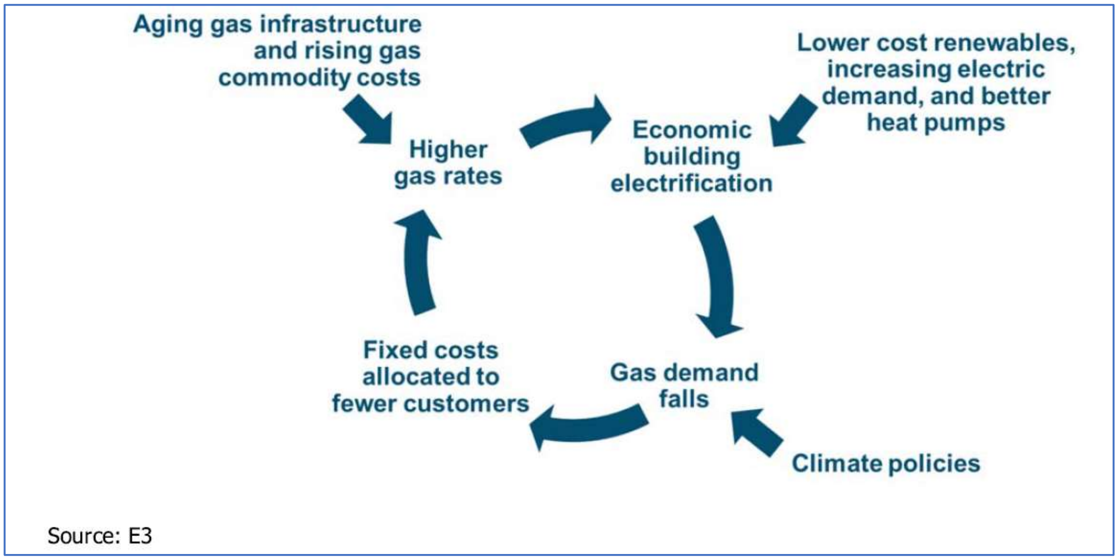
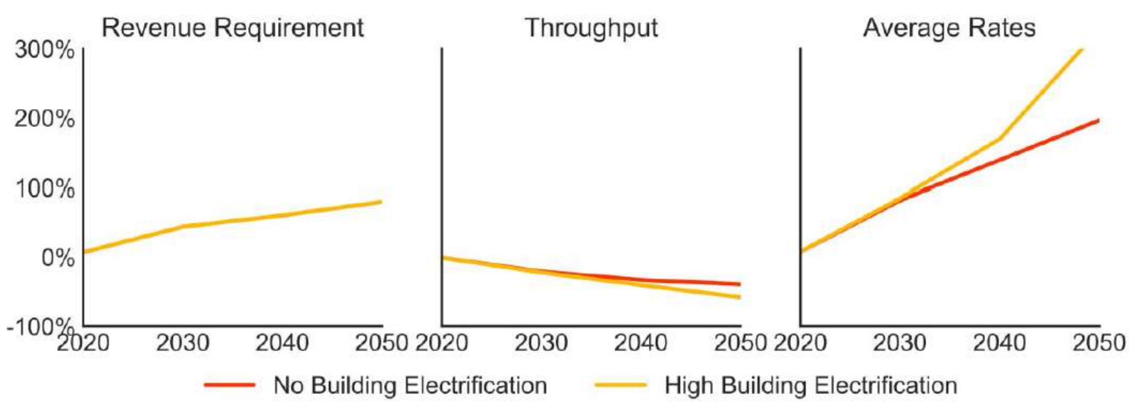
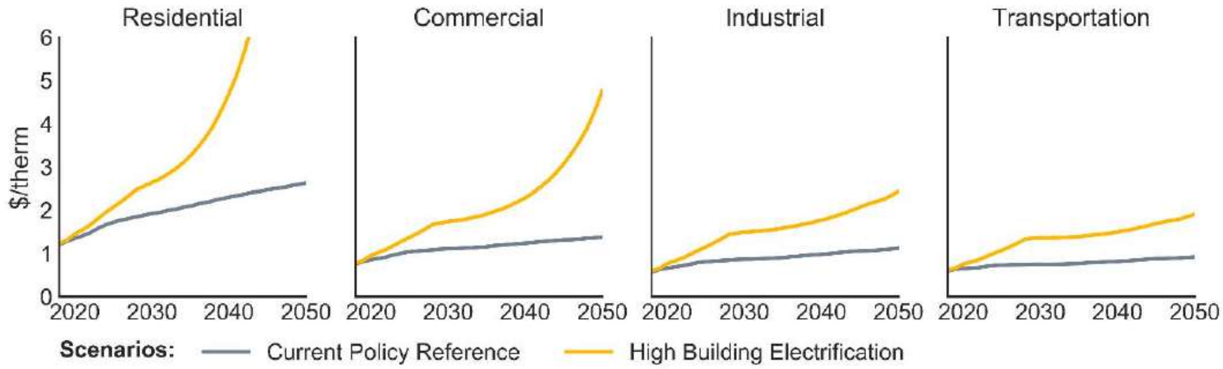


Figure D - Percentage Increase Relative to 2019 in Gas Sector Revenue Requirement, Throughput (retail gas consumption), and Average Rates. Assuming a high building electrification future (lower gas consumption) and increasing costs, average natural gas rates are forecasted to increase by 300%.



Source: E3

The Residential sector is expected to bear a higher burden relative to the other sectors as shown in Figure E, below.



Source: E3

6.4 ECONOMIC IMPACTS FOR ELECTRICITY PROVIDERS

Decarbonization of the electricity sector is expected to result in less upward rate pressure than the natural gas sector, especially in areas that already have a high concentration of carbon-free energy sources like the Pacific Northwest (PNW). As discussed in Phase 1 of the study, the Pacific Northwest (PNW) electric grid carbon intensity (CI) is much less than national average. The PNW generation portfolio is about 50% hydro and was an early adopter in wind generation making approximately 65% of electricity generation in the region[16] carbon free (EWEB's power portfolio is approximately 90% carbon-free).

Figure F - Existing PNW generating capacity[17] (MW)

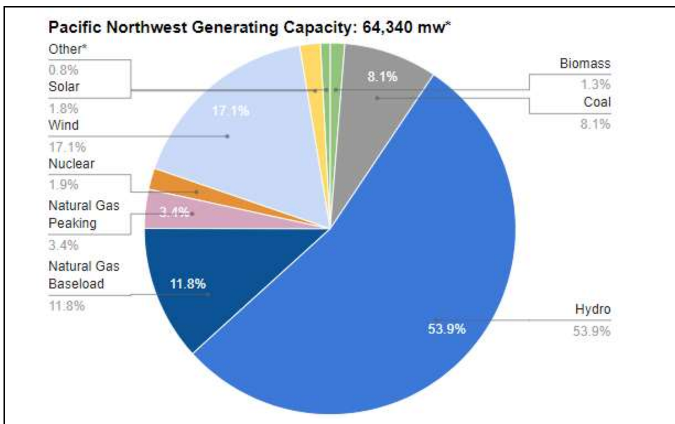
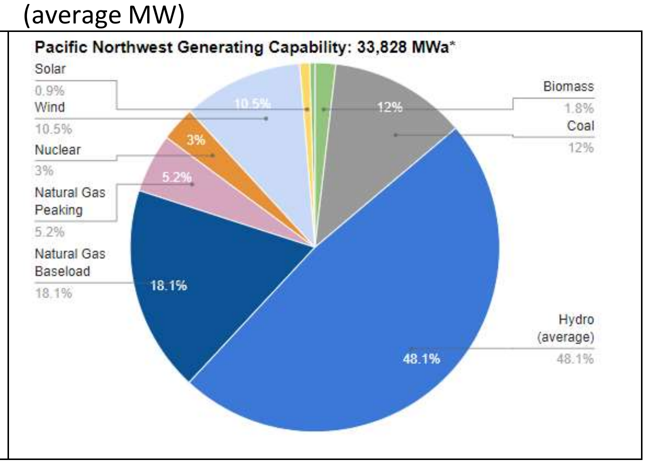


Figure G - Existing PNW generating capability[18] (average MW)



[16] https://www.nwcouncil.org/2021powerplan_defining-region

[17] Figures F - I (4 Figures total) Northwest Power and Conservation Council https://www.nwcouncil.org/2021-power-plan-technical-information-and-data

[18] The installed nameplate capacity of the system describes the manufacturer rated output of the generator. While a useful parameter, generators rarely run at full output at all times. Rather, by defining the average resource capability, we are describing the typical expected output that the generator could produce. This takes into account realistic discounts such as an estimated annual capacity factor for variable energy resources, forced outage rates for fossil fueled resources, and scheduled maintenance for nuclear resources (among other examples).

Going forward, coal generation is being retired from the system (Figure H) and new natural gas plant builds are expected to be limited. According to the Northwest Power and Conservation Council, most new generator additions (Figure I) are anticipated to be renewable, utilizing sources of energy like wind and solar to create electricity.

Figure H - Generation capacity additions and retirements

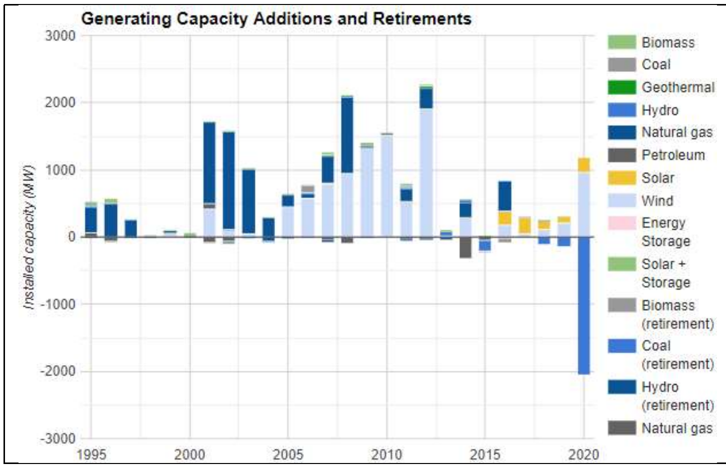
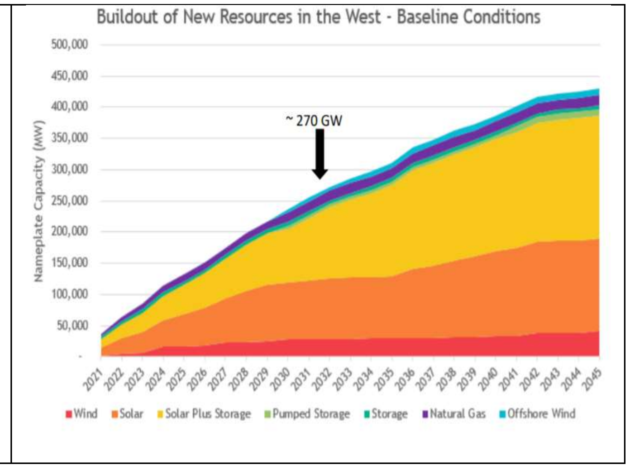
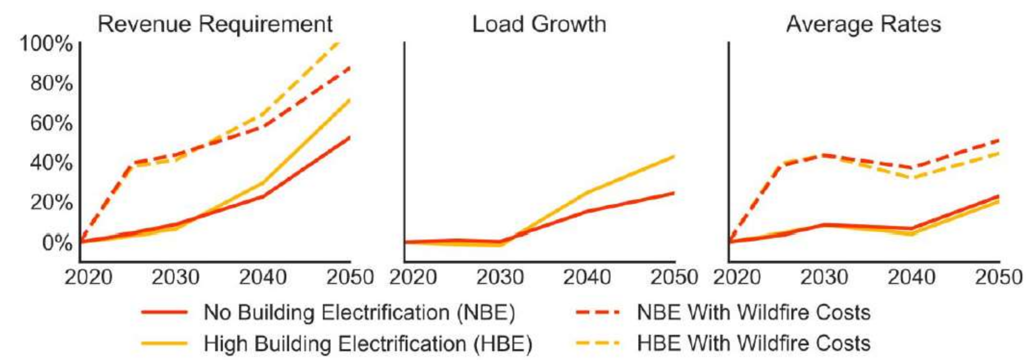


Figure I - Buildout of new resources in the west



The carbon intensity of the electricity sector is expected to decline over time and the rate impact is expected to be moderate. For example, per E3's analysis, California electric rates could increase 20 - 40% by 2050, depending on the scenario, where natural gas rates could increase by 300%.

Figure J – Percentage Increase in Electric Sector Revenue Requirement, On-Grid Loads and Average Rates

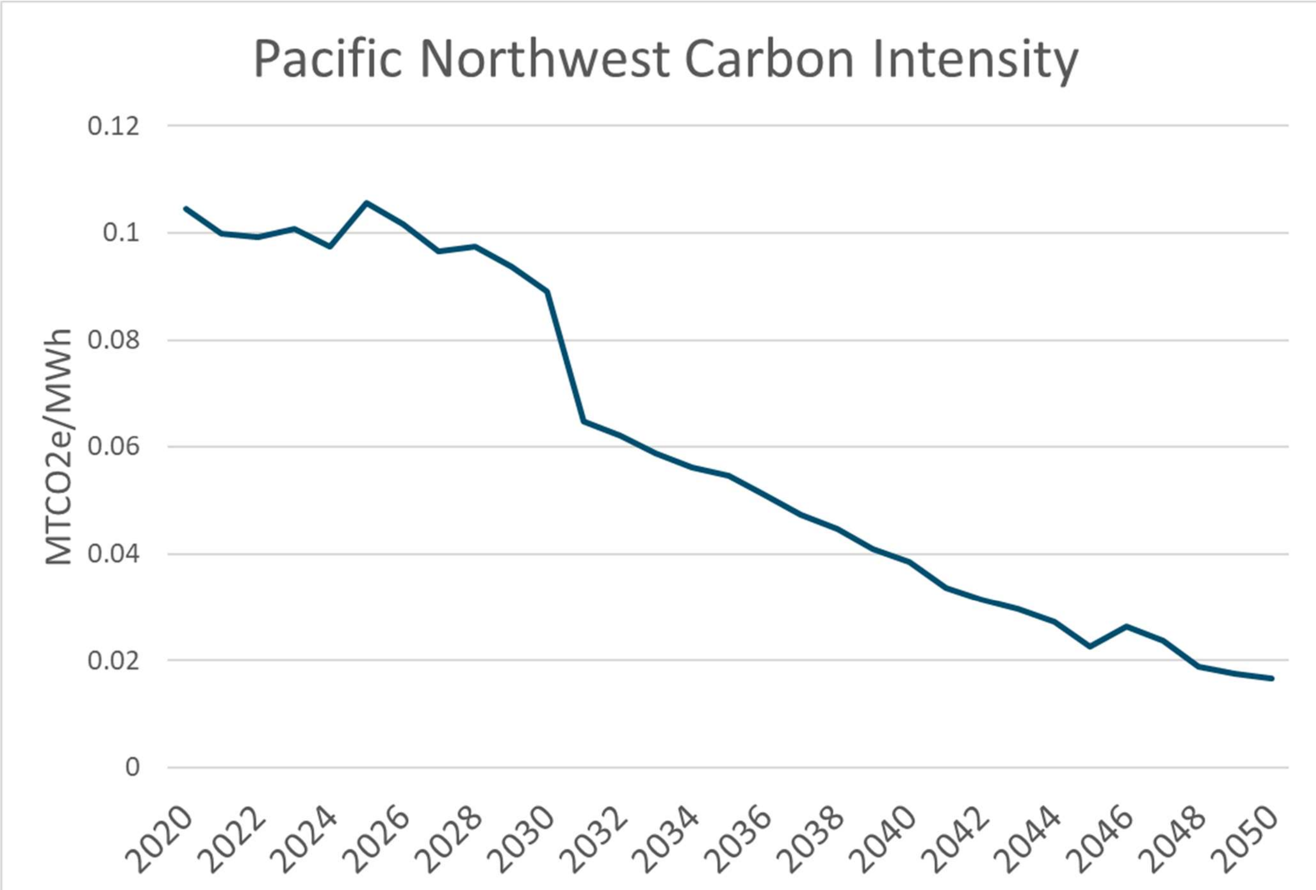


Source: E3

6.4.1 Declining Electric Grid Carbon Intensity

The modeling work performed in Phase 2 of the study utilized E3's modeling of the PNW, which has a lower carbon intensity than the NWPP footprint modeled in Phase 1 of the study. The PNW footprint is smaller and excludes some of the coal generation found in the larger NWPP region. However, the decarbonization trends in both the NWPP and PNW regions are similar, as both anticipate that as coal generation retires, it will be replaced by renewable electric resources. This is driven by legislative influences as well as the declining cost of solar and wind generation.

Figure K below shows the modeled PNW Carbon Intensity declining over time.



6.4.2 Electricity Supply Challenges

This transition to higher levels of renewables in combination with retirement of coal and other dispatchable resources creates new challenges for the electricity sector. The high build-out of solar generation is expected to present intra-day net load ramping challenges similar to those seen in California that will be increasingly difficult to manage. Dispatchable resources like hydro and natural gas will be important to integrate increased renewable, variable generation. Climate change is presenting new operational challenges to utilities with more volatility in customer demand as well as infrastructure challenges due to extreme weather and fire risks. In addition, adding new electrification load will put strain on existing generation, transmission and distribution assets. Significant electrification would impact the timing and amount of peak energy use in the region. The Northwest Power Pool (NWPP) is currently engaged in creating a resource adequacy program to help address these concerns. In addition, there has been increased regional discussion of market formation[19] in the West which some believe will be able to help the region better address these new reliability and resource adequacy challenges. However, these solutions will have financial impacts on the electricity supply and could be a threat to any economic benefits of electrification.

[19] https://www.energy.gov/eere/articles/new-doe-report-shows-how-continued-western-state-collaboration-can-support-affordable

7 BASE CASE ASSUMPTIONS & SENSITIVITIES

The next sections of the report present the economic analyses for electrification of light duty transportation and residential/small commercial buildings. These analyses rely on a number of assumptions for the base case (or expected 20-year future scenario). The purpose of this section is to define the key assumptions used throughout the study. Note that some assumptions are discussed in greater detail in the Modeling Sensitivities and Financial Impacts (Section 10).

7.1 GENERAL ASSUMPTIONS

- **Inflation** is assumed to be 2% throughout the study period.
- All perspectives assumed a **discount rate** of 5%. In some benefit/cost analysis, participants are assumed to have higher discount rates compared to ratepayers and participants due to higher borrowing costs. However, for the purpose of this benefit/cost analysis and simplicity staff have chosen to use the same discount rate for all perspectives.
- **Transmission & distribution losses** are assumed to be 7%.
- No electrical **panel upgrade costs** were assumed for the Base Case and Aggressive Carbon Reduction (ACR) scenario. However, this was tested as a sensitivity assuming average panel upgrades would cost $2,000 for any electrification measure.
- The study excludes the influence of existing **EWEB incentives** in the benefit/cost analysis. However, Federal and State tax incentives for EV adoption were included.

Electricity Rate Increases
For the EWEB participant perspective, EWEB's electricity rates are assumed to increase 3% on average throughout the study period in the base case. For the ACR scenario, a 6% annual rate increase was assumed to reflect increased electricity supply costs.

Electricity Supply Costs – Energy
The EWEB ratepayer perspective assumes that load growth due to electrification will be met with market rate energy. Regional energy markets are assumed to continue to reduce carbon content to very low (but non-zero) levels by 2050. **Marginal energy costs** are modeled in Aurora[20] on an hourly basis. Modeled marginal energy costs range between $15-$33/MWh on average. However, peak pricing can be much higher than average., The maximum marginal energy price modeled in a single hour was $311/MWh. Staff modeled a 100% increase in the assumed hourly energy costs as a sensitivity for the EWEB Ratepayer perspective.

Electricity Supply Costs – Other
EWEB's existing **Generation Capacity** is assumed to be $16 per kW-year in the base case based on premiums paid for market energy purchases. The high generating capacity cost sensitivity assumes a $90 per kW-year cost, which is roughly the cost of a natural gas combustion turbine generator's capacity.

- **Transmission Capacity** is assumed to cost $24 per kW-year based on BPA's existing network transmission tariffs.

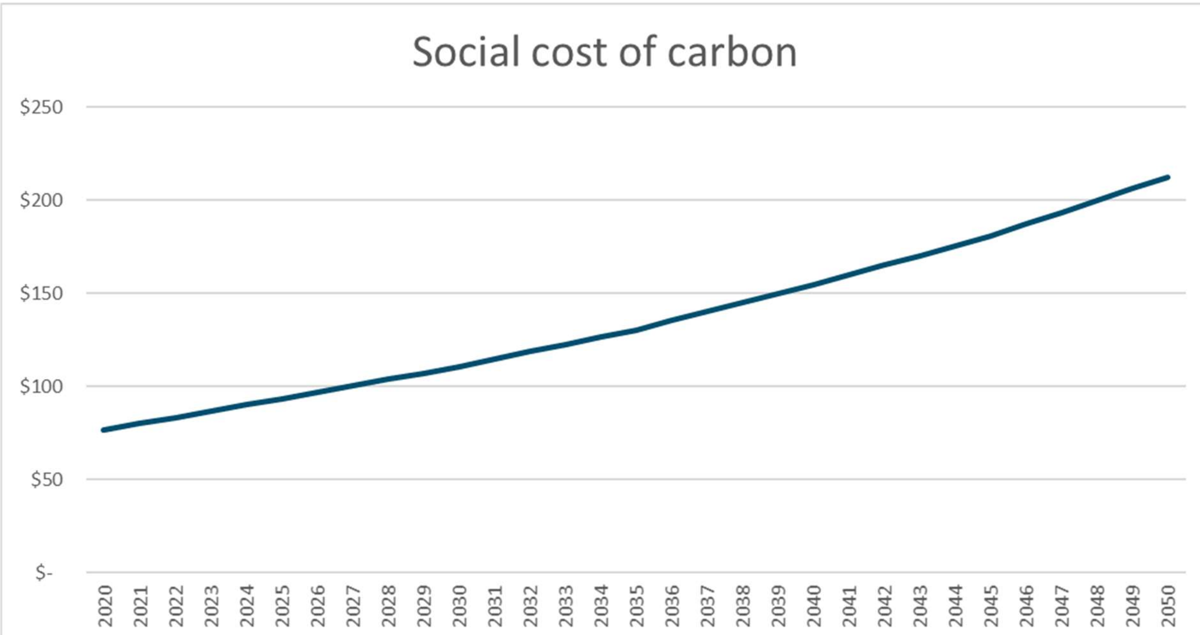
[20] Aurora is electric modeling forecasting and analysis software.

- **Distribution Capacity** is assumed to be $25 per kW-year based on marginal cost estimates for EWEB's existing distribution infrastructure (substations, poles, wires, etc.) and is an average across the system. This system wide average is to recognize that some portions of EWEB's existing system have capacity for growth with no costs, whereas other neighborhoods will require capacity upgrades.

Carbon Emissions Factors

- **Gasoline CO2** = .0087 metric tonne per gallon (Raw Data from GREET 2018)
- **Natural Gas CO2** = 0.005307 metric tonne per therm (Combustion emissions only. Including upstream methane emissions would increase this factor.)

Social cost of carbon based on values for Washington's Clean Energy Transformation Act (CETA)[21]



7.2 Transportation Electrification – Key Assumptions

- Vehicle lifetime is assumed to be 12 years[22]
- Conventional gas vehicles are expected to improve in efficiency over time. EV costs and carbon are calculated relative to the purchase of a new conventional gas vehicle. Conventional gas vehicles are assumed to have 34 MPG in 2021 and improve steadily to 49 MPG by 2040. EV efficiency may improve over time, but that remains uncertain. Therefore, the assumed efficiency of EVs (.31 miles/kWh) is held constant over time.
- Future gasoline prices were derived from the 2021 Energy Information Administration Annual Energy Outlook (EIA AEO) Pacific region forecasts. The base case assumes mid-level of gasoline price increases over time, which is approximately 4% on average.
- Home and Workplace Charging efficiency (Level 1 & 2) = 90%

[21] https://www.utc.wa.gov/regulated-industries/utilities/energy/conservation-and-renewable-energy-overview/clean-energy-implementation/social-cost-carbon
[22] https://ihsmarkit.com/research-analysis/average-age-of-cars-and-light-trucks-in-the-us-rises.html

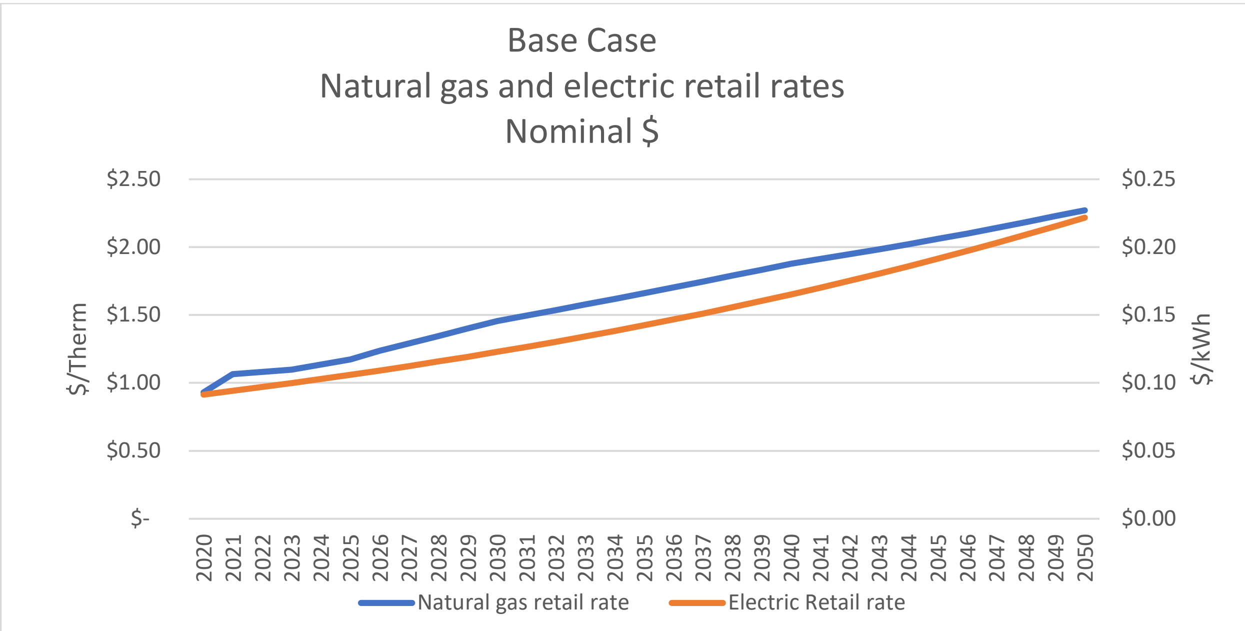
- Home Charging Access: 34% Level 1, 40% Level 2, 26% no home charging access.
- DC Fast Charging Efficiency: 85%

7.3 Building Electrification – Key Assumptions

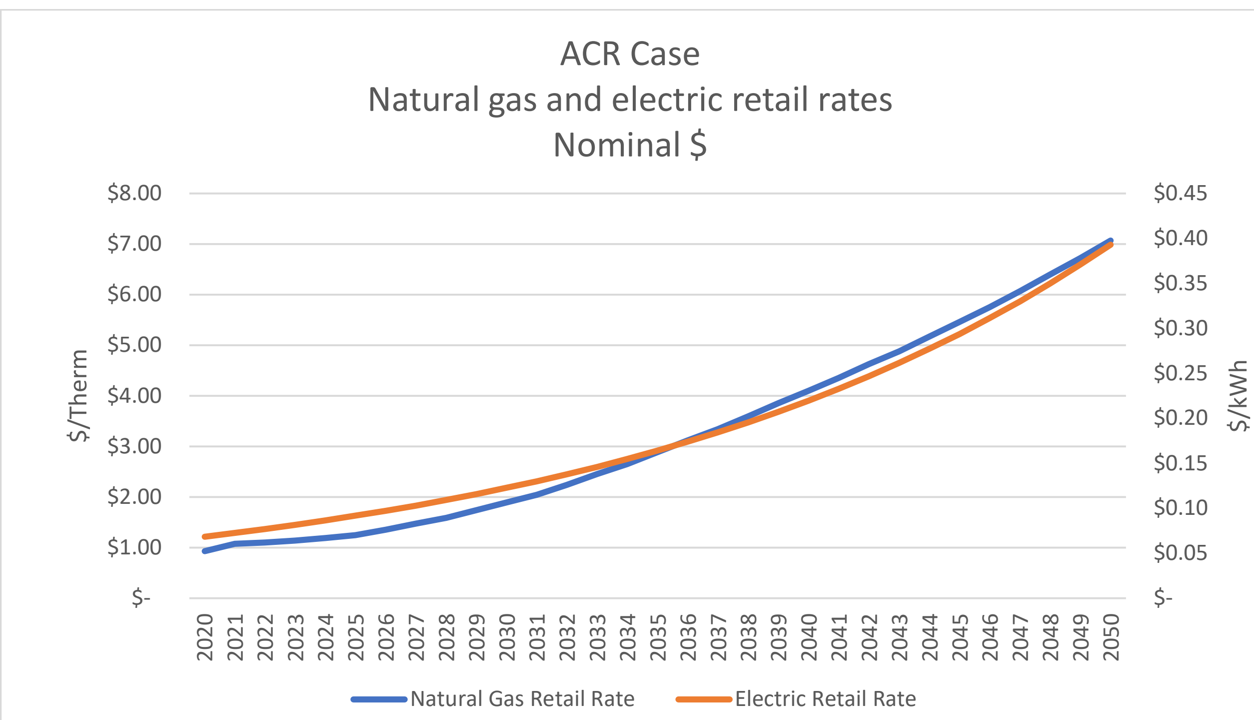
- Water heater lifetime: 10 years. Space Heater (heat pump/furnace) lifetime: 16 years.
- Single family dwelling (SFD) is assumed to be a 2,500 square foot (sq ft), 2-story detached home. Multi-family (residential) is assumed to be a 3-story, residential building containing 24 units with 1,400 sq ft. of space per unit. Small office (commercial) is assumed to be a 5,500 sq ft single story building, with average occupancy of about 28 people.
- The study assumed a 4.5-ton heat pump for SFD and 2.5-ton heat pump for MFD. Small office heat pump cost was assumed to be equivalent to 5 heating/cooling zones, each with a 3-ton heat pump unit (15 tons total). All Water heating units are assumed to be 3 tons.
- This study focuses on retrofit of existing natural gas buildings. New devices are installed at existing device end-of-life.
- For both HVAC and water heating, the model compares "like-for-like" replacement with a gas appliance. Heat pump HVAC unit is assumed to replace both gas furnace and air conditioner. Because spaces heated with natural gas utilize ducting, only ducted heat pumps were studied. However, ductless systems or "mini splits" offer a similar electrification opportunity as the ducted, cold-climate heat pumps studied.
- By default, the model assumes that the existing air conditioning (AC) is not fully depreciated at furnace expiration in the retrofit. Thus, only 50% of a new AC cost is considered "avoided" in the electrification process.
- Equipment and installation costs are based on cost estimates from the environmental and engineering firm AECOM and benchmarked against data from the Energy Trust of Oregon.
- Hourly labor rate for HVAC / water heater installation in Eugene based on data from the Bureau of Labor Statistics.
- In the Base Case, Renewable natural gas blend is assumed to be 15% RNG by 2030 and 30% by 2050, based on Oregon Senate Bill 98. Under the "high" RNG blending sensitivity analysis, it is assumed that the percent of RNG in the natural gas system will increase from 3% today at a consistent rate until it reaches 80% RNG by 2050.
- Retail rates for natural gas will be impacted by the RNG assumptions as well as commidity price forecasts. See the Independent Variables and Scenario Definition section for further details on RNG blening, RNG prices and natural gas commodity pricing.
- Natural Gas Delivery rates are assumed to increase at 2% annually in the Base Case, which is roughly the rate of inflation.
- From the participant perspective, "Avoided Gas Bills" is the avoided costs of natrual gas for the customer including the delivery charges to the customer. The society perspective looks at "Avoided Gas Supply Costs" which is the avoided natural gas commodity costs avoided by the natural gas utility. Because this study is focused on electrification of existing natural gas customers, the natural gas delivery

infrastructure is already built and considered unavoidable in this study. This may be a conservative assumption over time, should Northwest Natural be able to avoid repairs and maintenance costs due to electrification. These delivery infrastructure cost would be fully avoidable in new buildings, which would increase the societal benefits of going "all electric" in new buildings. However, new building electrification is outside the scope of this Phase 2 analysis.

- The overall impact of these assumptions is that natural gas prices (rates) and electric prices were estimated to annually escalate at similar rates in the Base Case (approximately 3-4% per year).



- In the ACR scenario, natural gas prices (rates) were estimated to annually escalate at slightly higher pace compared to electric prices (6.6% for natural gas and 6% for electric, annually).



8 Transportation Electrification Base Case Findings

HIGHLIGHTS

- While federal and state incentives help provide benefits to EV purchases today, the benefits of owning an EV are expected to dramatically improve by 2030, even as incentives go away.
- EVs provide benefits for owners, ratepayers, and society.
- Economic analysis indicates that EV adoption will rapidly increase after 2030, with nearly 85% of all vehicles on the road being electric by 2040.
- Phase 2 of the study estimates a lower coincident peak of EV charging (1 kW per EV) compared to Phase 1 of the study due to increased levels of off-peak workplace and public charging in the future.
- By 2040, Eugene’s total carbon emissions could be reduced by 38% due to EV adoption.

In Phase 2 of this study, the benefits and costs of purchasing an electric vehicle (EV) were quantified and analyzed from EWEB participant, EWEB ratepayer, and society perspectives. This analysis was performed over a 20-year future time horizon to understand how the economic value of purchasing an electric vehicle is expected to change over time. As the cost of battery technology and the efficiency of EV manufacturing improves, the purchase price of an EV is expected to decrease over time.

Figure L – Vehicle purchase prices over time as forecasted by the ICCT

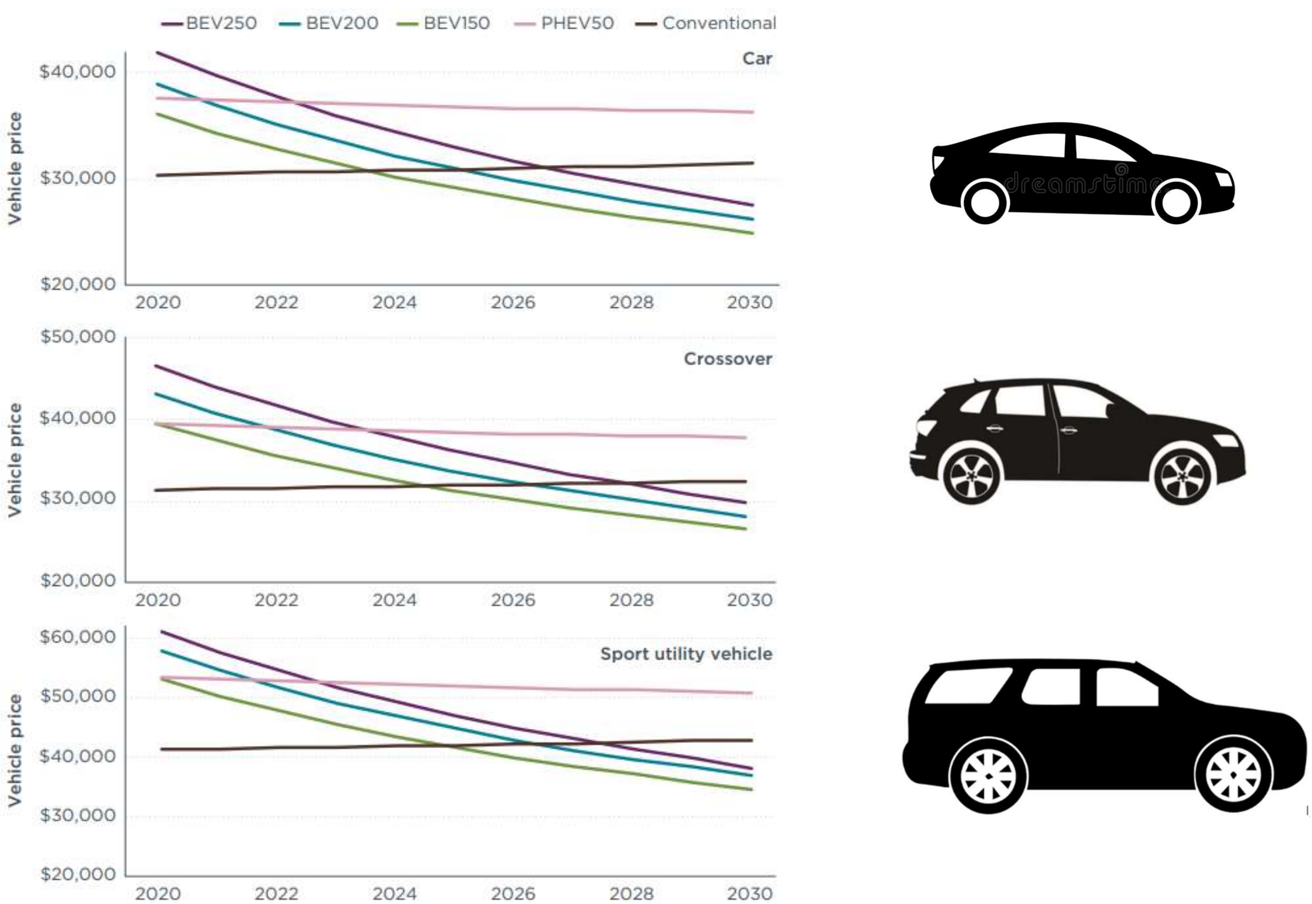
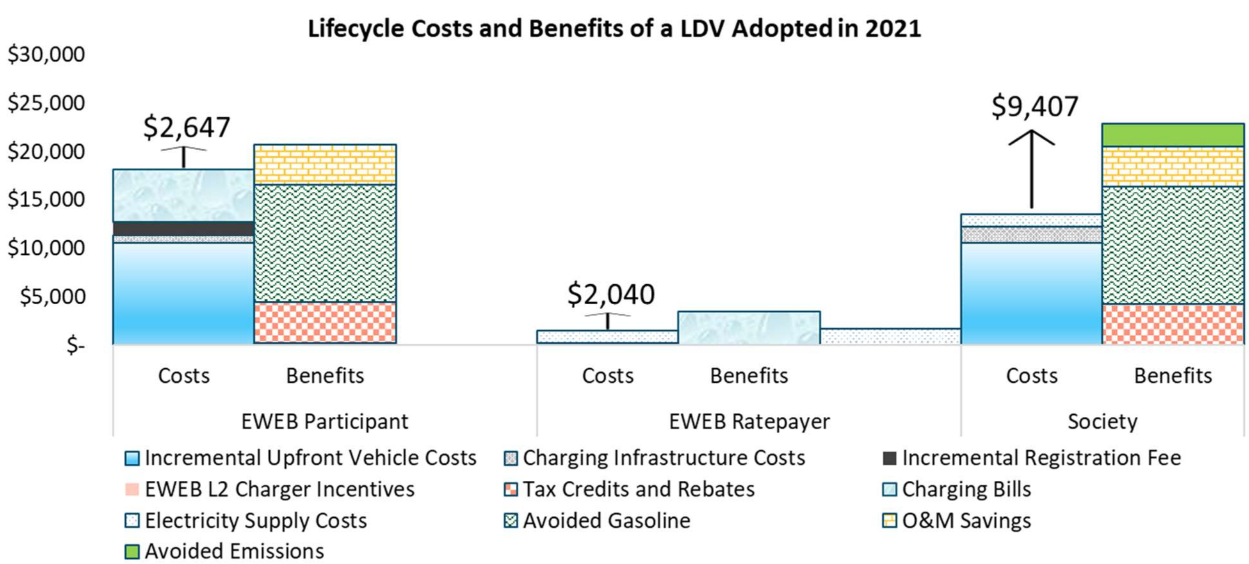


Figure L, above[23], from the International Council on Clean Transportation (ICCT), compares the forecasted purchase price of EVs, at various battery sizes[24], with the forecasted price of conventional gas vehicles. As shown in Figure L, all battery electric vehicles, regardless of size or vehicle type, are expected to become cheaper than conventional cars before 2030. Declining purchase price projections is a key component of the benefit-cost analysis and one of the largest drivers of forecasted EV adoption. Figure L shows that unlike EVs, PHEVs are not anticipated to reach cost parity with conventional vehicles, primarily due to their smaller battery sizes and need for both electric and combustion engine components. While pricing forecasts vary, with some studies showing faster or slower cost reductions compared to the ICCT trajectory, this electrification analysis assumes that projected cost reductions are achievable at the pace shown in the ICCT study.

Incentives play an important role address current price disparities between EVs and conventional vehicles. Federal tax credits (up to $7,500) are available for certain models of electric vehicles, but the number of qualifying vehicles is currently limited to 200,000 per manufacturer. For example, EVs made by Tesla no longer qualify for federal tax credits because Tesla vehicle sales have surpassed this cap. The Oregon Clean Vehicle Rebate Program offers a cash rebate for Oregon drivers who purchase or lease an EV and is set to run through January 2, 2024. The standard $2,500 rebate is limited to vehicles with a battery capacity of 10 kWh or more. A $1,500 rebate is offered for vehicles with a battery capacity less than 10 kWh. In all cases a vehicle must have an MSRP less than $50,000 to qualify. Oregon also offers the Charge Ahead rebate, which is an additional rebate (up to $2,500) that participants can receive based on income qualifications. EWEB offers incentives (up to $500) for Level 2 charger installation. Due to the uncertainty of future incentives, EWEB's benefit-cost analysis included only the incentive programs available today. Given incentive program limitations, it is assumed that only a portion of current incentives would be applicable to the average EV purchase (accounting for some vehicles not qualifying).

A discounted cash flow of costs and benefits for an EV adopted in 2021 under base case conditions is presented in Figure M, below, from the perspective of the EWEB participant, EWEB ratepayer and society.

Figure M - Benefit/cost Analysis of a Light Duty Vehicle adopted in 2021



[23] From Update on electric vehicle costs in the United States through 2030 https://theicct.org/sites/default/files/publications/EV_cost_2020_2030_20190401.pdf

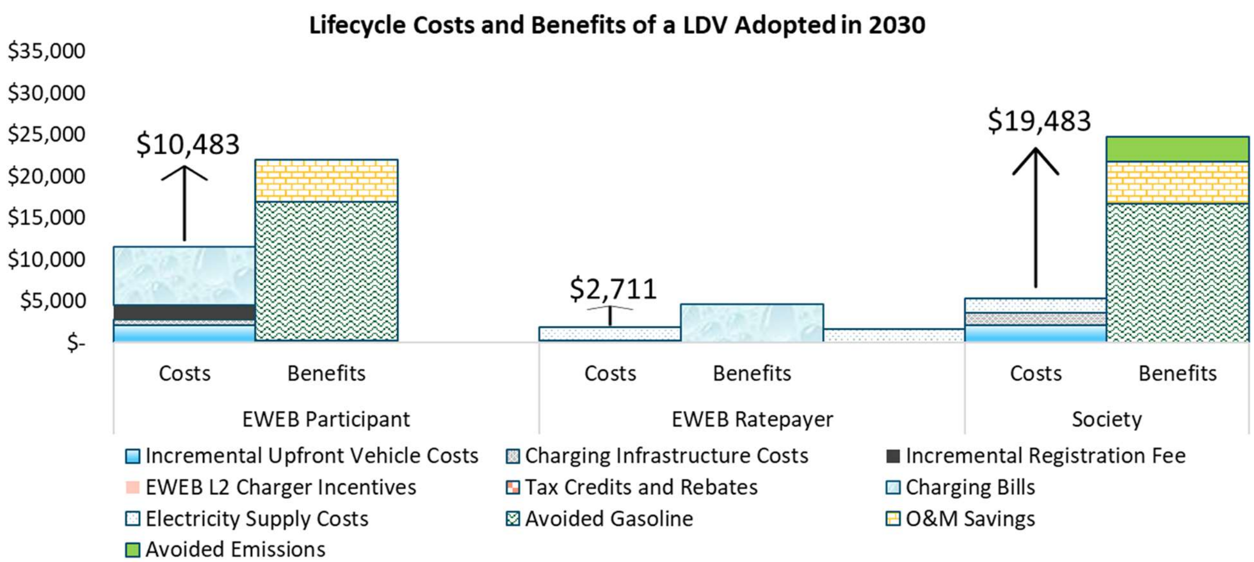
[24] The series names in the chart correspond with the potential vehicle range based on battery size. For example, BEV150 is a Battery Electric Vehicle with an assumed range of 150 miles. PHEV50 is a plug-in hybrid with 50 miles of range.

The base case assumes moderate increases in both gasoline and EWEB electricity rates over time (3-4% on average). Overall, the purchase of an EV presents a benefit to the EWEB participant, EWEB ratepayer and society on a net present value (NPV) basis.

In 2021, Federal tax credits and Oregon rebates are one of the primary reasons that there is a net present benefit to the EWEB participant. Without these incentives, purchasing an EV would become a net cost to the EWEB participant. From the EWEB ratepayer perspective, the adoption of an electric vehicle presents more than twice the net benefit received by the EWEB participant. The EWEB ratepayer benefit is primarily realized through the increased sales of electricity to the EWEB participant, the proceeds of which could be used to cover the fixed costs of the utility, reduce rates, pay for distribution infrastructure investments, or fund additional incentives for EV adoption. The society perspective shows the benefits from the other two perspectives and adds an additional benefit of $2,300 for carbon reduction. The NPV of carbon reduction is estimated using the social cost of carbon[25] multiplied by the annual emission savings over the vehicle life. Annual emissions savings are calculated by subtracting the carbon emissions associated with EV charging (based on a future year's electric grid carbon intensity) compared to a new gasoline vehicle's efficiency (MPG efficiency is assumed to improve over time in the study period).

By 2030, the net benefit of purchasing an EV is expected to gradually increase for the EWEB participant, EWEB ratepayers, and society. This increase is primarily driven by the projected declines in EV purchase price. These calculations assume that State and Federal incentives phase out before 2030. In Figure N, below, the benefit-cost calculations are shown for purchasing an EV in 2030.

Figure N - Benefit/cost Analysis of a Light Duty Vehicle adopted in 2030

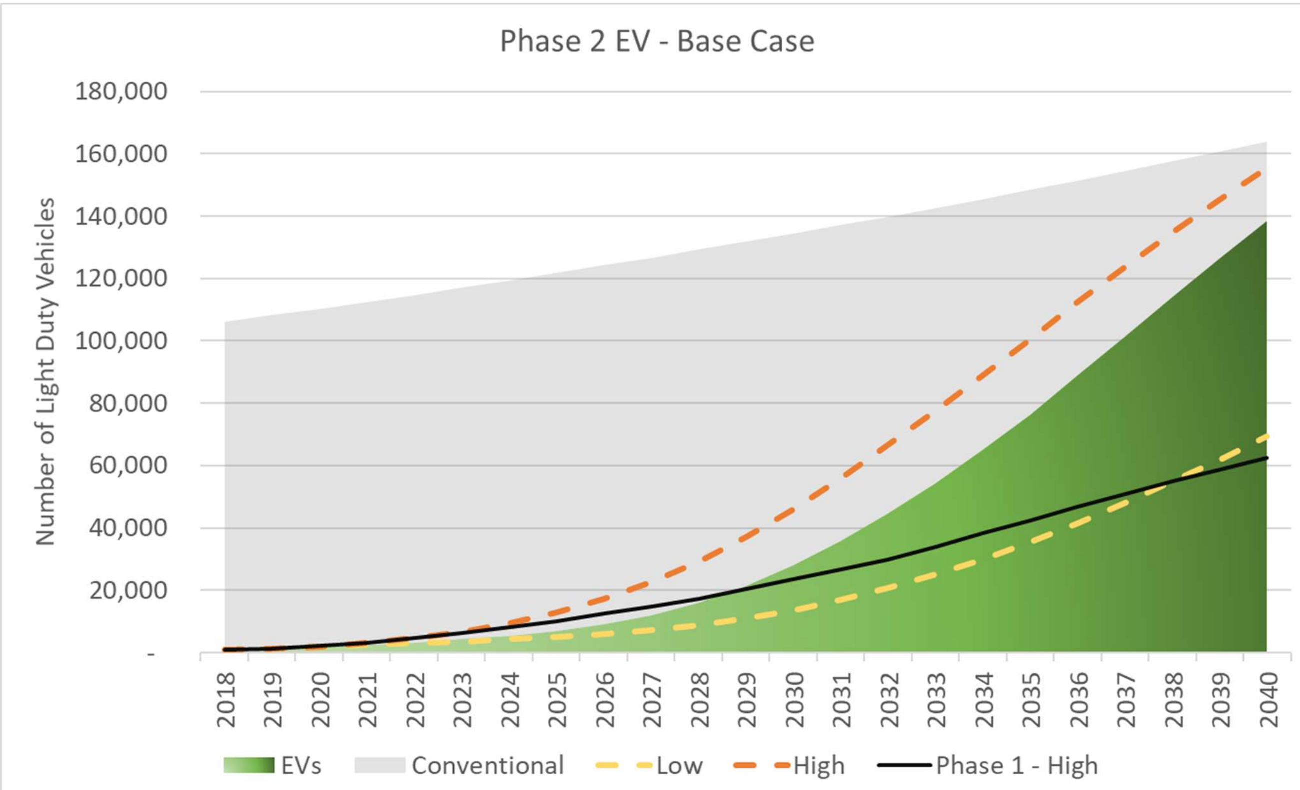


The incremental upfront costs for purchasing an EV are expected to decline from $10,500 in 2021 to approximately $2,000 in 2030. This forecasted decline in upfront costs, combined with projected annual

[25] To estimate the value of emissions reductions, the model used the social cost of carbon as adopted in the Washington Clean Energy Transformation Act and adjusted for an assumed inflation rate of 2%. The resulting social cost of carbon forecasted prices from $80/MTCO2e in 2021 to $155/MTCO2e in 2040. https://www.utc.wa.gov/regulated-industries/utilities/energy/conservation-and-renewable-energy-overview/clean-energy-implementation/social-cost-carbon

savings[26] leads to a steady improvement in the simple payback period for EVs (declining from 6 years simple payback in 2021 to only 2 years in 2030). Based on this improved simple payback period, the pace of EV adoption is expected to rapidly increase as the EV market matures[27]. Assuming the cost reductions projected are realized, this leads to much higher estimated EV adoption compared to Phase 1 of the electrification study published last year.

Figure O – Adoption forecast for EVs over time



The updated EV adoption forecast, shown in Figure O above, is represented by the green shaded area. To illustrate how sensitive the pace of EV adoption can be to forecast inputs, high and low trend lines were added in orange and yellow, respectively. The high trend line assumes the EV market matures two years faster than the base case, and the simple payback period of purchasing an EV improves over time. The low adoption trend line assumes a market maturing two years slower than base case and that the simple payback period in 2021 remains constant for the next 20 years. These adoption trends consider the economic benefits of EV adoption but are not adjusted for legislative influences which can accelerate or delay adoption of EVs.

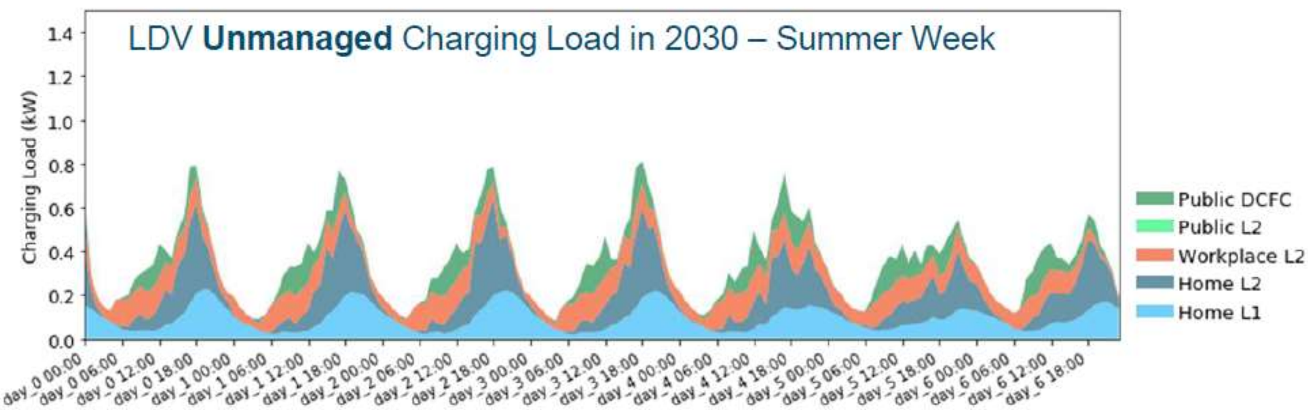
In the base case scenario, EWEB's adoption model estimates that in 2021 approximately 60% of customers would purchase an EV based on the simple payback analysis under "mature market" conditions. However, EVs only account for 2-3% of new car sales today, which implies that the market maturity for EV's remains a major constraint to EV adoption. Examples that the EV market still needs time to mature include lack of broad EV offerings (crossovers, SUVs, and pickups), battery range anxiety, low dealer EV inventory, and lack of customer awareness of the financial benefits of EVs in general. As EV availability and marketing improve, the market will mature to the point where there are fewer barriers for potential EV customers. At this time, many of the large

[26] Annual savings associated with EV ownership come primarily from fuel savings (electricity fueling costs lower than gasoline costs) and reduced operations and maintenance costs.
[27] See Vehicle Manufacturer Trends section for further discussion of market maturity.

vehicle manufacturers are committing to increased or even 100% electric offerings within the next 15 years, which indicates that the market will continue to mature over time.

8.1 Energy Impacts of EV Adoption

EWEB worked with E3[28] to incorporate more advanced modeling of charging behavior into Phase 2 of the electrification analysis. The model assumed drivers would choose the least cost charging options available to them, while also considering driving patterns, availability of home and workplace charging, and a forecasted mix of battery sizes. Utilizing these variables, E3 simulated a variety of charging profiles in the year 2030 (halfway through the study period) and scaled the load to a single vehicle. The chart below represents the unmanaged charging load at the scale of a single light-duty vehicle (LDV), but with the collective profile and mix of charging locations across an entire population of drivers.

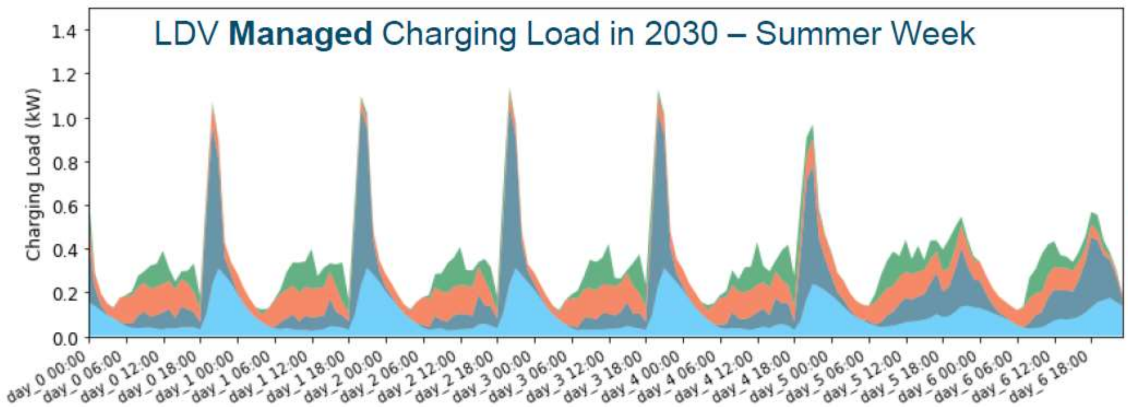


In Phase 1 of the electrification study, staff utilized a 2018 NREL charging behavior simulation to estimate the load shape of EV charging. The NREL study estimated that a single EV would add approximately 1.5 kW to system peak. However, E3's modeled results (above) estimate a lower peak EV load of less than 1 kW per EV. The difference between the studies is driven by E3's assumption of higher levels of workplace and public charging in the middle of the day. E3's model confirms that home charging remains the largest contributor to peak EV load, but the peak impact can be lessened through increased day-time workplace and public charging. This modeling is believed to be more representative of the charging behavior in 2030 as it reflects the reality that some EV drivers will not have access to home charging, or that people who do have home charging will still choose workplace and public charging based on the location of their vehicle throughout the day.

E3 simulated "managed" EV charging behavior to show the potential benefits of shifting EV charging away from EWEB's existing system peaks. This load profile assumes drivers would choose to optimize (find the cheapest solution) for charging their EV given a time of use (TOU)[29] rate. This load profile assumes that even though a customer's electric energy usage has shifted, they're still able to charge enough to complete their trips. Further, the E3 load profile assumes that after a high TOU rate period, customers will stagger vehicle charging start times to avoid a spike in consumption at exactly 10PM each night. As vehicle electrification increases, EWEB may want to develop programs to encourage this staggered charging behavior under a TOU rate structure.

[28] Energy + Environmental Economics - https://www.ethree.com/

[29] Time of use rates are rate structures which incent a customer to change their electric usage patterns, because they typically charge higher prices for consumption during peak periods.



It should be noted that the non-coincident load impact of managed charging is 1.3 kW per EV, which is higher than the unmanaged impact of 1 kW per EV. This is because managed vehicles are intentionally delaying their charging start times until non-peaking periods, to mitigate the impact to EWEB's existing system peak load. In other words, managed vehicle charging load is concentrating in off-peak periods to better utilize existing system infrastructure (a benefit to EWEB ratepayers), whereas unmanaged charging adds to EWEB's existing system peaks. Adding to EWEB's existing peaks will increase the potential need for future transmission and distribution system upgrades (a cost to EWEB rate payers.) Even with a well-managed program, it is assumed that some EV charging will occur during EWEB's peak load periods, which is why managed charging behavior still adds to EWEB's existing system peaks. From a high level, unmanaged charging is approximately double the peak impact of managed charging.

The table below shows the total forecasted change in average energy and peak load (comparing unmanaged and managed charging behavior) given the adoption ranges presented above. The percentage increase shown is based on EWEB's current system average load of 270 MW and a 1-in-10 peak of 510 MW.

2030	Low	Base Case	High	% Increase
Average	6 aMW	12 aMW	19 aMW	2-7%
Unmanaged Peak	13 MW	27 MW	43 MW	3-8%
Managed Peak	7 MW	15 MW	24 MW	2-5%

2040	Low	Base Case	High	% Increase
Average	29 aMW	57 aMW	64 aMW	11-24%
Unmanaged Peak	68 MW	131 MW	147 MW	14-29%
Managed Peak	40 MW	77 MW	86 MW	8-17%

Under a high EV adoption scenario, the Phase 2 peak energy impacts are 18% higher than estimates provided in Phase 1 high scenario and these impacts happen 10 years sooner (by 2040). This is due to increased levels of anticipated EV adoption, which is partially offset by the lower peak impact, per EV, derived from E3's advanced charging behavior model. Managed charging behavior significantly lowers the overall peak impact to the utility but requires coordination and greater diversification of charging locations to achieve. EWEB will need to work with customers in the coming years to know when and where to charge to avoid system peaks. Location diversity can be achieved through expanded investments in public and workplace charging infrastructure.

Currently, EWEB offers residential and commercial charging station incentives as well as education materials and workshops about the importance of charging during off-peak times[30]. New EWEB programs are being rolled out that support investments in EWEB-owned charging infrastructure (including DC Fast Charging), expanded EVSE

[30] http://www.eweb.org/residential-customers/going-green/electric-vehicles/ev-incentives

Infrastructure rebates (like multi-family EVSE), and electric mobility rebates (including e-bikes). In addition, staff are developing programs to expand access to EV technology through an affordable housing EV sharing pilot and electric mobility community grants.

8.2 EVs and Carbon Reduction

The City of Eugene's Climate Action Plan 2.0 estimated that annual carbon emissions from the transportation sector were 532,000 MTCO2e in 2017 (over 50% of total emissions[31]). Adjusting for the improved efficiency of gas engines over time, as well as the continued decline in carbon emissions from the regional electric grid, it is estimated that EV adoption could reduce transportation sector emissions by 14% by 2030. If the rapid transition to EVs continues after 2030, the annual transportation sector emissions could be reduced by 73% by 2040. Under base case conditions, these carbon reductions could happen nearly a decade earlier than was shown in Phase 1 of the electrification study.

	2030	**2040**
Number of EVs – Base Case	28,000	130,000
Estimated Annual Carbon Savings	(74,000 MTCO2e)	(390,000 MTCO2e)
% Carbon Reduction - Transportation Sector	14%	73%
% Carbon Reduction – Total Emissions[32]	7%	38%

9 Building Electrification Base Case Findings

HIGHLIGHTS

- Heat pump equipment for space and water heating has a higher upfront cost when compared to natural gas equipment.
- Economic analysis indicates minimal space heating electrification and moderate levels of water heater electrification by 2040.
- Base Case building electrification is estimated to increase average and peak energy use by less than 1% by 2040. Of the technologies studied, cold climate heat pumps have greatest carbon reduction potential, but have the lowest likelihood of adoption due to high upfront costs.

9.1 Background

Electrification of buildings is a key component to a comprehensive de-carbonization strategy. Removing or replacing the usage of fossil-based fuel (primarily natural gas) for space and water heating eliminates most of the greenhouse gases directly emitted by buildings. During Phase 1 of the electrification study, staff examined the impacts from three electrification scenarios that were based on fixed adoption percentages (10%, 50%, and 80% unitary adoption rates). This was an effective means to understand a wide range of potential impacts for energy, demand, and carbon reduction caused by switching from fossil-based fuels to electric end uses. While insightful, the Phase 1 analysis lacked economic grounding and wasn't helpful in understanding the likelihood of building electrification. In the absence of a legislated mandate to fuel switch, interest in building electrification

[31] Transportation is 53% of emissions using market-based accounting method for 2017. City of Eugene Climate Action Plan 2.0 - https://www.eugene-or.gov/4284/Climate-Action-Plan-20
[32] Total City of Eugene Cap 2.0 Market-based emissions in 2017 was 1,013,600 MTCO2e

will likely be governed by financial constraints. As such, the Phase 2 analysis examines adoption rates of various space and water heating technologies based on the economics of consumer choice.

The economics of building electrification were analyzed using three different assumed building types: single family dwellings (SFD), Multifamily Dwellings (MFD) and Small Office. The Small Office economic analysis is a small subset of the total commercial sector (about 7%), whereas SFD and MFD buildings are considered residential sector. It is estimated that there are approximately 16,300 SFDs and 3,900 multi-family units served by natural gas today (electrification opportunities). Electrifying SFDs is relatively simple, as natural gas space and water heating systems can generally be replaced with like-for-like electric equipment choices (like ducted heat pumps and heat pump water heaters).

The path to commercial electrification is more complex than the residential segment because commercial end use of natural gas is generally more varied. Only small office buildings share similar equipment replacement options like those found in the residential sector. As such, commercial segment electrification will require a broader range of equipment to be studied, with unique economic factors, which are beyond the scope of this phase of the study. As such, only the Small Office segment of the commercial sector will be analyzed in this economic analysis.

For space heating, customers have multiple electric technology options to consider when replacing existing natural gas technology. In addition, many homes with natural gas heating have separate air conditioning units (cooling load for EWEB today). As such, both space heating and space cooling needs were considered in the analysis.

The space and water heating technology options considered in this study include:

Space Heating Equipment	Modeled Efficiency (Single-family)	2021 installed cost[33] (Single-family)
Gas Furnace	80 AFUE	$4,800
Split Air Conditioner	10.8 EER, 2-speed	$6,100
Ducted Standard performance heat pump	12.5 EER (cooling), 8.5 HSPF (heating), 2-speed, 32° shut-off	$9,800
Ducted Cold Climate Heat Pump	13 EER (cooling), 10.5 HSPF (heating), variable, 5° shut-off	$16,400
Dual-fuel Heap Pump	Standard HP + Gas Furnace	$11,000

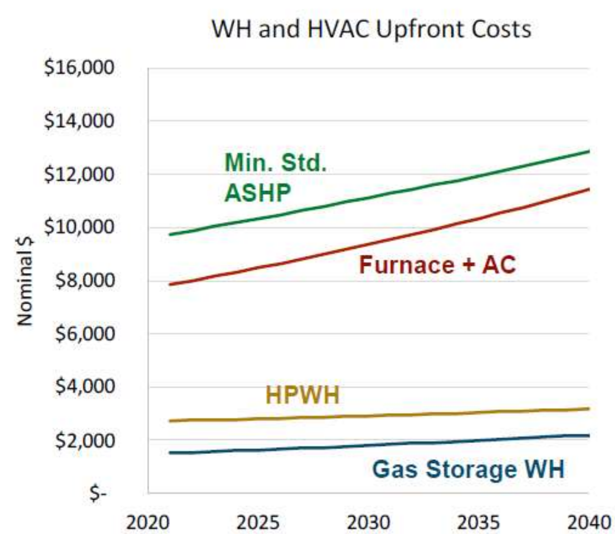
[33] Equipment and installation costs are based on cost estimates from AECOM and benchmarked against data from the Energy Trust of Oregon. The study assumed a 4.5-ton heat pump for SFD and 2.5-ton heat pump for MFD. Small Office heat pump cost was assumed to be equivalent to 5 heating/cooling zones, each with a 3-ton heat pump unit (15 tons total). All Water heating units are assumed to be 3 tons.

It should be noted that during this phase of the study, staff did not analyze the potential use of ductless heat pumps or "mini-splits" as a replacement technology for natural gas heating. While ductless heat pumps will likely be installed in specific electrification applications, it is more likely that a customer will choose to swap out their ducted natural gas furnace with another ducted electric or dual fuel solution. The same inverter-driven, variable speed compressor technology used in mini-split systems is used in cold climate heat pump technology and is included in this analysis. Customers choosing to electrify with ductless systems may have similar characteristics to the cold climate heat pumps modeled in this study. If a customer's needs can be met with a more affordable ductless system, then electrification may be more financially beneficial for that customer.

Water Heating Equipment	Modeled Efficiency (Single-family)	2021 installed cost[34] (Single-family)
Gas Storage[35]	0.6 Uniform Energy Factor (UEF)	$1,500
Heat Pump Storage	3.5 Energy Factor (EF)	$2,700

9.2 Upfront Equipment Cost Over Time

Standard air-source heat pumps have matured over the last few decades with proven reliability and efficiency standards. It is anticipated that over time, there will be only slight improvements in the cost competitiveness of heat pump equipment due to improvements in the technological learning curve or efficiencies gained through additional production scaling efforts. Equipment cost are roughly 50% of the total upfront cost of new space and water heating installations. The remaining upfront cost includes things like dealer markup, installation/ fabrication labor, electric labor, other parts and materials, and administrative overhead. Because the equipment itself is approximately half of the total cost, the anticipated cost improvements over time are muted. Unlike EV's, where the technology is still in early development, electric choices in space and water heating are more mature and unlikely to become cheaper than their gas counterparts.



In the chart to the right, minimum standard air source heat pump (ASHP) prices increase at a slower pace relative to gas furnace combined with air conditioning. Heat pump water heaters (HPWH) are also projected to remain more expensive than a gas storage water heater.

[34] Equipment and installation costs are based on cost estimates from AECOM and benchmarked against data from the Energy Trust of Oregon.

[35] Gas storage water heaters utilize a tank to hold the heated water. This technology is much less expensive than on-demand (tankless gas water heaters).

9.3 Other Economic Influences

9.3.1 Air Conditioning Unit Depreciation

This study assumes that existing natural gas customers have heating and cooling energy use and that the air conditioning (AC) unit is only 50% depreciated at furnace end-of-life. For example, the combined cost of an air conditioner ($6,100) and gas furnace ($4,800) in 2021 is $10,900 whereas a standard performance heat pump is assumed to cost $9,800 (an upfront savings of $1,100). However, because this study focuses on the retrofit of existing natural gas buildings, it is assumed that only 50% of the air conditioner cost can be avoided ($3,050) when electrifying, which makes an electric heat pump have a higher upfront cost relative to a gas furnace and AC unit combined. However, some customers do not currently have air conditioning. Thus, customers who are looking to replace their furnace, are looking to purchase an AC unit for the first time, or their existing AC units are at end of life will likely see greater value if they choose to electrify with a heat pump instead.

9.3.2 Rebates and Incentives

The benefit/cost analysis performed in the study does not include the influence of incentives or rebates. For residential customers, EWEB offers energy efficiency upgrade rebates for ductless ($800) and ducted ($1,000) heat pumps. These HVAC rebates are also available to natural gas customers looking to electrify. Commercial EWEB customers can also qualify for $350 per ton heat pump rebates if they are electrifying[36]. Northwest Natural offers new and existing natural gas customers incentives towards natural gas appliances, but they are subject to certain eligibility requirements[37]. EWEB currently offers an $800 incentive for heat pump water heaters and Northwest Natural offers a $500 rebate for natural gas water heaters[38]. These incentives can play an important role in the benefit/cost analysis for customers, but the qualification process can make it difficult to model across a larger population of customers. Further, these incentives can serve as a tool for utilities to influence customer choice as well as address inequity. For example, it is common to offer higher incentives to LMI customers. Incentive programs and rebates will be important tools that can change the baseline economics studied in this report and can be used to influence the pace and likelihood of electrification.

9.4 Base Case – Building Electrification

9.4.1 Benefit-Cost Analysis – Residential SFD

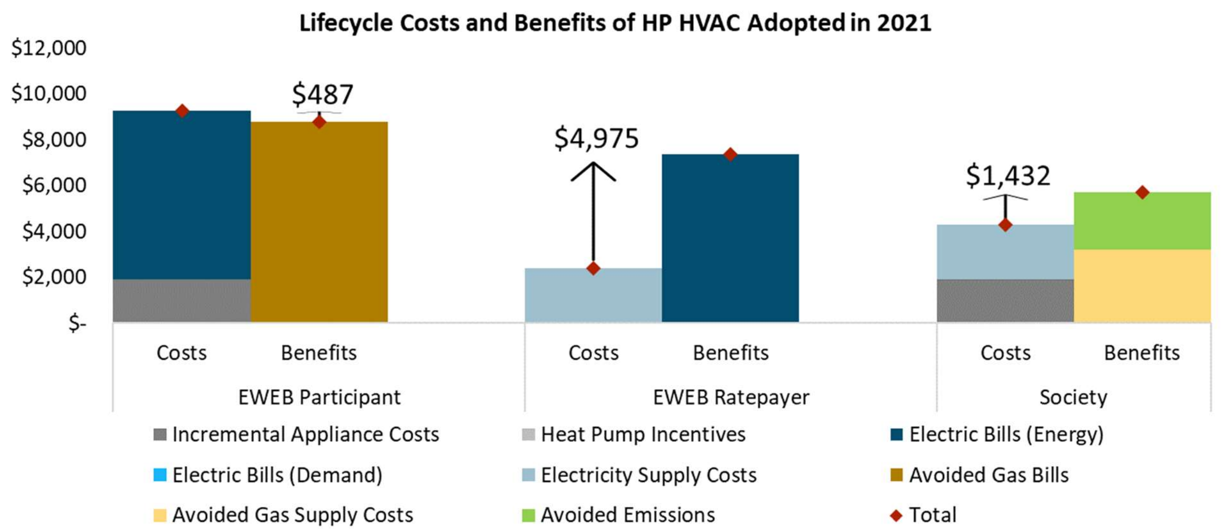
For the base case, electrification has a positive benefit from the EWEB ratepayer perspective, but the benefits for the participant and society are neutral to slightly negative. The table below summarizes the Benefit-Cost Ratio of an electrification measure by stakeholder group in both 2021 and 2030. A Benefit-Cost Ratio represents the Benefits divided by the Costs. A ratio greater than 1 indicates that benefits outweigh costs, which results in a positive economic outcome from the perspective studied. The results are presented in a heat map showing green with the highest net benefits and red with no net benefit (i.e., net cost). The society perspective is often a net cost because EWEB participants who choose these electric technologies are experiencing net costs which outweigh the monetized carbon reduction benefits.

36 http://www.eweb.org/business-customers/rebates-loans-and-conservation/hvac-systems-rebates
37 https://www.nwnatural.com/ways-to-save/rebates-offers
38 https://www.nwnatural.com/ways-to-save/rebates-offers/water-heater-offer

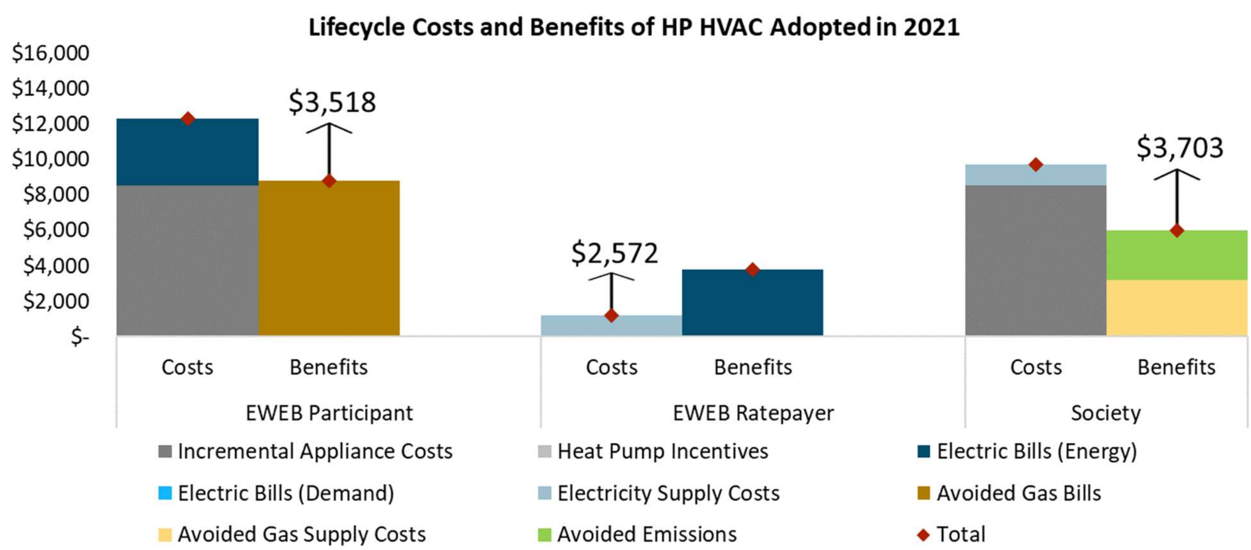
	Residential SFD Benefit-Cost Ratio (without EWEB incentives)					
	2021			2030		
Technology:	EWEB Participant	EWEB Ratepayer	Society	EWEB Participant	EWEB Ratepayer	Society
Standard HP	0.9	3.1	1.3	1.0	3.1	1.6
Cold Climate HP	0.7	3.1	0.6	0.8	3.2	0.8
Dual Fuel	0.9	3.7	1.1	1.0	3.8	1.5
Heat pump WH	0.8	2.8	0.7	1.1	2.7	1.0

For context, the benefit/cost Calculations (which are the underlying analysis for the benefit/cost Ratios) for 2021 are shown below. Note all perspectives assume a discount rate of 5%.

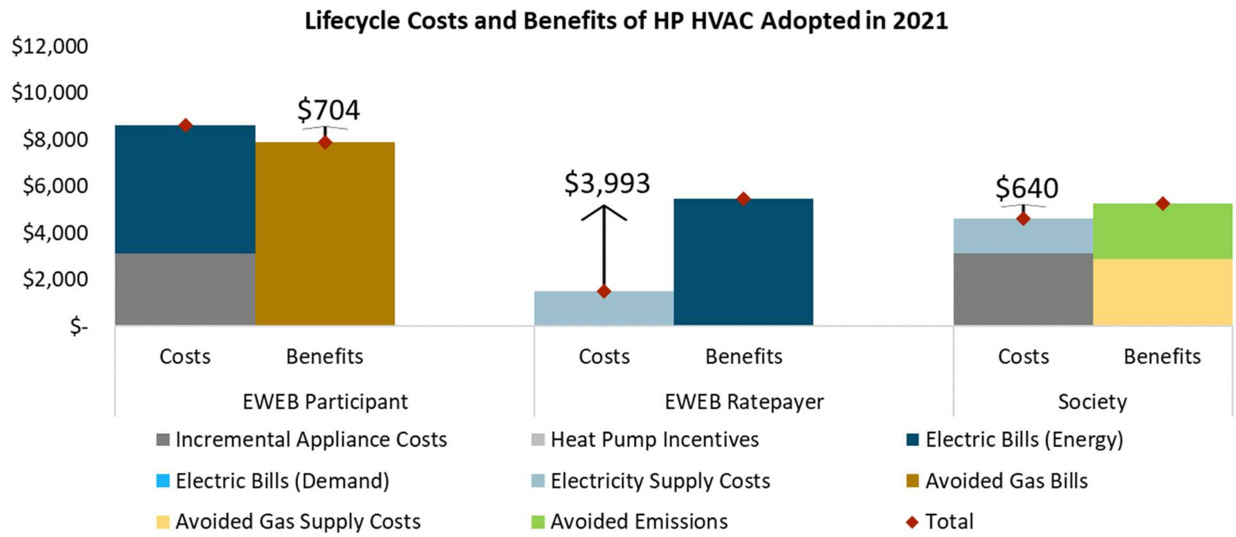
SFD – Standard Performance Heat Pump 2021



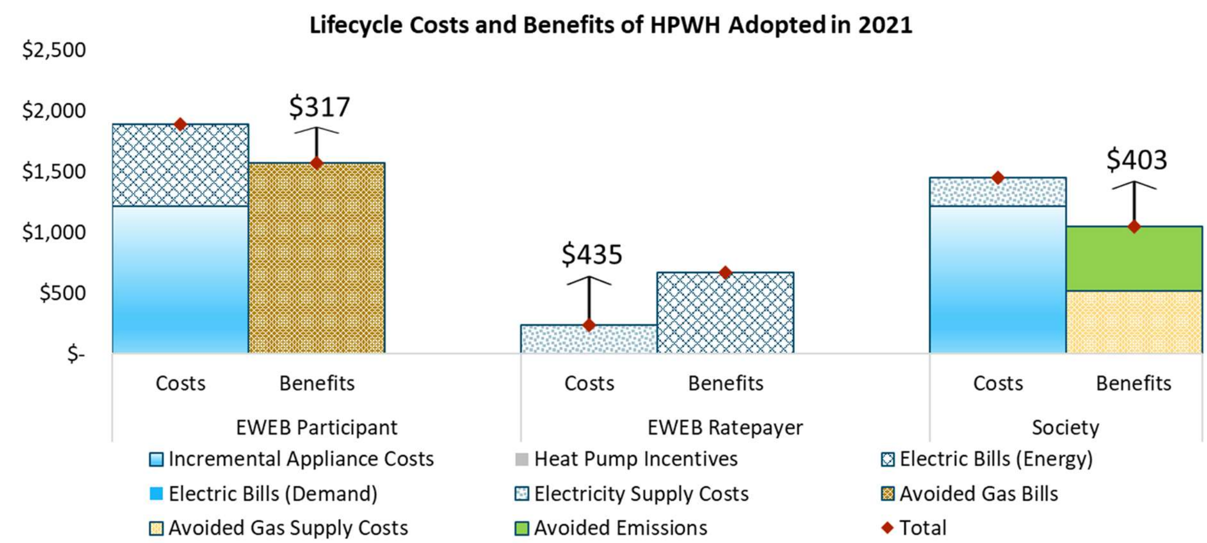
SFD – Cold Climate Heat Pump 2021



SFD – Dual Fuel Heat Pump 2021



SFD – Heat Pump Water Heater (HPWH) 2021



9.4.2 Impact of EWEB's Residential incentives[39]

Incentives can be an important influence over the economics of electrification. Below is a table illustrating benefit-cost ratios including EWEB energy efficiency incentives.

Heat pump water heaters currently have an $800 incentive from EWEB which represents a net benefit to the EWEB participant, but a net cost to the EWEB ratepayer. A $317 heat pump water incentive would represent a breakeven point between EWEB ratepayers and the EWEB participant perspective (i.e., both perspectives would have a benefit-cost ratio of 1).

EWEB currently offers a $1,000 energy efficiency incentive for residential ducted heat pumps that meet higher energy efficiency standards. The modeled standard heat pump does not qualify for the incentive, but the cold

[39] Information regarding EWEB residential incentives and program eligibility can be found at: http://www.eweb.org/residential-customers/rebates-loans-and-conservation

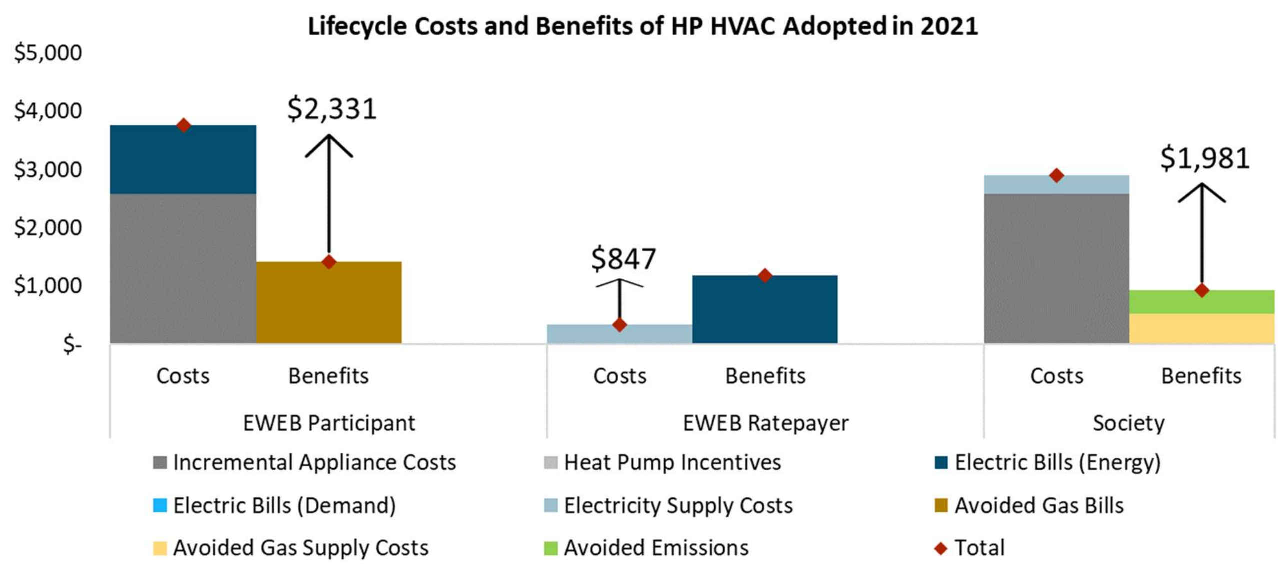
climate heat pump modeled in this study would qualify. While the incentive improves the benefit-cost ratio, it does not bring the cold climate heat pumps benefit-cost ratio above 1. There is no breakeven point at which both the EWEB participant and the EWEB ratepayer can have a benefit-cost ratio of at least 1 for cold climate heat pumps as studied.

	Benefit-Cost Ratio (with EWEB incentives[40])					
	2021			2030		
Technology:	EWEB Participant	EWEB Ratepayer	Society	EWEB Participant	EWEB Ratepayer	Society
Standard HP	0.9	3.1	1.3	1.0	3.1	1.6
Cold Climate HP	0.8	1.7	0.6	0.9	1.9	0.8
Dual Fuel	0.9	3.7	1.1	1.0	3.8	1.5
Heat pump WH	1.3	0.6	0.7	1.5	0.8	1.0

9.4.3 Benefit-Cost Analysis – Residential Multifamily Dwelling (MFD)

MFD have lower energy consumption than SFD, which makes it more difficult for MFD to recover the upfront costs of electrifying through annual energy savings. All the space heating electrification measures studied were a net cost to the participant, making electrification unlikely.

The benefit/cost Analysis below is for MFD electrification with a Standard Performance Heat Pump.



[40] Note EWEB incentives are influenced by BPA energy efficiency programs as well as other factors.

The heat map below summarizes the benefit/cost Ratios for all measures studied for Multifamily Dwellings.

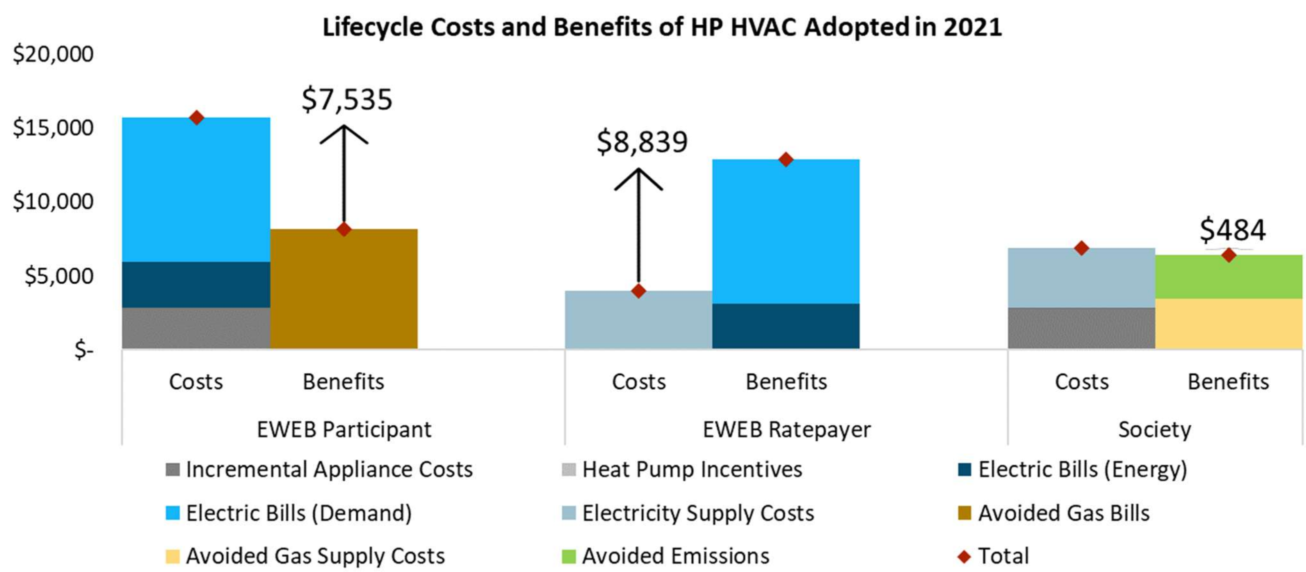
	Residential MFD Benefit-Cost Ratio (without EWEB incentives)					
	2021			2030		
Technology:	EWEB Participant	EWEB Ratepayer	Society	EWEB Participant	EWEB Ratepayer	Society
Standard HP	0.4	3.5	0.3	0.5	3.6	0.4
Cold Climate HP	0.2	2.5	0.1	0.2	2.5	0.1
Dual Fuel	0.3	3.7	0.2	0.4	3.8	0.3
Heat pump WH	0.8	2.8	0.7	1.1	2.7	1.0

Again, the key reason for the lack of participant benefit is the comparably smaller energy use of MFD compared to SFD. This makes it more difficult for MFD annual energy savings to offset the upfront costs of electrifying.

9.4.4 Benefit-Cost Analysis – Small Office (Commercial)

Small Office properties can utilize similar space and water heating technology to the residential heat pump technology included in this study. The commercial segment has different electric rates than residential customers and has a demand Charge[41] which is designed to send a peak pricing signal to commercial customers. Unfortunately, electrification is likely to add to the Small Office's existing peak load which would increase the electricity costs for that customer. While this rate design may send useful signals to commercial customers to reduce their peak energy use, it may also be a deterrent to commercial electrification. EWEB may consider alternative rate designs to encourage electrification in this sector.

The benefit/cost Analysis below is for a Standard Performance Heat Pump electrification for a Small Office property.



Note the large demand charges that commercial customers would receive over the heat pump lifetime because of electrification.

[41] EWEB's Small General Service (Commercial) Demand Charge is for peak kilowatt usage during the billing period. It is set on the highest consumption of power required in any 15-minute period during the billing period. http://www.eweb.org/business-customers/commercial-pricing

The heat map below summarizes the benefit/cost Ratios for all measures studied for Small Office buildings.

	Small Office Benefit-Cost Ratio (without EWEB incentives)					
	2021			2030		
Technology:	EWEB Participant	EWEB Ratepayer	Society	EWEB Participant	EWEB Ratepayer	Society
Standard HP	0.5	3.2	0.9	0.6	3.2	1.3
Cold Climate HP	0.3	3.0	0.3	0.4	3.1	0.4
Dual Fuel	0.7	2.6	0.9	0.8	2.7	1.3
Heat pump WH	0.2	1.9	0.1	0.2	1.8	0.2

Dual Fuel Heat Pumps (DFHP) would be much more beneficial for customers wanting to avoid the higher demand charges for peak energy use. However, the Phase 2 economic analysis indicates that even DFHP electrification has a benefit/cost ratio below 1. For Dual Fuel HP, there is a small breakeven point where both Ratepayers and Participants can be beneficiaries through an incentive. For Small offices, the incremental cost of a DFHP is approximately $4,000 greater than a comparable natural gas system in 2021. If there was a $4,000 incentive to offset this upfront cost, both the Participant and Ratepayer Benefit/Cost Ratio would be slightly above 1. Standard Performance Heat Pumps do have a breakeven point with an $7,500 incentive, but this incentive is much larger than the upfront equipment cost of $2,900.

9.4.5 Simple Payback Analysis

Simple payback is a leading indicator of consumer adoption. An example of a simple payback calculation for a residential water heater adopted in 2021 is shown in Figure P, below.

Figure P – Simple payback period calculation for SFD heat pump water heater in 2021

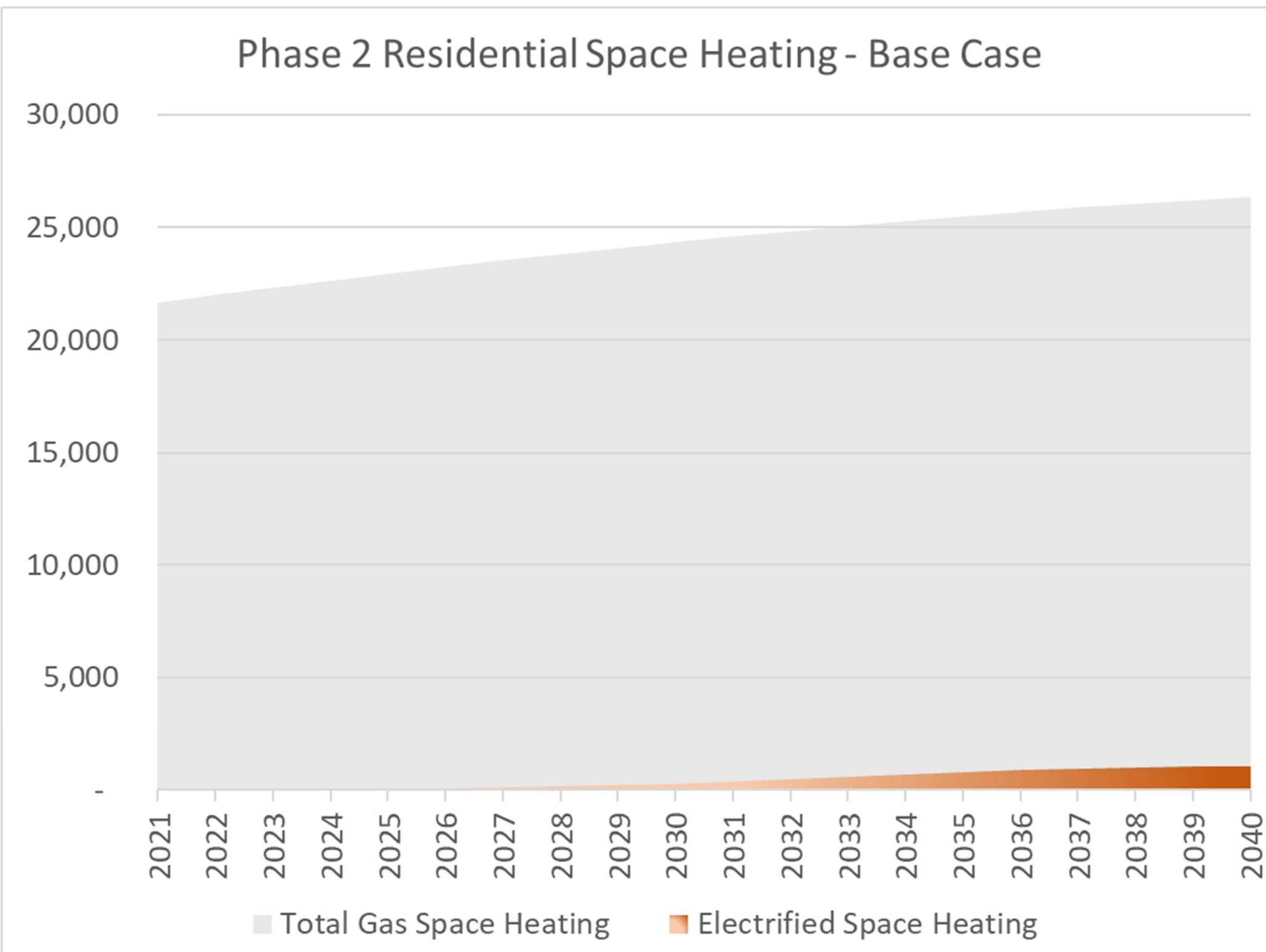
Residential Heat Pump Water Heater			
Total Costs			
Incremental Upfront Water Heater Costs	$	1,215	
Utility Incentive	$	-	
Total	**$**	**1,215**	
Total Opearting Cost Savings			
Avoided Gas Bills	$	1,969	
Increased Electricity Bills	$	(842)	
Annual Average	**$**	**113**	
Simple Payback Period		11	*Years*

The table below shows the simple payback periods (in years) for SFD space and water heating electrification technologies.

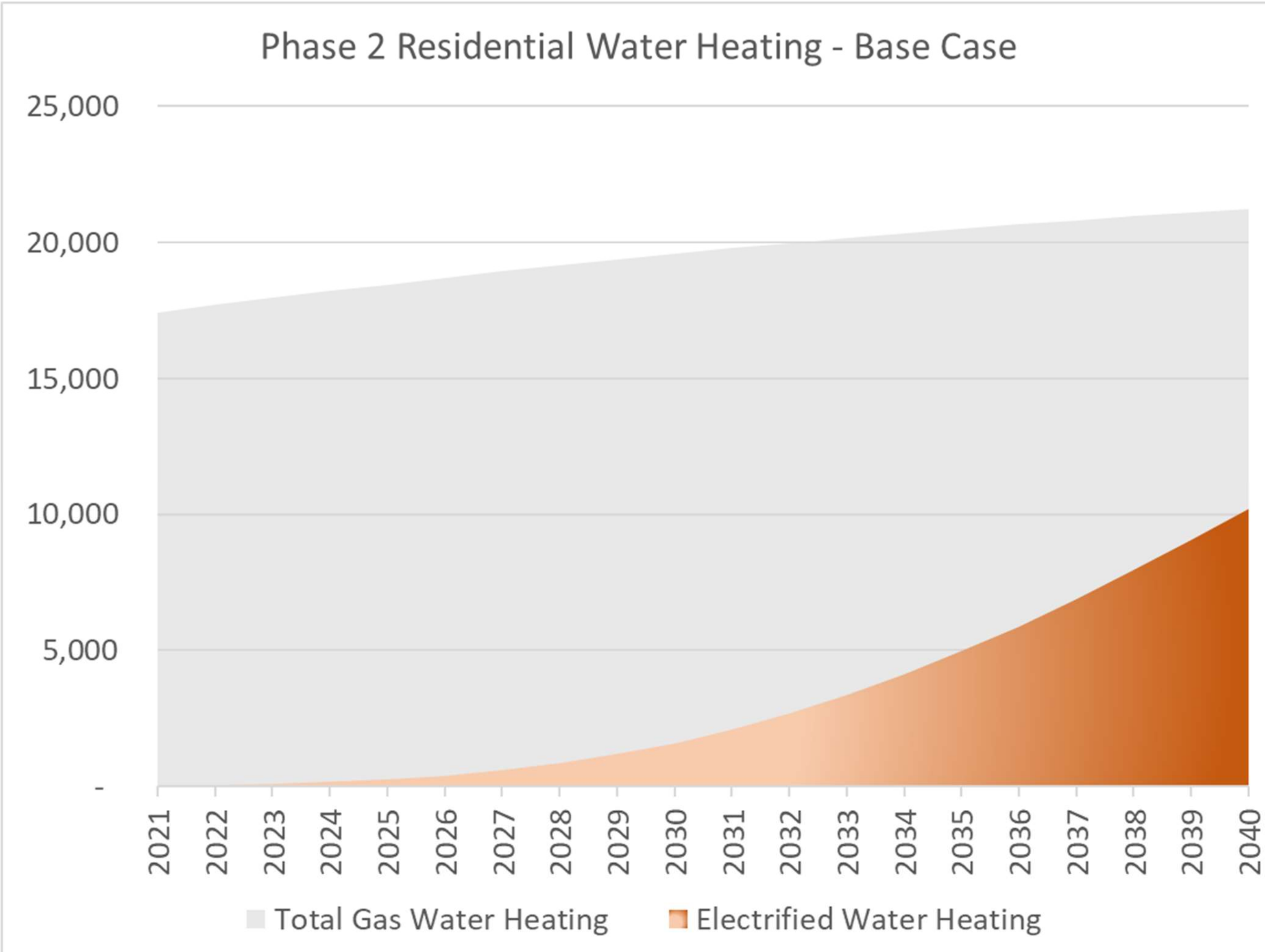
		Simple Payback		Simple Payback (with incentive)	
		2021	2030	2021	2030
Technology:	Assumed useful life	Base Case		Base Case	
Standard HP	16	14	11	Does not qualify	
Cold Climate HP	16	19	16	16	14
Dual Fuel	16	14	11	Does not qualify	
Heat pump WH	10	11	7	4	2

9.4.6 Adoption modeling based on simple payback

The life expectancy for a HVAC heat pump is assumed to be 16 years on average. In the base case, the simple payback analysis indicates that the initial heat pump investment will generally take more than 10 years to pay off for the customer. Using adoption modeling based on simple payback, these long simple payback periods significantly reduce the estimated number of customers who will choose to electrify. Therefore, there is very little electrification of space heating anticipated by 2040 under base case assumptions.



The life expectancy for a heat pump water heater is 10 years. Based on simple payback, the base case (without incentives) indicates by 2040, we would expect about 11,000 gas water heaters to convert to heat pump water heaters (roughly 50%). This is primarily driven by the improvements in the cost competitiveness of heat pump water heaters compared to natural gas water heaters over time.



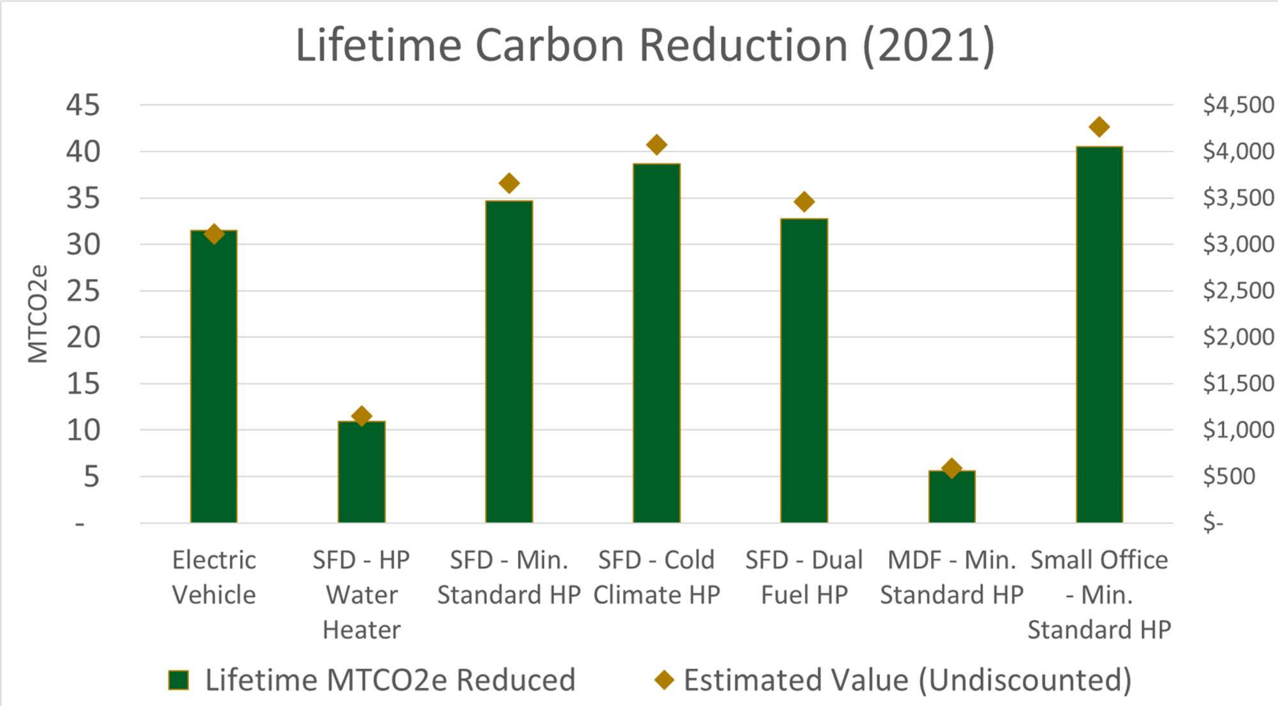
The adoption forecasts in the Base Case for space and water heating would have minimal levels of energy impact to the utility. Space heating electrification is unlikely and water heating is a relatively small energy use.

Base Case building electrification is estimated to be less than a 1% increase in average and peak energy use by 2040.

9.5 Base Case - Carbon Savings

Under Base Case assumptions, all the electrification measures studied can reduce carbon emissions over the equipment lifetime. For Space heating, technology choice can play a role in the total carbon savings associated with electrification. Figure Q below illustrates the lifetime carbon emissions that could be avoided by each electrification measure if it were adopted in 2021. This assumes the average carbon intensity for market rate electricity used to serve electrification load.

Figure Q



Electric vehicles are assumed to have a useful life of 12 years and space & water heating equipment are assumed to have useful lives of 16 years. Given the long useful life, the carbon reduction potential for EVs and space heating equipment is meaningful. Water heating and multifamily dwelling space heating represent the least carbon savings opportunities due to low amounts of energy use over the equipment life. Conversely, the carbon reductions for Small Office electrification are greater due to higher space heating energy use (compared to SFD space heating).

10 Modeling Sensitivities and Financial Impacts

HIGHLIGHTS

- Electricity prices (rates) are an important variable in the value of electrification. The value of electrifying is maintained so long as electricity rates can increase at a slower pace than fossil-fuel based energy sources.
- Increased blending of RNG is expected to increase natural gas prices, making electrification more appealing for participants.
- Ratepayer benefits of electrification would be reduced by increases in electricity supply costs or generation capacity costs.
- Electric panel upgrade costs can be a deterrent for electrification by adding an average upfront cost of $2,000 in addition to any other upfront costs to electrify.

Many assumptions were used in the modeling of base case results. The purpose of this section is to provide context regarding the sensitivities studied and the relative impact of these variables.

10.1 Independent Variables and Scenario Definition

The following table outlines major variables (sensitivities) and scenarios (groups of sensitivities) analyzed by staff. The sensitivities are also grouped to show whether they impact all electrification measures or a subset, like the building or transportation sectors, exclusively. The two scenarios include a "Base Case" (expected future) scenario, and an Aggressive Carbon Reduction (ACR) Scenario. The ACR scenario considers a future where both electric and fossil fuel energy sources are influenced by policies which prioritize carbon emission reductions and is based on trends and technology that exists today.

	Tested Sensitivity			**Scenarios**	
	Sensitivity 1	Sensitivity 2	Sensitivity 3	Base	Aggressive Carbon Reduction
All Measures					
Annual Electric Rate Increase	1.00%	3.00%	6.00%	3.00%	6.00%
Electric Supply Cost	Low	High		Low	Low
Rate Structure	Existing Flat	TOU		Existing Flat	TOU
Generation Capacity Cost	Low	High		Low	High
Panel Upgrade	No	Yes		No	No
Space and Water Heating					
Natural Gas Commodity Price	Low	Med	High	Med	High
RNG Percent Blend	Low	High		Low	High
RNG Commodity Price	Average	Marginal		Average	Marginal
Heat Pump Cost Reduction*	Low	High		Low	High
Electric Vehicles					
Gasoline Price	Low	Med	High	Med	High
Managed EV Charging	No	Yes		No	Yes

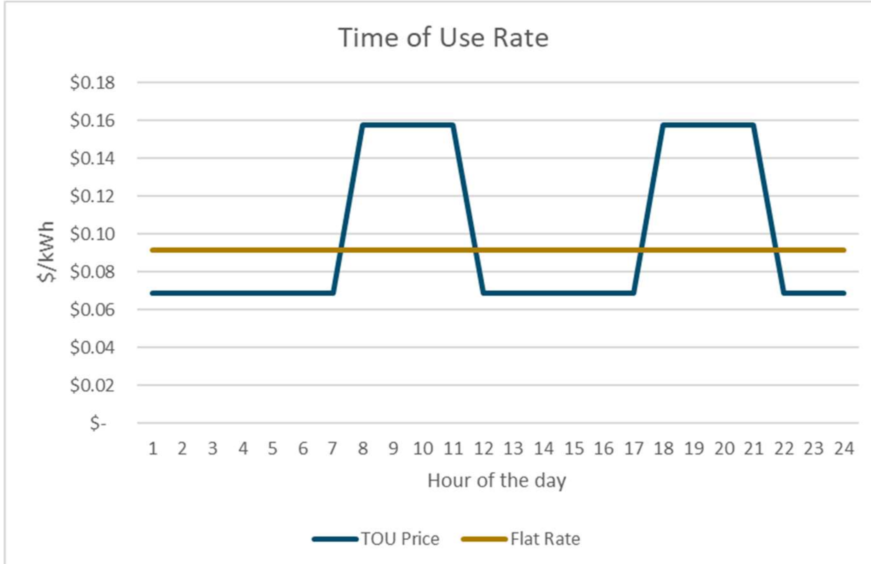
*Reductions in cold climate heat pump manufacturing cost, given increased production maturity

10.1.1 Sensitivity Definitions:

- **Annual Electric Rate Increase:** The relative increase in EWEB's annual electric rates over time. Higher electric prices reduce the economic benefit of electrification to the participant but increases the benefit to ratepayers.

- **Electric Supply Cost:** The assumed marginal cost of electric energy to EWEB. As this cost increases, the benefit to the EWEB Ratepayer diminishes. The low sensitivity is based on an Aurora modeled forecast of spot market values. The high sensitivity assumes the same Aurora modeled forecast for market energy but increased by 100%.

- **Rate Structure:** The design of electric rates, or how EWEB recovers costs, can influence the economic benefit of electrification to the participant. This analysis compared EWEB's current, "flat" rate structure to a Time of Use (TOU) rate structure. TOU rate structures incent the participant to shift consumption behavior by shaping the cost of energy throughout a 24-hour period.



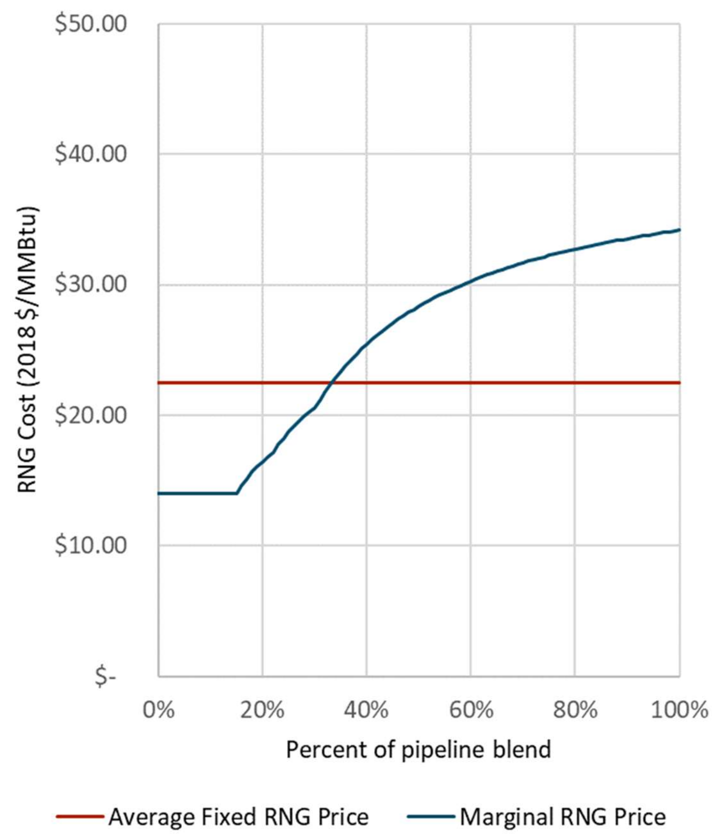
- **Generation Capacity Cost:** The incremental cost of generation used to serve EWEB's capacity needs. What EWEB pays for capacity in the future is unknown, but it will have an impact on EWEB's ability to promote electrification in the future. Higher capacity costs reduce the value of electrification to ratepayers. Today, EWEB's capacity cost are low (assumed to be $16 per kW-year based on market pricing), but it is thought that EWEB's capacity costs could be higher in the future. For this analysis, high capacity costs are assumed to be $90 per kW-year (roughly equivalent to natural gas generator capacity on standby).

- **Panel Upgrade:** Panel upgrade costs increase the upfront cost of electrification over time. A panel upgrade will likely be required in older/smaller homes where the existing electric service was sized to meet the basic space and water heating needs of the time (estimated to be about 12% of all housing units in Eugene). Staff assumed that a panel upgrade would average $2,000 and that it would impact the upfront cost of electrification. A panel upgrade will reduce the economic benefit of electrification to the participant.

- **Natural Gas Commodity Price:** The relative increase in natural gas commodity prices over time. This sensitivity directly impacts the cost of natural gas purchased by the participant. Higher natural gas prices increase the value of electrification to the participant over time.

- **Renewable Natural Gas Percent Blend:** The percent of RNG required for natural gas end use. As natural gas utilities look to decarbonize (either voluntarily or due to carbon reduction policies), they'll likely need to introduce greater amounts of non-fossil based (renewable or synthetic) natural gas into their pipelines. It is assumed that RNG will be more expensive than conventional sources of natural gas, especially as required volumes increase, given limitations in RNG supply. Higher percentages of RNG improve the value of electrification over time due to increased natural gas supply costs.

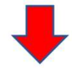
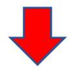
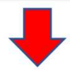
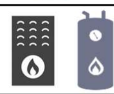
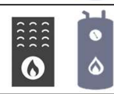
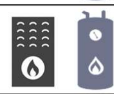
- **Renewable Natural Gas Commodity Price:** RNG costs significantly more than fossil fuel natural gas, which improves the value of electrification over time. The model has two options: Average or Marginal RNG Price. Average assumes a $22.50 fixed cost for RNG throughout the study. Marginal assumes a supply curve of RNG costs that the availability of lower cost RNG will be depleted over time and that supplying greater quantities of RNG will become more expensive over time. The chart to the right illustrates the difference between average and marginal price assumptions.



- **Heat Pump Cost Reduction:** The degree to which manufacturing of heat pump technology improves with maturity (efficiencies of scale). This variable impacts cold climate heat pumps only, as it is assumed that traditional heat pumps are a fully matured technology. This reduces the upfront cost of electrification for the participant for cold climate heat pumps.
- **Gasoline Price:** The relative increase in gasoline prices over time. This measure only impacts vehicle electrification. Higher gasoline prices increase the value of electrification over time.
- **Managed EV Charging:** The existence of utility programs designed to proactively shift vehicle charging away from traditional energy peaks. Load management programs (like managed EV charging) may help to avoid or delay distribution system upgrades.

It should be noted that direct incentives from EWEB ratepayers to participant to electrify were not measured as an explicit variable for this analysis.

The following table illustrates how each variable can impact benefit/cost analysis, for participants and EWEB ratepayers, and can be either an accelerant or deterrent to electrification:

Tested Sensitivity	Impacted Measure	Participant BCA Impact	EWEB Ratepayer BCA Impact	Accelerator/Deterrent
Increasing Annual Electric Rates				Deterrent
Increasing Electric Supply Costs				Deterrent for utility
TOU Rates Implemented				Deterrent (vs today's flat rate structure)
Increasing Generation Capacity Cost				Deterrent for utility
Panel Upgrade Needed				Deterrent
Increasing Natural Gas Commodity Prices				Accelerator
Increasing RNG Percent Blend				Accelerator
Increasing RNG Commodity Prices				Accelerator
Future Heat Pump Cost Reductions*				Accelerator
Increasing Gasoline Prices				Accelerator
Managed EV Charging Implemented				Accelerator for utility

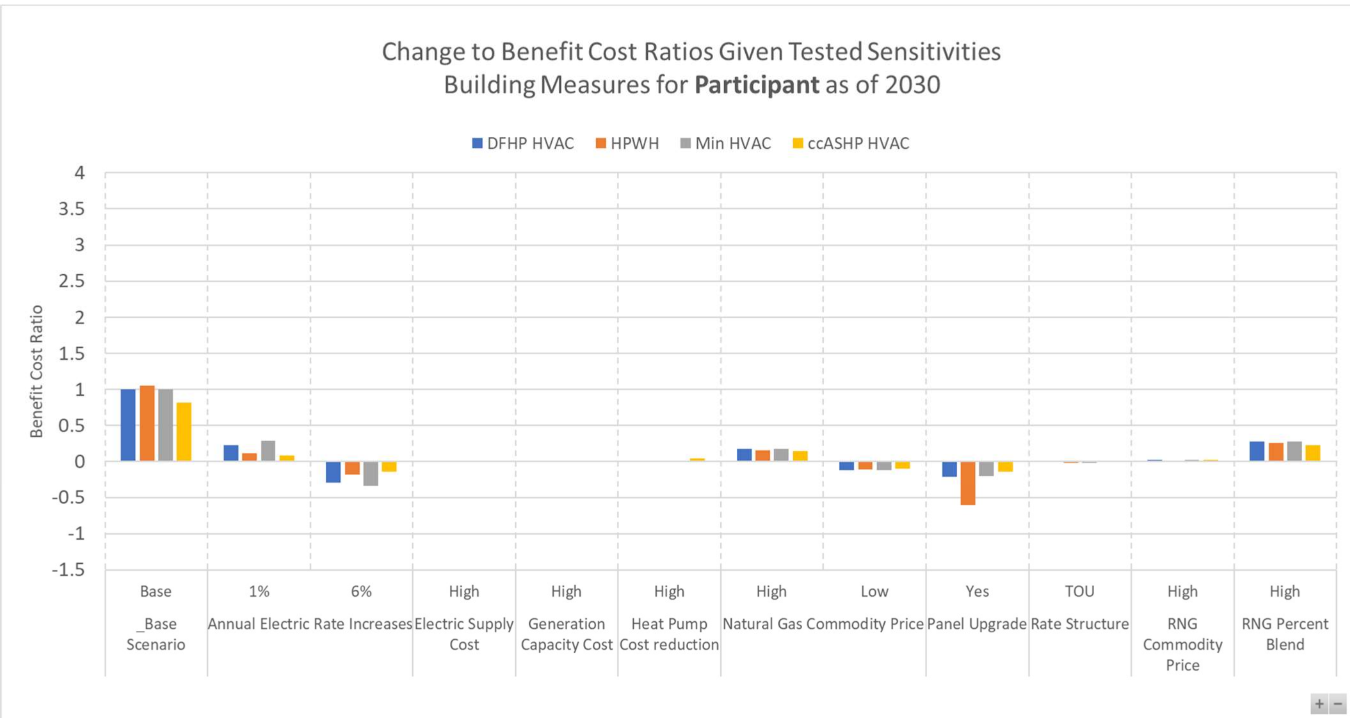
Note that some variables only impact the participant or ratepayer perspective. If the field is blank, it indicates that the variable does not have a direct financial impact from that perspective.

10.2 Benefit/Cost Ratio Sensitivities to Independent Variables

10.2.1 Building Electrification Findings

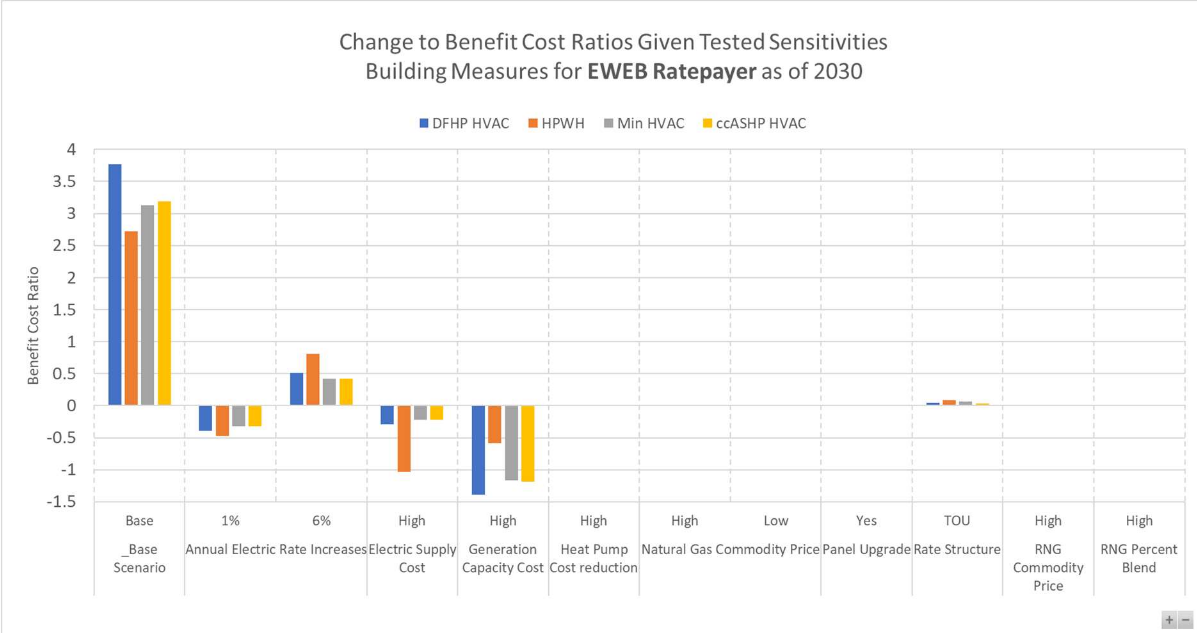
For Single-family Participants by 2030

- The base scenario shows that most space and water heating measures have a benefit/cost ratio (BCR) of ~1.0, except for cold climate heat pumps. This implies that most HVAC measures should be close to economic breakeven over the life of the measure, though only by a slim margin. Cold climate heat pumps do not break even economically, and as such, are less likely to be adopted by the participant.
- Most of the sensitivities that impact the BCR generally pertain to the ongoing cost of operation; the cost of electricity (annual rate increase, TOU rate structure) or the avoided cost of natural gas (natural gas commodity price, RNG blend, RNG Price) being the largest two contributing factors.
- Another large factor is whether a panel upgrade is required. A panel upgrade reduces the BCR for all measures, but especially heat pump water heating.



For EWEB Ratepayers, given electrification of single-family homes by 2030

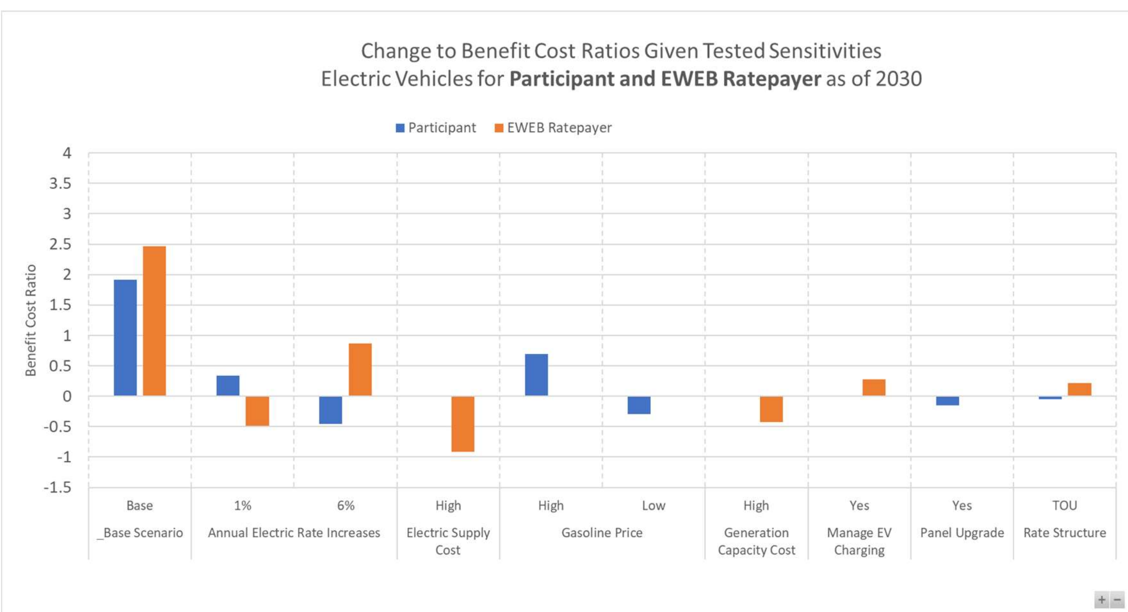
- The base scenario shows that all space and water heating measures benefit EWEB ratepayers by a large margin. BCR ratios range from ~2.7-3.7 with heat pump water heating being the least beneficial, and dual fuel heat pumps being the most beneficial to EWEB ratepayers.
- EWEB ratepayer BCRs are generally impacted by electric rates (annual electric rate increases, TOU) and the assumed cost of energy (electric supply and generation capacity). It should be noted that even under an adverse scenario (low electric rates, and high electric supply and generation capacity costs) EWEB ratepayers may still see a benefit to electrification.



10.2.2 Electric Vehicle Findings

For Participants and EWEB Ratepayers by 2030

- The base scenario shows that, by 2030, BCRs for the participant and EWEB ratepayers exceed 1.0, by a large margin.
- Much like building electrification, the major influencing factors can be generally categorized as ongoing costs like electricity (annual electric rates, TOU), and the avoided cost of gasoline.
- For the participant, panel upgrades can still influence the ratio, but to a lesser extent, compared to building electrification, given the relative cost of a panel upgrade compared to the lifetime savings achieved from electric vehicle conversion.
- For the EWEB ratepayer, electric supply and generation capacity cost are a large factor, but their impact appears to be offset from the benefits that can be achieved through managed EV charging programs.



10.2.3 Additional variable findings

All Sensitivities

When reviewing these sensitivity charts, it's important to remember that the benefit/cost value is a normalized ratio and not an explicit measurement of nominal dollar value. Further, the sensitivity deltas shown above are supposed to illustrate how a variable may impact a specific measure alone. While there are trends across measure types, the magnitude of impact is not directly comparable across measures. A seemingly large shift for one measure compared to another indicates overall sensitivity, but it doesn't lend itself to understanding the gross dollar impact to the participant or the EWEB ratepayer.

Electric Rate Increases and Structure

Increasing electric rates over time is an overall deterrent to electrification for all measures studied. The benefits of electrification are built on the assumption that electric rates will increase at a slower pace than fossil-fuel based energy sources like gasoline and natural gas. Maintaining affordable electric rates will be key to incentivizing electrification. From the EWEB ratepayer perspective, minimizing rate increases (from electric supply and generation capacity) will be important to maintaining benefits for electrification participants.

From a financial perspective, TOU rates studied were not as impactful as other variables, but they can be helpful by sending consumers price signals regarding the timing of electricity consumption. This impact of TOU on electrification and consumption will likely grow with the overall value of capacity. From the EWEB ratepayer perspective, the increased revenue from customers unable to avoid TOU rates would be used to offset the higher costs incurred to serve customers who consume energy during those peak periods. If done correctly, time-based rate structures like TOU (examples include critical peak pricing, peak time rebates, real time pricing) can send price signals to help participants and ratepayers save money. This is often seen as a cost-effective mitigation tool that utilities can use to reduce peak energy use, but typically requires advanced metering infrastructure to implement.

Electric Supply Costs and Generation Capacity Costs

These costs are born directly by the utility as load from electrification increases. The impact of electricity supply costs (energy or capacity) on the benefit of electrification are a function of both the diurnal (daily) and seasonal load shape of a specific measure.

Space heating measures tend to have larger incremental usage in winter, and early spring periods[42] where energy is forecasted to be cheaper. As such, changes in energy supply costs are not very impactful to the EWEB ratepayer. However, because of the variability (i.e. "peakiness") of the space heating loads, generation capacity costs tend to be high, so shifts in generation capacity cost can have a larger impact.

Water heating and EV load shapes are less peaky and generally maintain the same level of consumption throughout the year (limited seasonality). As such, EWEB ratepayers will see a larger reduction in benefit from shifts in energy supply costs when compared to shifts in generation capacity cost.

Panel Upgrade

Panel upgrade costs can easily surpass $2,000. This can be a major deterrent to electrification[43].

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[42] This study assumes that natural gas customers who convert to electric space heating already have air conditioning load in the summer. As such, the incremental impact on space heating in the summer is very small.

[43] https://www.utilitydive.com/news/residential-electric-panels-represent-a-nearly-100b-roadblock-to-full-el/605829/?

Though not addressed in this study, we assume that homes built prior to 1950 will most likely require panel upgrades to accommodate EV charging. This represents about 12% of all housing units in Eugene. Building codes can be used to address panel sizing to help ensure panel sizes are ready for future electrification. Heat pump water heaters appear to be more sensitive to panel upgrade costs, but this is generally a function of the overall cost of the measure itself. For more expensive measures, like purchasing an EV or a new space heating system, the impact of a panel upgrade is more diffuse. It should be noted that all future electrification can be facilitated with a single panel upgrade. If a participant needs to upgrade to support EV charging, it may make sense to ensure that their panel can also facilitate all other electric end uses at that time.

Natural Gas and Gasoline Cost

These are costs that are avoided by the participant when they electrify. As the price disparity between gas and electricity grow, the benefit to the participant will increase.

Increases in natural gas commodity costs are expected to grow from both increases in demand and efforts to decarbonize with RNG. The influence of RNG will likely be predicated on how much voluntary or mandated RNG is blended into natural gas pipelines. Higher levels of RNG appear to have a significant cost impact and will likely be a key driver for the disparity between natural gas and electric rates. See discussion of the impacts of decarbonization in the gas sector in Section 6 - Key Context: Electric and natural gas supply decarbonization.

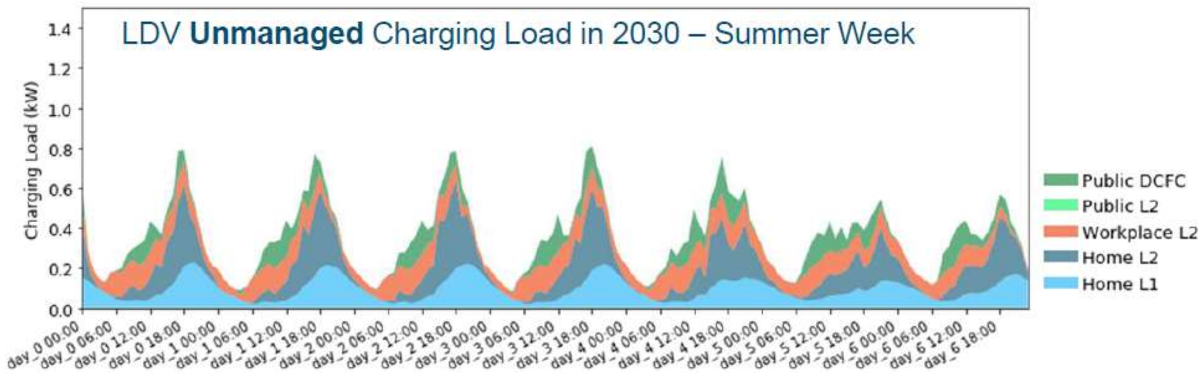
Gasoline prices are also expected to grow both from general supply and demand dynamics, but also due to cost adders like carbon credits mandated by Oregon's clean fuels program.

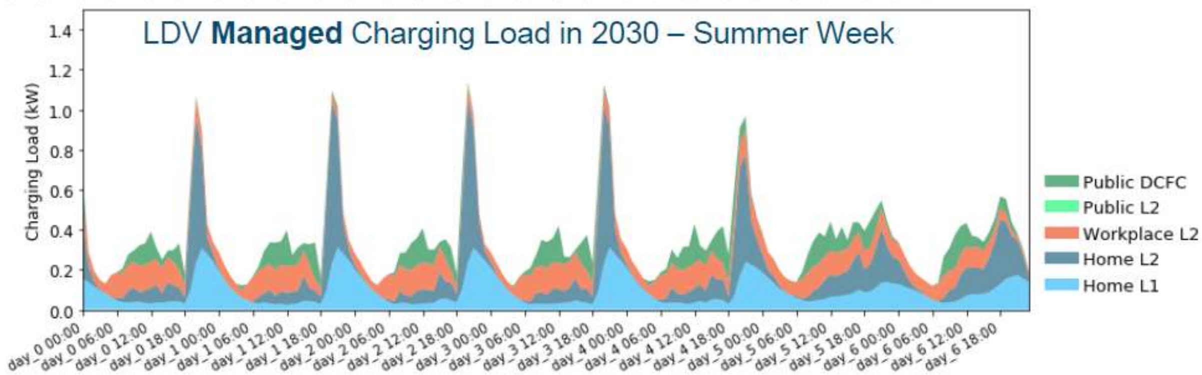
Heat Pump Cost Reductions (Cold Climate Heat Pumps only)

This study only looked at ducted cold climate heat pump systems, which are relatively new. This inverter driven, variable speed technology was already common in mini-split ductless systems and is expected to become more common for ducted heat pumps as well. While maturation in manufacturing practices can reduce the total installation cost of these types of systems, the overall impact of this sensitivity appears to be limited.

Managed EV Charging

E3 modeled both managed and unmanaged charging behavior based on driving behavior. To determine the likely location of EV charging, they analyzed the amount of time that a driver spends at home, the workplace or driving between locations. In the unmanaged charging scenario, it is assumed drivers would distinguish among charging locations based on cost but would charge with no attention paid to peak and off-peak time of use rates. For managed charging, they assumed they would optimize charging behaviors against TOU rates and assumed cascading charging to limit all drivers charging exactly at the transition between peak and off-peak hours (i.e., not all EVs would immediately charge at 10PM, but rather vehicles would stagger off-peak charging behavior in some way).





It should be noted that managed charging behavior does increase the peak EV load, but the impacts are not as meaningful because the peak is shifted away from EWEB's system peak hours. Looking at the chart, one can see an approximate 0.8 kW per EV peak around 6PM in the unmanaged charging behavior compared to a peak of 1.3 kW around 11PM for managed charging. It should also be noted that the managed peak is primarily controlled by Level 2 home charging habits.

The time of use variable indicates only a minor net cost to the participant (assuming they modify their charging behavior to the best of their ability) and provide a net benefit from the ratepayer perspective. Utilizing Time of Use rates and helping incentivize managed charging behavior are actions focused on a sub-set of customers who have more discretion regarding the timing of their charging behavior. EWEB currently has incentives for Level 2 chargers and encourages customers with Level 2 charging at home to schedule charging during off-peak periods. For EV adoption, time of use and managed charging variables are not financially impactful and are not expected to influence EV adoption. However, both variables are important for EWEB to consider in order to influence discretionary charging behavior and help mitigate increased costs to ratepayers.

11 Aggressive Carbon Reduction Scenario

HIGHLIGHTS

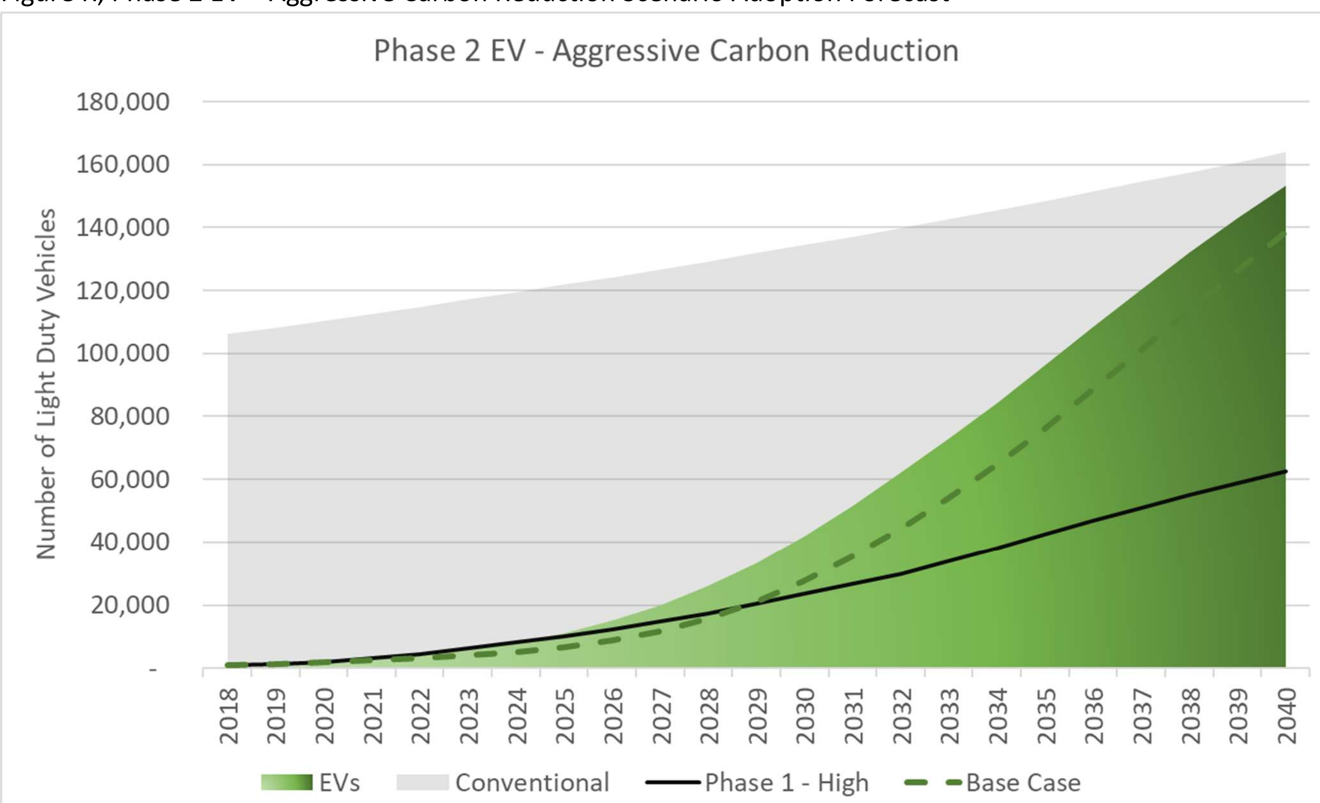
- Under the ACR scenario, there is a significant increase in space and water heating electrification compared to base case leading to meaningful carbon reductions (particularly from space heating).
- EWEB could see an increase of 3-12% to existing 1-in-10 peak energy use compared to the Base Case due to increased space heating loads in the ACR scenario.
- Slight increase in EV adoption by 2040 is driven by the assumption that the market maturing at a faster pace.
- Increased RNG leads to higher natural gas pricing compared to electricity costs.

As discussed in section 10.1 Independent Variables & Scenario Definition, the ACR scenario considers a future where both electric and fossil fuel energy sources are influenced by policies which prioritize carbon emission reductions and is based on trends and technology that exists today. In this scenario, it is likely that the pace of electrification would be faster than base case assumptions.

11.1 Aggressive Carbon Reduction Scenario – Transportation Sector

EV adoption was already anticipated to be high in the future under base case assumptions. The ACR scenario simply accelerates the pace of electrification, leading to approximately 95% of all light duty vehicles being electrified by 2040 (up from 85% in the base case).

Figure R, Phase 2 EV – Aggressive Carbon Reduction Scenario Adoption Forecast



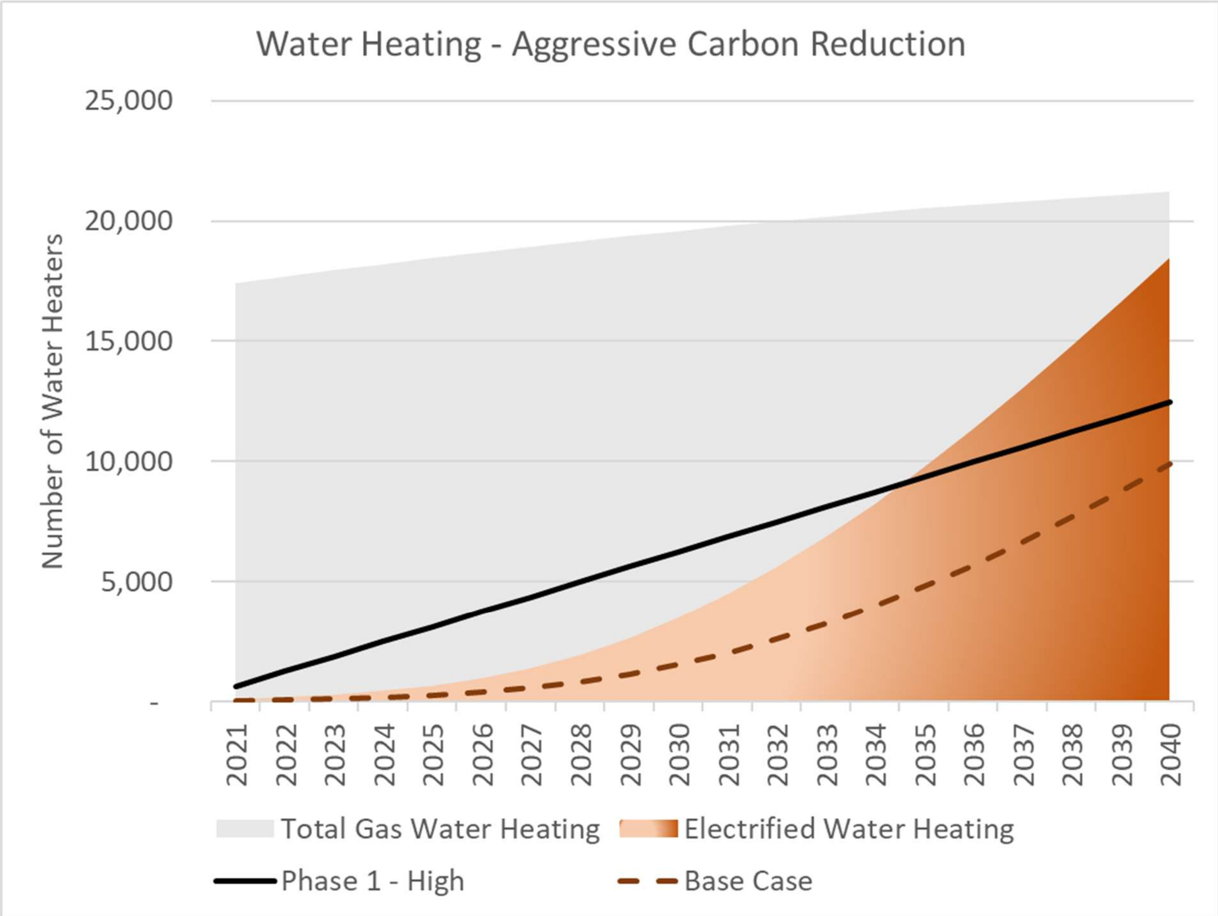
Overall, this slight increase in vehicle electrification by 2040 is expected to be 2% higher than the average and peak energy estimates in the Base Case. See the Cumulative Energy Impacts (Section 12) for a table showing the differences.

11.2 Aggressive Carbon Reduction Scenario – Building Sector

11.2.1 ACR Water Heating Energy & Carbon Impacts

Water heating electrification is anticipated to be much higher under the ACR scenario with approximately 85% of existing natural gas water heating electrified by 2040.

Figure S, Phase 2 Existing Natural Water Heating Units Electrified – Aggressive Carbon Reduction



Water Heating represents a relatively small use of energy and only a portion of EWEB customers use natural gas for water heating today. Even high levels of electrification by 2040 are estimated to have small impacts on both average and peak energy use.

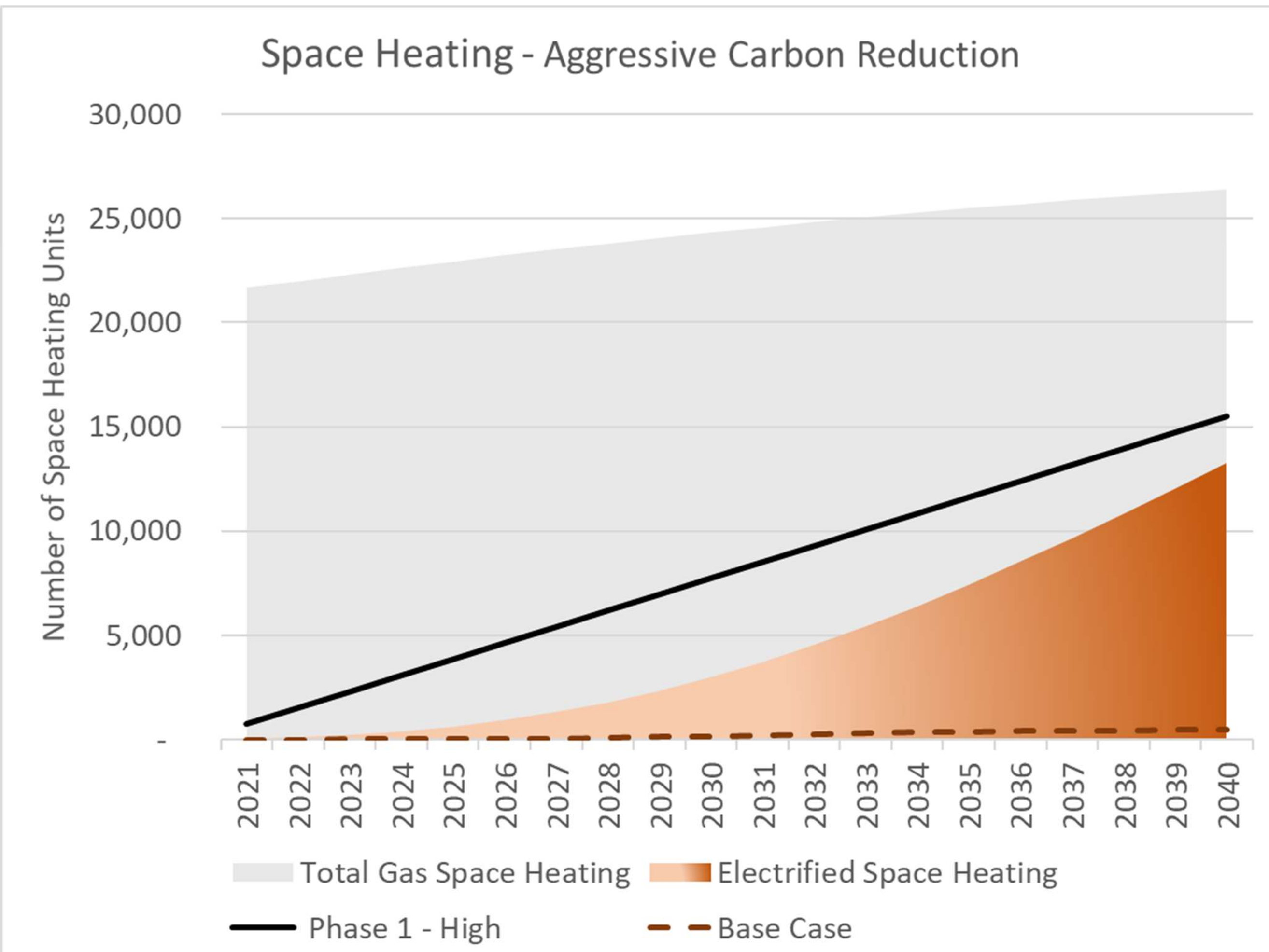
2040	Base Case	ACR Scenario	% Increase
Average	1 aMW	2 aMW	0.3-1%
Peak	1.5 MW	3 MW	0.3-1%

This study sought to quantify the relative carbon emission reduction benefits of electrification. Carbon savings from higher percentages of RNG are outside the scope of this study. The annual reductions shown in the table below are only related to electrification and any savings associated with increased RNG use would be in addition to the MTCO2e reductions as a result of electrification.

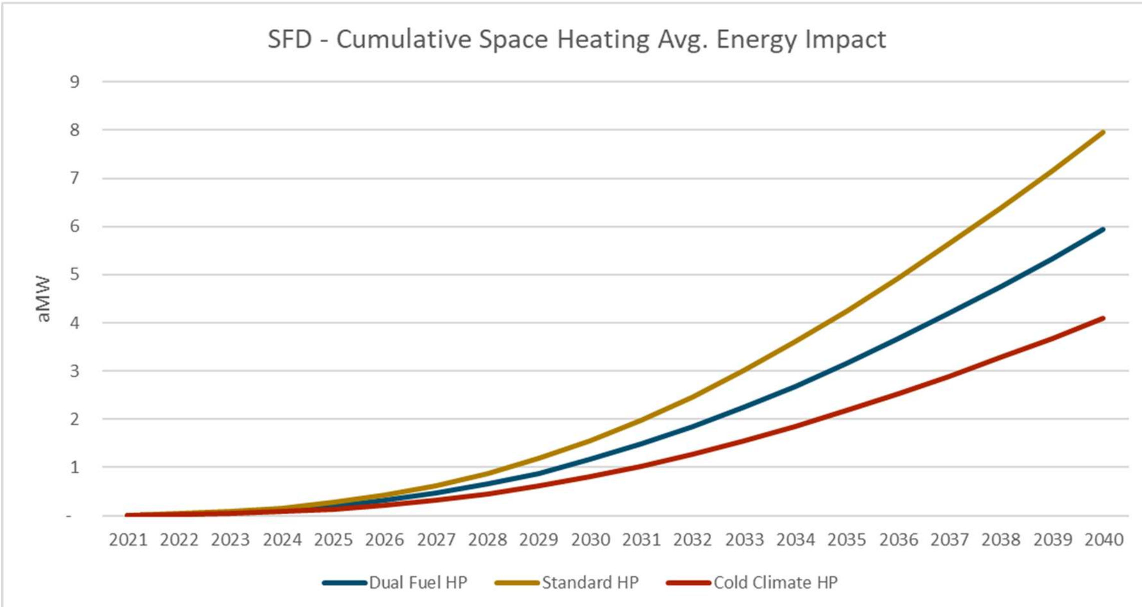
Water Heating Annual Carbon Reductions	2040	
	Base Case	ACR Scenario
Electrification	5,700 MTCO2e	6,500 MTCO2e
RNG Blend	23%	53%

11.2.2 ACR Space Heating Energy & Carbon Impacts

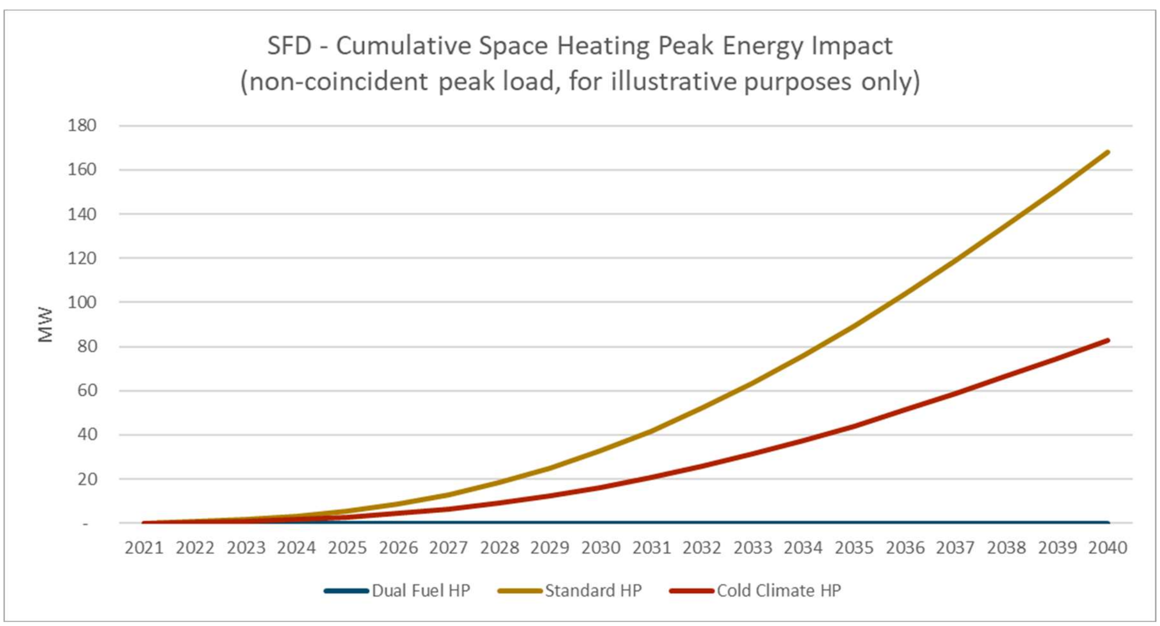
Under base case assumptions, space heating electrification is very unlikely due to lack of participant benefits. In the ACR scenario, the high costs of blending RNG is anticipated to increase natural gas rates and improve the benefits of electrification. The chart below shows the number of space heating units currently served by natural gas (which is a sub-set of all space heating units in EWEB's service territory). By 2040, approximately 50% of existing natural gas space heating units could be electrified.



For space heating electrification, the choice of technology has a strong influence over the average and peak energy impacts to the utility. To illustrate the impacts, the charts below show the energy impacts assuming 100% of the units electrified chose the same space heating technology. The results are shown based on single family dwelling (SFD) energy use.



The peak impacts of these technology choices are significant, as cold climate heat pumps are able to utilize the compressor at very low temperatures and reduce reliance on backup electric heat. Dual fuel heat pumps are assumed to switch over to natural gas below 32 degrees Fahrenheit, meaning they would add only a minimal amount to EWEB's existing peak load. For context, EWEB's existing 1-in-10 peak system load is 510 MW.



The chart above shows the non-coincident peak load of electrifying space heating units. The coincident peak impacts are anticipated to be much lower, as equipment diversity and customer behavior reduce the system peak impacts the utility would see as a result of electrification. It should also be noted that different customers will choose different space heating technologies, so the impacts are further diversified by different equipment types.

Under base case assumptions, carbon reduction for space heating is expected to be minimal because electrification is unlikely. However, the higher space heating adoption in the ACR scenario does show meaningful carbon reduction as a result of electrification. The amount of carbon reduction is influenced by space heating technology choice, hence a range of potential MTCO2e in carbon reduction is shown.

Space Heating Annual Carbon Reductions	2040	
	Base Case	ACR Scenario
Electrification	Minimal	14-16,000 MTCO2e
RNG Blend	23%	53%

12 Cumulative Energy Impacts & Electrification Opportunities

This study focuses on light-duty vehicle electrification in the transportation sector. The building sector analysis focuses on space and water heating technologies for existing buildings in EWEB's service territory using natural gas which can be electrified. It should be noted that this economic analysis focused primarily on the residential sector and only looked at the possible electrification of small office buildings in the commercial sector. The likelihood of larger commercial building electrification is more difficult to estimate due to the wide range of HVAC types that serve these customer's space heating needs. Industrial uses of natural gas are significant but encompasses many unique applications requiring a case-by-case analysis. In this study, the economic analysis is helpful for assessing the likelihood of electrification if left to consumers (participants) to choose as well as the anticipated impacts on energy consumption and related carbon emissions reduction. The following tables and charts summarize the cumulative electrification findings and highlight the differences between the Base Case and the Aggressive Carbon Reduction (ACR) scenarios.

12.1 Cumulative Energy Impacts

The cumulative energy impacts are relative to EWEB's existing system loads and existing peak demand periods. The percentage increase is based on EWEB's existing system average load of 270 aMW and a 1-in-10 peak of 510 MW, which is a common planning standard for electric utilities.

2040 - Base Case					
Electrification Measure	% Electrified	Average Energy Increase (aMW)	% Increase	1-in-10 Peak Increase (MW)	% Increase
Electric Vehicle - Managed	85%	57	21%	77	15%
Electric Vehicle - Unmanaged	85%	57	21%	131	26%
Heat Pump Water Heater	50%	1	0.3%	1.5	0.3%
Standard Performance Heat Pump	< 2%	Without significant incentives or mandates, impactful space heating electrification is unlikely if driven by participant economics (consumer choice).			
Cold Climate Heat Pump	< 2%				
Dual Fuel Heat Pump	< 2%				

2040 - Aggressive Carbon Reduction					
Electrification Measure	% Electrified	Average Energy Increase (aMW)	% Increase	1-in-10 Peak Increase (MW)	% Increase
Electric Vehicle - Managed	95%	63	24%	85	17%
Electric Vehicle - Unmanaged	95%	63	24%	145	28%
Heat Pump Water Heater	85%	2	1%	3	1%
Standard Performance Heat Pump*	50%	8	3%	33-61	6-12%
Cold Climate Heat Pump*	50%	4	2%	17-31	3-6%
Dual Fuel Heat Pump*	50%	6	2%	Minimal	Minimal

*Space heating energy impacts shown assume 100% of space heating electrifcation assuming a single technology to illustrate that space heating technology choice matters. In reality, customers will choose a mix of the 3 different space heating technologies. Peak impacts are presented in ranges due to uncertainty regarding coincident load of units. Utilizing AMI data in the future, EWEB could better estimate the coincident load of these space heating technologies.

Consumer-driven electrification of light-duty vehicles and water heating are likely in the next 20 years and should be included in EWEB's load forecasting going forward. Between the two scenarios studied, consumer-driven space heating electrification remains the most uncertain. In the ACR scenario, higher levels of building electrification (50% of the installed base as shown above) will have varying levels of energy impacts depending on the space heating technology that customers choose. Cold climate heat pumps provide the greatest carbon benefit but are the highest priced option for consumers. For transportation electrification, the greatest peak mitigation comes from developing programs to manage charging behavior. This could complement EWEB's existing and future energy efficiency programs which are designed to reduce peak energy use. The goal for all peak mitigation efforts would be to shift customer consumption away from, if not reduce, EWEB's existing system peaks using the least cost interventions. EWEB's Customer Solutions and Energy Management staff are well positioned to help develop both electrification and energy efficiency programs to actively manage the impacts of customer choices.

12.2 Cumulative Carbon Impacts

The table below shows carbon reduction by measure under the two scenarios studied. Again, the study considers the likelihood of electrification based on economic analysis and consumer choices and is only for specific measures within scope. As mentioned in Phase 1, electrification is just one of the pillars of decarbonization. Although separate from the benefits of electrification, staff provided an estimate of the potential carbon reduction benefits of RNG based on the Eugene Climate Action Plan's 2017 carbon inventory for additional context. In the Base Case, RNG blend is assumed to be 15% RNG by 2030, 23% by 2040 and 30% by 2050, based on Oregon Senate Bill 98. Under the high RNG blending sensitivity in the ACR Scenario, it is assumed that the % of RNG in the natural gas system will increase from 3% today at a consistent rate until it reaches 53% by 2040 and 80% by 2050.

Annual Carbon Reductions	2040					
	Base Case			Aggressive Carbon Reduction Scenario		
Carbon Reduction Measures	% Electrified	MTCO2e Reduced	% Carbon Reduction	% Electrified	MTCO2e Reduced	% Carbon Reduction
Vehicle Electrification	85%	(390,000)	-38%	95%	(432,000)	-43%
Water Heating Electrification	50%	(5,700)	-1%	85%	(6,500)	-1%
Space Heating Electrification	0%	-	0%	50%	(16,000)	-2%
Residential RNG Benefits*		(19,600)	-2%		(45,100)	-4%
Commercial & Industrial RNG Benefits*		(45,300)	-4%		(104,400)	-10%
Total Annual Carbon Reductions		(460,600)	-45%		(604,000)	-60%
Total 2017 Carbon Emissions (City of Eugene CAP 2.0)		1,013,600	100%		1,013,600	100%

*The Base Case assumes a blend of 23% RNG by 2040 and the Aggressive Carbon Reduction scenario assumes a blend of 53% RNG by 2040. The estimated carbon reduction benefits of increased carbon-free RNG are shown in addition to the benefits of building electrification for context.

12.3 Electrification Opportunities

As EWEB considers how to engage with customers on electrification, the utility should be looking for electrification measures that are both impactful and sustainable. Technologies that show lower likelihood of consumer-driven adoption may require more resources to influence customer choices. In addition, EWEB should consider the benefits of reduced carbon emissions while maintaining reliability and affordability. Adding to existing system peaks may increase reliability risks because it could both increase utilization (reduce available capacity) of EWEB's existing local distribution network, as well as increase reliance on the regional electric grid, where decarbonization efforts are impacting the availability of existing transmission and generation capacity. To manage the reliability risk, additional distribution, transmission, and generation assets potentially need to be procured at a cost to EWEB, which represents a risk to future customer affordability.

The Electrification Scorecard below was developed to provide a high-level comparison for the different electrification measures studied in Phase 2. Leaves are used to highlight the relative benefits of total lifetime carbon reduction, with more leaves indicating higher benefits. For each of the benefit/cost analysis perspectives, the measure was assigned green to show a net benefit, yellow to show neutrality, or red to indicate a net cost as of 2030. The benefit/cost Analysis is based on adoption in a single year, so 2030 BCA results are shown below to illustrate economic benefits in the mid-point of the study period. Lightning bolts illustrate the 1-in-10 peak impacts for each measure while the band-aids symbolize the potential for the utility to influence customer behavior to manage peak impacts. For example, electric vehicles have three band aids because managed charging behavior represents a meaningful opportunity for the utility to reduce incremental peak impacts. Space heating has less opportunity to shift energy because peaks are typically caused by weather conditions, but some space heating technology choices have lower peak impacts compared to the standard performance heat pump. Therefore, EWEB's Peak Management Potential has more to do with influencing customer space heating technology choices, than shifting the timing of customer consumption. In the EWEB Engagement Opportunities column, staff highlighted actions that EWEB could consider when evaluating electrification.

Electrification Scorecard	Carbon Reduced	Base Case 2030			1-in-10 Peak Adder	Peak Management Potential	EWEB Engagement Opportunities
		EWEB Participant	EWEB Ratepayer	Society			
Electric Vehicle	🍃🍃🍃	🟢	🟢	🟢	⚡⚡⚡	🩹🩹🩹	Encourage managed charging to avoid peak, increase public and workplace charging opportunties
Heat Pump Water Heater	🍃	🟢	🟢	🟢	⚡	🩹🩹	Consider existing energy efficiency incentive program's influence on electrification of water heating
SFD - Standard Heat Pump	🍃🍃	🟡	🟢	🟢	⚡⚡⚡	🩹	Participant benefits are neutral, making electrification unlikely. Possible incentive opportunity.
SFD - Cold Climate Heat Pump	🍃🍃🍃	🔴	🟢	🔴	⚡⚡	🩹🩹	Participant benefits are lacking, making electrification unlikely. Possible incentive opportunity.
SFD - Dual Fuel Heat Pump	🍃🍃	🟡	🟢	🟢	⚡	🩹🩹🩹	Participant benefits are neutral, making electrification unlikely. Possible incentive opportunity.
Multi-Family Dwelling Space Heat	🍃	🔴	🟢	🔴	⚡	🩹🩹	Participant benefits are lacking, making electrification unlikely. Possible incentive opportunity.
Small Office Space Heat	🍃🍃	🔴	🟢	🟢	⚡⚡	🩹🩹	Participant benefits are lacking, making electrification unlikely. Consider rate design changes for commercial electrificaiton.

Electrification Scorecard	Carbon Reduced	Aggressive Carbon Reduction 2030			1-in-10 Peak Adder	Peak Management Potential	EWEB Engagement Opportunities
		EWEB Participant	EWEB Ratepayer	Society			
Electric Vehicle	🍃🍃🍃	🟢	🟢	🟢	⚡⚡⚡	🩹🩹🩹	Encourage managed charging to avoid peak, increase public and workplace charging opportunties
Heat Pump Water Heater	🍃	🟢	🟢	🟢	⚡	🩹🩹	Consider existing energy efficiency incentive program's influence on electrification of water heating
SFD - Standard Heat Pump	🍃🍃	🟢	🟢	🟢	⚡⚡⚡	🩹	Influence customer space heating technology choices to mitigate peak impacts.
SFD - Cold Climate Heat Pump	🍃🍃🍃	🟢	🟢	🟢	⚡⚡	🩹🩹	Influence customer space heating technology choices to mitigate peak impacts.
SFD - Dual Fuel Heat Pump	🍃🍃	🟢	🟢	🟢	⚡	🩹🩹🩹	Influence customer space heating technology choices to mitigate peak impacts.
Multi-Family Dwelling Space Heat	🍃	🔴	🟢	🔴	⚡	🩹🩹	Participant benefits are lacking, making electrification unlikely. Possible incentive opportunity.
Small Office Space Heat	🍃🍃	🔴	🟢	🟢	⚡⚡	🩹🩹	Participant benefits are lacking, making electrification unlikely. Consider rate design changes for commercial electrificaiton.

Electrification of light-duty vehicles and water heating creates value (marginal benefit/marginal cost) from all perspectives (participant, EWEB ratepayer, society) in both the Base Case and ACR scenario, indicating electrification is likely and beneficial. In the case of light-duty vehicles, carbon reduction is substantial and the electric peak impact, while significant, can be mitigated with managed or diversified charging behavior. EWEB can encourage this diversified charging behavior by increasing the availability of public and workplace charging infrastructure and utilizing dynamic energy price signals (like Time-of-use rates) to encourage vehicle charging to shift to non-peak times. EWEB will need to actively manage the peak energy impacts to the utility to maintain both ratepayer and participant value over time.

Even without incentives, water heating electrification has economic benefits for all three electrification perspectives by 2030. The aggregate carbon reduction benefits are small compared to other end-uses, due to relatively low energy consumption of water heaters, but so is the electric system peak impact. EWEB's existing heat pump water heater incentive is helping to encourage electrification today. Given the ability to leverage an existing incentive program, and the low energy and peak impacts, electrification of water heating should be sustainable.

The economics and impacts of space heating electrification is more complex and uncertain. Removing other variables (mandates, incentives, equity, personal choice), substantial single-family dwelling electrification of space heating is unlikely under the Base Case scenario given lack of economic benefit created for the decision-making participant. From this value perspective, for a residential property, electrifying with standard performance heat pump or dual-fuel heat pump technology creates the most economic value for both the participant and society, but the standard heat pump has the most electric system peak impact, which may be more difficult to mitigate given its correlation to EWEB's existing system peaks.

The type of space heating technology (minimum standard, cold climate or dual fuel) chosen by a customer is a key variable in this study. The results of technology choice have been presented to illustrate their potential energy impacts. Standard performance heat pumps may offer the lowest upfront costs to consumers, but they have the most impact on system energy peak, as they rely on less efficient backup electric resistance heaters during low temperature conditions. Cold climate heat pumps (CCHP) can offer meaningful carbon reduction benefits over their lifetime, but high upfront costs remain a barrier. Today EWEB provides incentives customers to consider more cost-effective CCHP technologies like ductless heat pumps, or "mini splits", that can operate efficiently at low temperature, but this solution may not be as cost-effective for larger natural gas heated homes. Partial electrification with dual-fuel heat pump technology showed economic value from all perspectives (participant, ratepayer, society with upfront costs between standard heat pumps and cold climate heat pumps. Dual-fuel heat pump systems have the lowest peak electricity impact, while providing carbon emissions savings from increased electricity usage. While dual-fuel systems rely on natural gas backup heating during low temperature periods, this technology could allow customers who do not wish to discontinue their use of natural gas entirely an opportunity to decarbonize. However, the carbon emissions benefit of partial electrification using dual fuel heat pump technology is less certain and will depend on the carbon intensity of both the electric and gas grids under peak conditions over time, and the frequency of the circumstances requiring gas backup/peaking in this region.

Substantial multi-family space heating electrification is economically challenging in both scenarios, barring other variables, due to comparably lower energy needs and less opportunity to recover upfront costs with monthly savings. Small commercial/office electrification is also challenging due to increased demand charges to the commercial customer, indicating that the demand charge component of the electric rate structure may be acting as a deterrent to commercial electrification. To the extent that electrification provides financial benefits to participants, EWEB programs will need to consider access to these benefits and equity among customers. Exclusion of multifamily housing incentives, for example, may inadvertently exclude low and moderate income (LMI) communities from the benefits.

12.4 Conclusions

Overall, the study finds that the pace of customer-driven electrification, if based on economic value alone, will be slow in the next decade with EV adoption appearing to be the most likely and impactful form of electrification based on the large conversion potential (number of cars). In the near term, EWEB's engagement and collaboration with electric vehicle owners and the City of Eugene to shift charging times to non-peak hours of the day when carbon benefits are highest, and costs are lowest, will be beneficial to the impact and rate of electrification.

Space heating electrification creates the most tradeoffs between conversion options, including standard heat pump, cold climate heat pump, and dual fuel heat pump (partial electrification) technologies. Cold climate heat pumps (that operate at low temperatures) provide the most carbon emissions reduction but are the most expensive option. Standard heat pumps are the cheapest but provide less carbon benefit because of their reliance on more carbon-intensive peak electricity that will need to be managed. The carbon emissions benefit of partial electrification using dual fuel heat pump technology is less certain and will depend on the carbon intensity of both the electric and gas grids under peak conditions over time, and the frequency of the circumstances requiring gas backup/peaking in this region.

13 Distribution Grid Visibility

HIGHLIGHTS

- Phase 1 of the electrification study indicated that EWEB's electric system has the capacity and flexibility to manage low-to-moderate electrification levels in the near term, but such capacity varied within the service territory.
- Phase 2 of the study highlights the need for more granular distribution system planning.
- Advanced Metering Infrastructure (AMI) offers an opportunity to measure load at the individual transformer level, specifically via the Harris SmartWorks Compass Meter Data Management (MDM) application.
- Transformer health can be monitored using existing information technology, but further modernization may require additional investment.
- Knowing transformer capacity utilization can help manage future load growth (EV, Batteries, DR, EE, PV, DER), which is becoming a standard industry practice.

Significant electrification of the transportation and building sectors can create challenges for utility distribution systems. As discussed in Phase 1, EWEB's distribution system appears to have sufficient capacity to accommodate a low-to-moderate increase in load from electrification, but the amount of available capacity varies by area within EWEB's service territory. As customers electrify, they will likely do so unevenly across EWEB's system, with load growth clustering in neighborhoods and other smaller areas based on consumer choices. As such, having a high degree of grid visibility will become an increasingly important planning tool. Ongoing in-depth analysis of the distribution system will highlight the potential opportunities EWEB has to manage the impacts of electrification.

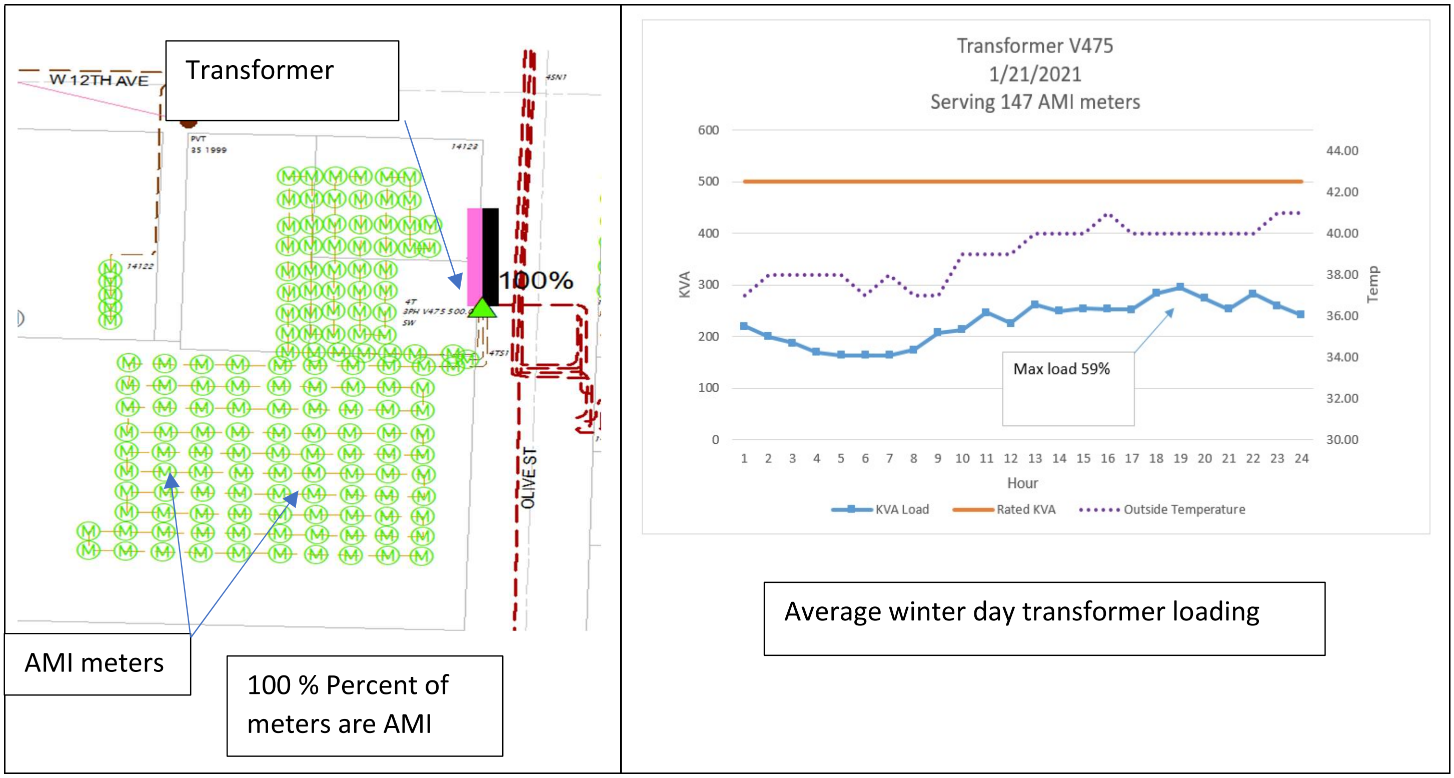
Since transformers are a high-cost component of EWEB's distribution system, monitoring transformer capacity can help manage or mitigate the impacts of load growth. Developing distribution system awareness can enhance system planning efforts by proactively identifying system constraints, voltage issues, or overloaded transformers before failure occurs. Targeted distribution system upgrades (rather than running equipment to failure) may help reduce the number and overall cost of unplanned outages to EWEB and its customers.

Currently, EWEB has over 18,000 units in its transformer fleet. As such, it is not cost effective to set up individual meters for each transformer. However, one of the major benefits of advanced metering infrastructure (AMI) is the visibility it can provide into the capacity utilization of distribution transformers. By integrating the relational information from GIS[44] and meter information from MDM[45], it becomes possible to group together AMI meters

[44] Geographical Information System (GIS) is mapping software used to visually represent, map, and analyze information about equipment used by utilities.
[45] Meter Data Management (MDM) is software used to track consumption data gathered from customer meters.

to create “virtually metered” transformers. This enables a comprehensive mapping of each transformer to the load it serves. By comparing the sum of all metered consumption associated with a transformer with the equipment’s capacity rating, staff can derive its real capacity utilization factor, in hourly granularity.

Below is an example of how a virtual transformer can be metered. This 500 KVA[46] transformer (green triangle, pictured below on the left) from the GIS system serves an apartment complex of nearly 150 residential AMI meters (green M symbol).



Each connected meter (child) is assigned to its virtual transformer (parent). Hourly load data from each of the individual meters is summed for each hour and the maximum hourly load can be compared to the transformer’s capacity rating, as illustrated in the image on the right.

EWEB is in mid-stream deployment of AMI and expects to have most electric meters changed in the next few years. Additionally, other necessary back-office systems, such as the SmartWorks Compass Meter Data Management (MDM) system will need to be configured for additional functionality to support emergent areas of operational work. Included in these back-office tools are a variety of reports and metrics that measure transformer capacity utilization, voltage, coincident peak, weather correlation, and other elements which aid in distribution system visibility. After the build out of this required foundational work, it may be possible to have hourly capacity utilization metrics for EWEB’s entire transformer fleet.

These technology improvements can help EWEB monitor transformer loading (heat/stress) under more extreme weather conditions in both winter and summer periods. Additionally, the same data sets would allow EWEB to better understand coincident peak consumption by customer class (e.g., residential, commercial). When combined with additional customer information, the data could be further broken out by customer segment (single family, multi-family, office, retail, box store, restaurant, motel, etc.). Developing a detailed understanding

[46] Kilovolt-Amperes (KVA) are a measure of a transformers apparent size (capacity).

of customers' energy usage is becoming a standard industry practice, as these insights are instrumental for electricity supply planning, customer program development, and rate design. However, it should be noted that this modernization effort may require additional investment in data integration and analytical tools.

Energy Use Analysis with Advanced Metering

Beyond determining transformer loading with virtual meters, this data can be useful for understanding and measuring the energy use impacts of electrification. Below are some example statistics for the 150-unit apartment complex with electric heating and cooling discussed on the previous page. The statistics shown are for an average (1-in-2) winter day and a rare (1-in-1,000) summer day (June 2021 Heat Dome). Note these statistics are representative of a single day and are not representative of annual energy use

Electric only customers (air-source heat pump heating and cooling) - Virtual Meter (VM)

Residential apartments	Meter Count	Non-coincident Peak (kW)	Coincident Peak (kW)	Peak Diversity Factor	% of rated Transformer Capacity
Average Winter day	150	534	280	52%	59%
Heat Dome peak day	150	611	379	62%	80%

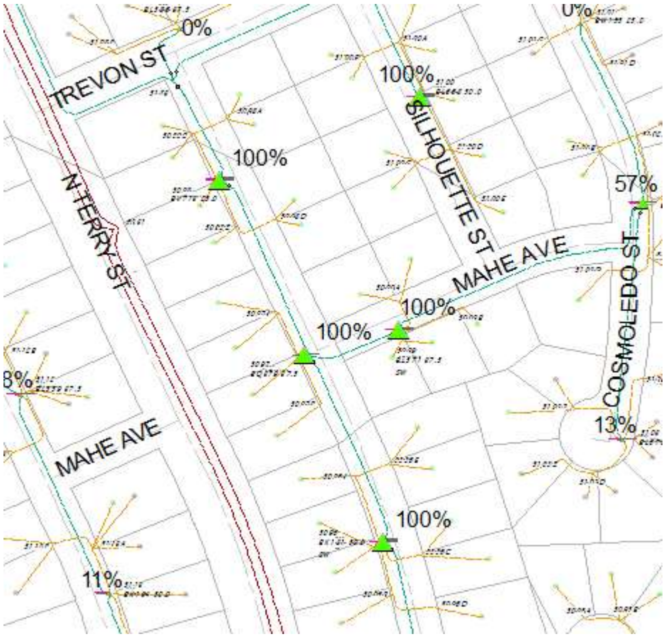
Many electrification studies assume that once a single home's peak is known, you can simply add up the number of homes to find the total peak. This is known as non-coincident peak and assumes that each home peaks at exactly the same time which overestimates actual system. Metered data (like the virtual meter from above) shows that the actual peak (coincident peak), for an average winter day, is much less (only 52%) than the non-coincident peak load. Understanding the coincident peak load can be helpful in system planning for estimating the impacts of many customers choosing to electrify. Additionally, the statistics for these 2 virtual meter examples represent the total energy from the whole dwelling and not just a single end-use, such as a heating, hot water, or cooling system.

Below are some example statistics for a group of single-family dwellings which have gas space heating and electric cooling Note these statistics are representative of a single day and are not representative of annual energy use.

NWNG customers (gas heating and electric cooling)- Virtual Meter (VM)

Residential single family dwellings	Meter Count	Non-coincident Peak (kW)	Coincident Peak (kW)	Peak Diversity Factor	% of rated Transformer Capacity
Average Winter day	34	82	48	58%	25%
Heat Dome peak day	34	181	132	73%	69%

Below is a GIS representation of the NWNG heated homes that were gathered to create a virtual meter for analysis.



Unfortunately, this early EWEB advanced metering data is limited. What is missing from this analysis is a collection of electric-only SFD statistics to compare to the statistics for SFD with natural gas. This could be useful when trying to estimate the impacts of electrification on SFDs. After AMI is fully deployed and analytical tools are developed, along with customer segmentation information, it may be possible to better understand and predict customer driven load profiles and their cumulative impacts on EWEB's distribution system. This type of data can inform our end-use models and energy resource needs in the upcoming IRP.

Grid Visibility and Modernization

Electric utility customers expect affordable, clean, and reliable power. As the distribution network becomes more dynamic, its complexity increases, and the volume of data that utilities need to understand and integrate change will continue to multiply. Historically, the Supervisory Control and Data Acquisition (SCADA) system delivered monitoring and control while the Outage Management System (OMS) assisted in power restoration. But these systems do not provide utilities with the ability to proactively monitor the health of our evolving grid. Ultimately, additional systems, like CIS[47], GIS, MDM, EMS[48], and outside data sources, like natural gas availability databases, need to be integrated to provide sufficient grid visibility to better manage customers' changing energy needs.

An integrated approach is often referred to as an Advanced Distribution Management Solution (ADMS). Ultimately, providing dispatchers and distribution system planners with location specific, real-time data and advanced analytics will benefit both the utility and their customers. ADMS takes a bottom-up distribution system planning approach, allowing for location specific solutions, in areas with the greatest need. Though this type of planning may not be a requirement for EWEB today, a growing number of utilities are implementing these tools. For example, Portland General Electric is developing grid visibility tools to help plan for future DER[49], DR[50], as well as providing customers with local grid information. This level of detail enables a collaborative partnership between the utility and its customers to develop and manage change in the most cost-effective manner.

[47] Customer Information Systems (CIS) track general customer account information.
[48] Energy Management Systems (EMS) track customer conservation information.
[49] Distributed Energy Resource (DER) are small scale generators that are located close to where energy is consumed.
[50] Demand Response (DR) is a programmatic change in customer consumption to better match power supply.

14 Appendix A: Electrification Study Glossary

aMW	Average megawatt is calculated by totaling the annual power consumed in a year (in this case megawatts or MW) and dividing that total annual consumption by the number of hours in given year (typically 8,760 during non-leap years). In Electricity Supply Planning, the average megawatt can provide useful context for understanding the average energy required to meet demand on an annualized basis.
Advanced Metering Infrastructure (AMI)	Advanced metering infrastructure (AMI) is an integrated system of meters, communications networks, and data management systems that enables two-way communications between utilities and customer meters.
Balancing	Balancing or matching load with resources to meet demand. Commonly referred to as load/resource balance.
Annualized Fuel Utilization Efficiency (AFUE)	Annualized Fuel Utilization Efficiency (AFUE) Furnaces are rated by the Annual Fuel Utilization Efficiency (AFUE) ratio, which is the percent of heat produced for every dollar of fuel consumed. Any furnace with an efficiency of 90% or higher is considered high efficiency.
Benefit/Cost Ratio (BCR)	A ratio used to summarize a benefit-cost analysis to determine if a proposed project's benefits outweigh the costs. If the BCR is greater than one, the net present value of taking action is expected to be positive. If the BCR is less than one, the costs outweigh the benefits.
BTU and BTUH	British Thermal Unit (BTU) is a measure of heat energy. BTUH is British Thermal Unit per hour. One BTU is the amount of energy needed to raise 1 pound of water by one degree Fahrenheit.
Capacity Utilization	Capacity utilization measures the maximum rate of potential output used over a set period of time.
Carbon	Short for Carbon Dioxide, a greenhouse gas produced by burning fossil-based fuels and other sources.
Carbon Intensity	The amount of carbon emitted per unit of energy consumed.
Capacity	The maximum output or electrical rating, commonly expressed in megawatts (MW).
Climate Change	The rise in average surface temperatures on Earth due primarily to the human use of fossil-based fuels, which releases carbon dioxide and other greenhouse gases into the air.
Coefficient of Performance (COP)	An efficiency ratio that measures useful heating or cooling provided relative to the work required. In electric heat pumps, this is the relationship between the energy that is delivered from the heat pump as cooling or heat (BTUh is converted to equivalent power kW), and the power (kW) that is supplied to the compressor.
Coincident Demand	The sum of two or more demands that occur in the same time interval[51].
Cold Climate Heat Technology	The most efficient type of air source heat pump designed for cold climates using variable speed drive compressor technology.
Commodity	An economic good that can be bought and sold and interchangeable with other goods of the same type.
Controlled Charging	Controlled or managed EV charging enables the utility and customer to align charging behavior that will potentially mitigate higher costs and carbon impacts during peak demand hours.
Cost-parity	Same price for product that is equivalent in value.
Critical Peak Pricing	Critical Peak pricing is a price-responsive mechanism designed to incentivize customers to reduce or shift electricity usage during a critical event.

[51] https://www.eia.gov/tools/glossary

Demand	The rate at which energy is being used by the customer.
Demand Response (DR)	Demand response is a measure to reduce or shift electricity usage during peak periods or as a response to supply constraints.
Demand Side Management (DSM)	An action to effectively reduce or modify the demand for energy. DSM is often used to reduce load during peak demand and/or in times of supply constraint.
Direct Air Capture	A technology to capture CO2 from the atmosphere.
Direct Load Control (DLC)	The consumer load that can be interrupted at the time of peak load by direct control of the utility[52].
Discounted Cash Flow	A method to estimate the present value of an investment based on the expected future cash flows.
Discount Rate	The interest rate used to determine the present value of future cash flows.
Dispatchable	The operating control of an integrated electric system involving operations such as the assignment of load to specific generating stations and other sources of supply to effect the most economical supply as the total or the significant area loads rise or fall[53].
Distributed Energy Resources (DER)	DER refers to systems that generate electricity at or near the load it is intended to serve and connected to the distribution system.
Distribution Assets	The portion of the electric system's poles, transformers, and other equipment dedicated to delivering electricity at the required voltage for the end-user.
Distribution Capacity	The installed capacity and capable load of individual circuits within the distribution asset system.
Diurnal	Diurnal variation refers to daily fluctuations.
Duct System	A system of tubes and pipes used for heating, ventilation, and air conditioning
Electric Panel	The electric service panel or circuit breaker box connects the main power line and distributes electrical currents to circuits within a home or building.
Electric Vehicle (EV)	A vehicle that derives all or part of its power from electricity supplied by the electric grid. Primary EV options include battery, plug-in hybrid, or fuel cell. • Battery Electric Vehicles (BEV) typically do not have an internal combustible engine (ICE) or fuel tank and rely solely on its battery charged by electricity to operate the vehicle. Typical driving ranges are considerably less when compared to other vehicle options but newer models coming out with advanced battery technology support higher ranges. • Plug-in Hybrid Electric Vehicles (PHEV) are powered by an on-board battery and gasoline with the ability to operate solely on its battery, ICE, or a combination of both. When the battery is fully charged and gasoline tank full, the PHEV driving range is comparable to a conventional ICE vehicle. • Fuel Cell Electric Vehicles (FCEV) run on compressed liquid hydrogen. Combining hydrogen with oxygen generates the electrical energy that either flows to the motor or to the battery to store until it's needed. FCEVs have a driving range comparable to a conventional ICE vehicle.
Electric Vehicle (EV) Charging Stations	EV charging stations typically fall under three primary categories: Level 1, Level 2, and Level 3 also referred to as DC Fast Chargers[54]. • Level 1: Provides charging through a 120 V AC plug and does not require installation of additional charging equipment. Can deliver 2 to 5 miles of range per hour of charging. Most often used in homes, but sometimes used at workplaces. • Level 2: Provides charging through a 240 V (for residential) or 208 V (for commercial) plug and requires installation of additional charging equipment.

52 https://www.eia.gov/tools/glossary
53 https://www.eia.gov/tools/glossary
54 https://www.energy.gov/eere/electricvehicles/charging-home

	Can deliver 10 to 20 miles of range per hour of charging. Used in homes, workplaces, and for public charging. • DC Fast Charge: Provides charging through 480 V AC input and requires highly specialized, high-powered equipment as well as special equipment in the vehicle itself. (Plug-in hybrid electric vehicles typically do not have fast charging capabilities.) Can deliver 60 to 80 miles of range in 20 minutes of charging. Used most often in public charging stations, especially along heavy traffic corridors.
End Use	The use of energy for a specific purpose where electricity is converted into useful work. Examples include transportation, heating or cooling.
Energy Efficiency (EE)	Refers to programs that are aimed at reducing the amount energy used in homes and other buildings. Examples include high-efficiency appliances, lighting, and heating systems.
Energy Efficiency Ratio (EER)	The Energy Efficiency Ratio (EER) of an HVAC cooling device is the ratio of output cooling energy (in BTU) to input electrical energy (in watts) at a given operating point.
Energy Factor (EF)	The energy factor (EF) indicates a water heater's overall energy efficiency based on the amount of hot water produced per unit of fuel consumed over a typical day.
Fossil Fuel	An energy source formed in the Earth's crust from decayed organic material. The common fossil fuels are petroleum, coal, and natural gas[55].
Generation	The process of producing electricity from water, wind, solar, fossil-based fuels, and other sources.
Generation Capacity	The maximum output, commonly expressed in megawatts (MW), that generating equipment can supply to system load[56]
Green	Green or clean electricity produced with little-to-no environmental impact or contributes to global warming caused by greenhouse gas emissions.
Greenhouse Gas (GHG) Emissions	GHG emissions are gases, such as carbon dioxide, that trap heat in the atmosphere. The largest source of GHG emissions from human activities in the U.S. is from burning fossil-based fuels for electricity, heat, and transportation[57].
Grid	The electricity grid, or grid, refers to the system that moves electricity from its source through transformers, transmission lines, and distribution lines to deliver the product to its end-user, the consumer.
Heat Pump	Heating and/or cooling equipment that, during the heating season, draws heat into a building from outside and, during the cooling season, ejects heat from the building to the outside. Heat pumps are vapor-compression refrigeration systems whose indoor/outdoor coils are used reversibly as condensers or evaporators, depending on the need for heating or cooling[58].
Heating seasonal performance factor (HSPF)	Heating seasonal performance factor (HSPF) is a term used in the heating and cooling industry. HSPF is specifically used to measure the efficiency of air source heat pumps. HSPF is defined as the ratio of heat output (measured in BTUs) over the heating season to electricity used (measured in watt-hours).
HVAC	HVAC is an acronym for heating, ventilation, and air conditioning.
Incremental Cost	See Marginal Cost
Inflation	The growth rate of a price index. Inflation occurs when the purchasing power of your dollars decreases due to rising prices.

[55] https://www.eia.gov/tools/glossary
[56] https://www.eia.gov/tools/glossary
[57] https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions
[58] https://www.eia.gov/tools/glossary

Integrated Resource Plan (IRP)	An IRP is a plan that outlines how a utility will meet its future electricity needs over a long-term planning horizon.
Interval Metering	Interval metering data is a series of measurements of energy consumption, taken at pre-defined intervals, typically sub-hourly. In end-use studies, energy consumption is measured in 15-minute or 1-minute granularity.
Intra-day Net Load Ramping	Net load ramping occurs within the day when renewable generation decreases at the same time load rises.
Light-duty Vehicles	Light-duty refers to gross vehicle weight rating and includes passenger cars, SUVs, trucks, and vans that weigh up to 10,000 pounds.
Line-loss	The amount of electricity lost during the transmission and distribution phases as it travels across the grid.
Load	The amount of electricity on the grid at any given time, as it makes its journey from the power source to all the homes, businesses.
Load Shape	A method of describing peak load demand and the relationship of power supplied to the time of occurrence[59]. Interval metering of end-uses is one method used to develop a load shape.
Marginal Cost	The change in cost associated with a unit change in quantity supplied or produced[60].
Marginalized Communities	Communities that experience discrimination and exclusion from social, economic, and/or cultural life.
Market-based pricing	Prices of electric power or other forms of energy determined in an open market system of supply and demand under which prices are set solely by agreement as to what buyers will pay and sellers will accept. Such prices could recover less or more than full costs, depending upon what the buyers and sellers see as their relevant opportunities and risks[61].
Market Liquidity	Market liquidity refers to the extent a market, such as the wholesale electricity market or real estate market, allows assets to be bought and sold with price transparency.
Megawatt (MW)	The standard term of measurement for bulk electricity. One megawatt is 1 million watts. One million watts delivered continuously 24 hours a day for a year (8,760 hours) is called an average megawatt.
Mini-Split Ductless System	A ductless heating and cooling system for use in smaller spaces or individual rooms. Mini-split systems have two main components: an outdoor compressor/condenser and an indoor air-handling unit(s).
MPGe	Miles per gallon of gasoline-equivalent. Think of this as being similar to MPG, but instead of presenting miles per gallon of the vehicle's fuel type, it represents the number of miles the vehicle can go using a quantity of fuel with the same energy content as a gallon of gasoline. This allows a reasonable comparison between vehicles using different fuels[62].
MSRP	MSRP is the acronym for manufacturer's suggested retail price.
MTCO2e	Metric tons of carbon dioxide equivalent is a unit of measurement. The unit "CO2e" represents an amount of a GHG whose atmospheric impact has been standardized to that of one unit mass of carbon dioxide (CO2), based on the global warming potential (GWP) based on the global warming potential (GWP) of the gas.
NESC	National Electric Safety Code
Nominal Dollar	Nominal or current dollars have not been adjusted for inflation.

[59] https://www.eia.gov/tools/glossary
[60] https://www.eia.gov/tools/glossary
[61] https://www.eia.gov/tools/glossary
[62] https://www.epa.gov/fueleconomy/text-version-electric-vehicle-label

Noncoincident Demand	Sum of two or more demands on individual systems that do not occur in the same demand interval[63].
1-in-2 or 1-in-10	A statistical measure used for risk analysis. The probability or chance of something occurring one year such as a one-hour peak in year 2, 1-in-2 year, is 1 / 2 or 50%. A 1-in-10 year has 1/10 or 10% chance of occurring in any one year.
Peak Demand	The largest instance of power usage in a given time frame.
Peak Diversity Factor	Peak Diversity Factor is the ratio of coincident peak demand to the non-coincident peak demand over a given period of time. This ratio illustrates the relationship between the peak electricity use of a population relative to the sum of all individual peak electricity use within the population. A high peak diversity factor (100%) indicates that the individual units within the population peak simultaneously, whereas a low peak diversity factor illustrates that individual units within the population peak at different times.
Peak Time Rebate	A pricing mechanism designed to incentivize reducing energy during peak time events by offering a rebate.
Peaker Plant	Peaker plant, also known as a peaking power plant or simply peaker, is a power plant that generally runs during times when demand for electricity is high or at its peak time. Peaker plants are typically gas turbines that burn natural gas.
Photovoltaic (PV)	PV is the process of converting sunlight into electrical energy using semiconducting materials.
Power	The rate of producing, transferring, or using energy, most commonly associated with electricity. Power is measured in watts and often expressed in kilowatts (kW) or megawatts (MW)[64].
PUC	Public Utility Commission
Quad	Quadrillion Btu 10^{15} Btu. The quantity 1,000,000,000,000,000(10 to the 15th power).[65]
Qualitative	Qualitative data is descriptive, conceptual, and is non-numerical.
Quantitative	Quantitative data is anything that can be counted, measured, or quantified using a numerical value.
Real-time	Actual time of occurrence.
Real-time Pricing	Real-time Pricing is designed to charge each kWh delivered based on fluctuating wholesale prices or production costs.
Renewable Natural Gas (RNG)	RNG is derived from the decomposition of organic waste and has lower carbon emissions than conventional natural gas.
Residential Building Stock Assessment (RBSA)	An assessment developed to capture the residential building sector that considers building practices, fuel choices, and diversity of climate across the region.
Resource Adequacy	Ensuring there are sufficient generating resources when and where they are needed to serve the demands of electrical load in "real time" (i.e., instantaneously). An adequate physical generating capacity dedicated to serving all load requirements to meet peak demand and planning and operating reserves, at or deliverable to locations and at all times.
Resource Portfolio	All of the sources of electricity provided by the utility.
Scenario	A projection or forecast that provides a framework to explore plausible outcomes. Scenario analysis is the process of analyzing plausible outcomes and typically includes base-case, expected-case, and worst-case scenario analysis.
Sector	Group of major energy consumers developed to analyze energy use. Commonly referred to as residential, commercial, industrial, and transportation sectors.

[63] https://www.eia.gov/tools/glossary
[64] https://www.eia.gov/tools/glossary
[65] https://www.eia.gov/tools/glossary

Segment	Customer segmentation or segment means separating the diverse population of end-use customers in groups based on similarities in customer needs and preferences.
Sensitivity	Sensitivity analysis is a method to determine how changes in methods, models, values of variable or assumptions may lead to different interpretations or conclusions by assessing the impact, effect or influence of key assumptions or variable.
Social Cost of Carbon	The estimated economic damage in dollars from emitting one ton of carbon dioxide.
Therms	A measurement of heat energy in natural gas. One unit of heat is equal to 100,000 British thermal units (BTU).
Time of Use (TOU) Rate	Time of use rates are rate structures which incent a customer to change their electric usage patterns, because they typically charge higher prices for consumption during peak periods.
Total Lifecycle	Lifecycle of a targeted measure refers to the expected life from the time the product is introduced in the market until it's removed.
Transformer	An electrical device for changing the voltage of alternating current[66].
Transmission	An interconnected group of lines and associated equipment for the movement or transfer of bulk energy products from where they are generated to distribution lines that carry the electricity to consumers.
Transmission Capacity	The maximum line and associated equipment available to move or transfer bulk energy across a transmission system.
Uncontrolled Charging	Uncontrolled charging allows for charging at any time of time without restraints including differences in price to charge. Also known as unmanaged charging.
Uniform Energy Factor (UEF)	A water heater's UEF rating is a measure of its energy efficiency, with higher numbers denoting more efficient units. The UEF calculation is based off how much energy the water heater uses and how much energy is used to power the water heater itself.
Upstream Emissions	Upstream typically refers to accounting for the all the emissions associated with extracting and processing resources used to create energy.
Variable Generation	Variable generation is produced using renewable resources (e.g., solar, wind, or run-of-river hydro) that is intermittently available.
Voltage	The difference in electrical potential between any two conductors or between a conductor and ground. It is a measure of the electric energy per electron that electrons can acquire and/or give up as they move between the two conductors.[67].
Wholesale Market	The market for buying and selling of electricity before it is sold to the end-user.

[66] https://www.eia.gov/tools/glossary
[67] https://www.eia.gov/tools/glossary

15 APPENDIX B: 2021 EWEB RESIDENTIAL ENERGY PROGRAM SUMMARY

Program	Rebates Available	Loan Limit (0% interest)	Program Requirements
Ducted Heat Pump	$1,000 Income eligible: $3,800 for owner occupied or $1,000 for rentals	$12,000 for site-built homes, $7,000 for manufactured	• Air-source heat pumps only. • For income eligible amount, home must have electric heat. • Learn more at **bit.ly/EWEBductedhp**
Ductless Heat Pump	$800 Income eligible: $3,800 for owner occupied or $1,000 for rentals	$4,000, plus $1,500 per additional head, up to $10,000	• For buildings with more than 4 units (side-by-side condos/townhouses, or apartments) check with EWEB for eligibility. • Homes with existing operable ducted heat pumps are not eligible to participate. • If there is a pre-existing ductless heat pump, it must be removed. • For income eligible amount, home must have existing electric heat. • Learn more at **bit.ly/EWEBdhp**
Insulation & Air Sealing	$0.80/sf of insulation, up to 50% of eligible cost, plus $0.10/sf for air sealing Income eligible: 100% of eligible insulation cost, plus $0.10/sf for air sealing	$4,000 plus $1,000 for air sealing	• Home must have electric heat and be poorly insulated. • For income eligible, a minimum of 2 bids are required. • Air sealing limited to being an additional component of an attic and/or underfloor crawlspace insulation project in single-family homes. • Learn more at **eweb.org/weatherize**
Windows	$4.00/sf of glass Income eligible: $20/sf for owner occupied or $10/sf of glass for rentals	$4,000 for U-factor ≤ 0.25 or $6,000 for U-factor ≤ 0.22 Multifamily: $3,500 + $500/unit up to $20,000	• Home must have electric heat and existing single pane or double pane metal windows. • Unless otherwise specified, must have U-factor ≤ 0.22. • For income eligible, the home must have electric heat and existing single pane windows. Windows with U-factor ≤ 0.30 are allowed for owner-occupied. • Learn more at **eweb.org/weatherize**
New Construction	$1,000 heat pump, ducted or ductless $800 heat pump water heater NEEM-certified manufactured homes: $1,200 for v1.1 or $1,400 for v2.0	N/A	• EWEB encourages homes to be built with efficient low-carbon electric heating and water heating systems. • Rebates for multifamily, affordable housing and custom projects are available but not listed here, contact us for details. • Learn more at **bit.ly/EWEBnewconst**
Solar Electric Net Metering	$0.40/AC output watt up to $2,500	N/A	• Site must have at least an 85% total solar resource fraction to receive rebate. • 25 kW max. Direct generation option available in lieu of net meter. • Learn more at **eweb.org/solar**
Level 2 EV Charger	$500	N/A	• Charger must be Level 2 (240V, 30 Amp minimum power output capacity), equipped with the SAE J1772 standard or Tesla connector plug, installed in compliance with applicable codes. Learn more at **eweb.org/ev**

Program	Rebates Available	Loan Limit (0% interest)	Program Requirements
Heat Pump Water Heater	$800 Income eligible: $1,700 for owner occupied, $1,000 for rental	$2500	• Must be Tier 3 and on a qualified products list, with at least a 40-gallon tank. • For income eligible amount, home must have electric water heat. • Learn more at **bit.ly/EWEBhpwh**
Toilets	$50 for 1.28 gpf toilets, or $100 for 1.0 gpf toilets	N/A	• New toilet must be WaterSense and use either 1.28 gallons per flush or 1.0 gallons per flush or less. • New toilets must replace an existing toilet using 1.6 gallons per flush or more. • Rebate is paid via bill credit. Learn more at **eweb.org/waterconservation**
Hand Valve	Free valve (or $75 bill credit) and $75 bill credit for installation	N/A	• Shut-off valve to be installed on customer side of water meter by a plumber. Valves may be provided by plumber or EWEB. • Learn more at **eweb.org/waterconservation**
Water Service Line Replacement	N/A	$5,000	• Replacement of a leaking water service line between the meter and the house only. Must be done by a qualifying plumber. • Learn more at **eweb.org/leakassistance**
Leak Repair Assistance	100% of eligible costs, income eligible only	N/A	• Applies to minor plumbing repair and/or service line replacement.
Septic	$250 to inspect and pump out septic system	$10,000 for repair or replacement of septic system	• Property must be within the McKenzie River Pure Water Partners Boundary. • Learn more at **eweb.org/septic**
EWEB Greenpower	N/A	N/A	• Support clean energy & encourage renewable energy projects in our community by assigning 100% of your electricity to Greenpower or choosing blocks of Greenpower for as little as $1.50 per month. • Learn more at **eweb.org/greenpower**
Efficiency Education Program	FREE	N/A	• Income qualified customers receive a free kit with energy and water-saving products and basic emergency preparedness supplies. We visit your home and evaluate it, looking for opportunities to reduce your monthly bill, improve your home comfort and lower your carbon footprint. Contact us for details.
Home Energy Score	FREE	N/A	• Focused on rental properties, either tenants or rental owners can apply and receive an energy report with recommendations. Tenants can choose to have recommendations sent to landlord. Learn more at **eweb.org/rentals**
Electric Service Upgrade	N/A	$20,000	• Property must be in EWEB electric service territory. Examples include electric panel or meter base replacement, underground service work, or new services. • Learn more at **eweb.org/service-upgrade**
Backup Generator	N/A	$2,000 $4,000 with well for domestic water	• Installation must include a transfer switch and be permitted. Applicant must be an EWEB electric customer and be the owner of the property. • Learn more at **eweb.org/generatorloan**

1. Unless otherwise noted, customer is eligible for a loan OR rebate, not both, unless income eligible. Loans and rebates are capped at project cost, including installation.
2. An application submitted by the homeowner is required. Apply online for most programs at **https://secure.eweb.org/ProgramApp.aspx**.
3. Program restrictions may apply. Rebate and loan amounts are subject to change at any time, please contact EWEB at **541-685-7088**, or visit our web site, for the most current program information.
4. Loan funding may be used to cover costs of labor from participating contractors. See lists of contractors online at **eweb.org/contractorlist**.
5. Information about all of EWEB's rebate and loan offerings can be found at **http://www.eweb.org/saveenergy**.
6. To qualify for the limited-income funding, households must meet income guidelines, which can be found at **bit.ly/EWEBLI**.
7. Aggregate loan limit is $20,000 per customer. The term for an EWEB loan is 48 months when borrowing under $5,000, or 60 months when borrowing $5,000 or more.
8. Homes with gas, oil, wood, or propane heat can qualify for non-income eligible rebates for Ducted of Ductless Heat Pump programs.

16 Appendix C: EWEB Business Commercial Programs, Rebates, and Loans - Program Summary

Commercial Lighting	Rebates Available	EWEB Code	Program Requirements
Lighting Rebates	$2 per LED tube	N/A	• Actual rebate is determined by EWEB's lighting calculator. **See EWEB Lighting Rebates for complete list of rebates** • An increase or decrease in the number of fixtures may be allowed. • Installed LED products must be listed by DLC or ENERGY STAR. • Rebates not to exceed 50% of the project cost. For new construction projects, rebates not to exceed 50% of the incremental cost for the LED package. • Rebates over $2,500 need EWEB pre-approval. • Additional rebates available for networked lighting controls. • All lamps, ballasts, and fixtures must be disposed of according to law • Learn more at http://bit.ly/EWEBclt
	$2-5 per small screw-in LED		
	$20-200 per General Indoor/Outdoor LED fixture		
	$30-500 per LED fixture replacing HIDs or High Bay		
	$30 – 500 LED Exterior		
	$20 per LED exit sign		
	$10-40 per lighting controls such as occupancy sensors		

Commercial HVAC	Rebates Available	EWEB Code	Program Requirements
Ductless Heat Pumps	**$1,300 per ton – existing electric heat	DHP-30	• System must replace an existing zonal or forced-air electric resistance or gas system. • Systems with no ductwork must have a minimum HSPF of 11. Systems with any mix of ductwork must have a minimum HSPF of 10. • Learn more at http://bit.ly/EWEBchvac
	$350 per ton – existing non-electric heat	DHP-40	
	$300 per ton – existing DHP upgrade or new construction	DHP-50	
Variable Refrigerant Flow (VRF)	**$1,300 per ton of cooling capacity, retrofit	VRF-110	• Replacing existing electric resistance heat for retrofit. If replacing existing gas heat, see Custom Projects. • Installed system must have an AHRI certificate showing it meets minimum efficiency requirements. Requirements vary with system capacity, see website for details.
Packaged Heat Pumps	$1,000 per ton – existing resistance heat	HP-100	• Air-source heat pumps only. Ground-source heat pumps do not qualify. • Split systems have an indoor air handler and a separate outdoor compressor. A packaged system has the heating and cooling equipment in a single package, often located on the roof. • Installed system must have an AHRI certificate showing it meets minimum efficiency requirements. Requirements vary with system capacity, see website for details. • Learn more at http://bit.ly/EWEBchvac
	$350 per ton – existing non-electric heat	HP-110	
	$150 per ton – existing heat pump upgrade or new construction	HP-140	
Split System Heat Pumps	$1,000 per ton – existing resistance heat	HP-120	
	$350 per ton – existing non-electric heat	HP-130	
	$150 per ton – existing heat pump upgrade or new construction	HP-150	

Commercial HVAC (Cont.)	Rebates Available	EWEB Code	Program Requirements
Packaged Terminal Heat Pump (PTHP)	$600 per unit – replacing PTAC or zonal electric resistance heat	PTHP-100	• Retrofit of existing installations and new equipment are both eligible. • Only lodging facilities (hotel, motel, B&B, dormitory, or shelter) or residential care buildings (nursing homes, retirement homes, and assisted living facilities) are allowed.
	$100 per unit – new construction	PTHP-110	
Variable Frequency Drives (VFD)	$300 per fan motor horsepower – electric or gas heat	VFD-100	• Retrofits only. Must be installed on a single-speed air handling unit fan. • Any existing AHU throttling or bypass devices must be removed or permanently disabled.
Connected Thermostats	$350 per thermostat – electric heat	CT-100	• For retrofits only. Heating system can be electric or gas. • Not available for lodging, 24/7 occupancy, or semi-conditioned spaces. • A building is eligible to receive payment for more than one thermostat. • Product must be on qualified list. Learn more at http://bit.ly/EWEBchvac
	$350 per thermostat – gas heat	CT-110	
Advanced Rooftop Unit Controls (ARC)	**$200 per ton – Lite: VFD or controller for multispeed fan operation	ARCL-1	• Existing rooftop units must be unitary systems (split-systems are not eligible), have a cooling capacity of at least 5 tons, and use constant speed supply fans (RTUs with variable speed fans are not eligible). • RTU heating fuel type may be electric or gas. • Installed controls must be on a qualified products list. • Learn more at http://bit.ly/EWEBchvac
	**$300 per ton – Full: VFD or controller for multispeed fan operation, plus digital economizer control and demand control ventilation with CO2 sensor	ARCF-11	
Commercial Weatherization	**Rebates Available**	**EWEB Code**	**Program Requirements**
Windows	$4 per square foot of glass – electric air source heat pump	WIN-100	• Retrofits only. Pre-existing windows must be single pane, single pane with storms, or double pane metal. • Installed windows must have a U-factor of 0.22 or less. Patio doors must have a U-factor of 0.25 or less.
	$4 per square foot of glass – electric forced air furnace or zonal heat	WIN-110	
Insulation	$0.80 per square foot, up to 50% of cost – electric heat – attic or roof insulation	INSA-100	• Retrofits only. Pre-existing insulation must be between R-0 and R-5.
	$0.80 per square foot, up to 50% of cost – electric heat – wall insulation	INSW-110	
Process and Manufacturing	**Rebates Available**	**EWEB Code**	**Program Requirements**
Small Compressed Air Systems	$0.18 per annual kWh saved, up to a maximum of 70% of project cost	AIR-100	• VFDs applied to a single air compressor or installation of cycling refrigerated air dryers of 75 horsepower or less. Incentives for air compressors over 75 hp, and for other compressed air savings measures, are available through EWEB's custom incentive program. • Each VFD compressor must be submitted as an individual project (i.e. compressors may not be combined or divided).
High Frequency Battery Charger	$0.18 per annual kWh saved, up to a maximum of 70% of project cost	HFBATT-100	• New construction projects are not eligible. • This measure applies to the replacement of existing ferroresonant or silicon-controlled rectifier (SCR) chargers ONLY. • Installation of a new, high-frequency inverter-based battery charger, with rated input power of more than 2 kW and that uses 10W or less of standby power. • Power conversion efficiency no less than 89%.

Welder Upgrade	$0.18 per annual kWh saved, up to a maximum of 70% of project cost	WELD-100	• New construction projects are not eligible. • Installed inverter-based welder must be rated for a minimum of 200 amps.
Block heaters	$200 – for generators under 3 kW	GBH-100	• Retrofit of existing installations and new equipment are both eligible. • The generator or engine must be stationary and fixed. • Installed generator engine block heater must be forced-circulation heaters. • A Project Information Form is required.
	$1,500 – for generators 3 kW and greater	GBH-110	

New Construction & Custom	Rebates Available	EWEB Code	Program Requirements
Commissioning (RCx)	$0.07 per kWh of first year savings $0.03 per kWh of second year savings $0.03 per kWh of third year savings	N/A	• Savings are determined using billing data from year prior to commissioning work, and weather-adjusted billing data from subsequent years.
Custom Projects	$0.18 per annual kWh of saved, or custom	N/A	• Custom projects typically require a measurement and verification plan before project begins. • Partial payment is generally processed upon project completion, with remaining payment being processed after measurement and verification plan is met.
New Construction Projects	$0.18 per annual kWh of saved, or custom	N/A	• For efficient electric HVAC systems. • Additional rebates for qualifying affordable housing new construction are available. Contact EWEB for details.

Commercial Food Services	Rebates Available	EWEB Code	Program Requirements
Commercial Food Services Rebates	$500 per combination oven – 5 to 15 pans	FS-414	• Installed product must be electric and meet ENERGY STAR v2.2 requirements. • Learn more at http://bit.ly/EWEBcfs
	$500 per combination oven – 16 to 20 pans	FS-415	
	$400 per full size convection oven	FS-412	
	$200 per half size convection oven	FS-413	
	$250 per commercial fryer	FS-405	• Installed product must be electric and meet ENERGY STAR v3.0 requirements. • Learn more at http://bit.ly/EWEBcfs
	$250 per insulated holding cabinets, half size	FS-406	• Installed product must be electric and meet ENERGY STAR v2.0 requirements. • Learn more at http://bit.ly/EWEBcfs
	$500 per insulated holding cabinets, full size	FS-407	
	$1,000 per insulated holding cabinets, double	FS-408	
	$500 per steam cooker, 6-pan capacity	FS-603	• Installed product must be electric and meet ENERGY STAR v1.2 • Learn more at http://bit.ly/EWEBcfs
Demand-Controlled Kitchen Ventilation	$200 per horsepower - single control sensor	FS-450	• Controls must reduce fan speed during times of low demand and must be applied to both primary ventilation and make-up air units in a kitchen. • Controls can be applied to either new or modified existing exhaust hoods. • Learn more at http://bit.ly/EWEBcfs
	$400 per horsepower - multiple control sensors	FS-455	

Commercial Refrigeration	Rebates Available	EWEB Code	Program Requirements
Reach-in Case Anti-Sweat Heater Controls	$40 per linear foot - medium temp (1° F - 35° F)	RF-162	• Controls must reduce run-time of the anti-sweat heaters in the door rail, glass and/or frame by at least 50%. • This rebate does not apply to existing doors already equipped with low/no anti-sweat heat. • Learn more at http://bit.ly/EWEBcref
	$40 per linear foot - low temp (below 0° F)	RF-161	
Strip curtains	$9 per square foot – Cooler, grocery	SC-100	• Applies to retrofits only. • Must install strip curtains or swinging doors at least 0.06 inches thick. • Learn more at http://bit.ly/EWEBcref
	$9 per square foot – Freezer, grocery	SC-110	
	$9 per square foot – Freezer, convenience store	SC-120	
	$9 per square foot – Freezer, restaurant	SC-130	
Efficient Fan Motors for Coolers	$140 per motor – walk-in – 23 watts or less	RF-080	• Existing equipment must be standard efficiency shaded pole fan motors in a refrigerated display case, walk-in cooler or freezer. • Walk-in cooler or freezer fans must have a diameter of at least 10 inches. • Installed motors must be electronically commutated motors (ECMs). • Learn more at http://bit.ly/EWEBcref
	$140 per motor – walk-in – greater than 23 watts	RF-081	
	$55 per motor – display case	RF-172	

Rebates cannot exceed 100% of program cost.

* An application must be submitted by the property owner or owner's representative. Low-interest loans may also be available, upon approved credit.

** Promotional Incentive. Project application must be approved by September 30, 2021.

*** Program restrictions may apply. Rebate and loan amounts are subject to change at any time.

Please contact EWEB at 541-685-7088 for the most current program information.