Oregon Energy Strategy Complementary Analysis

4/16/2025

Prepared for:

Oregon Department of Energy

Clean Energy Transition Institute

Rockcress Consulting

Evolved Energy Research

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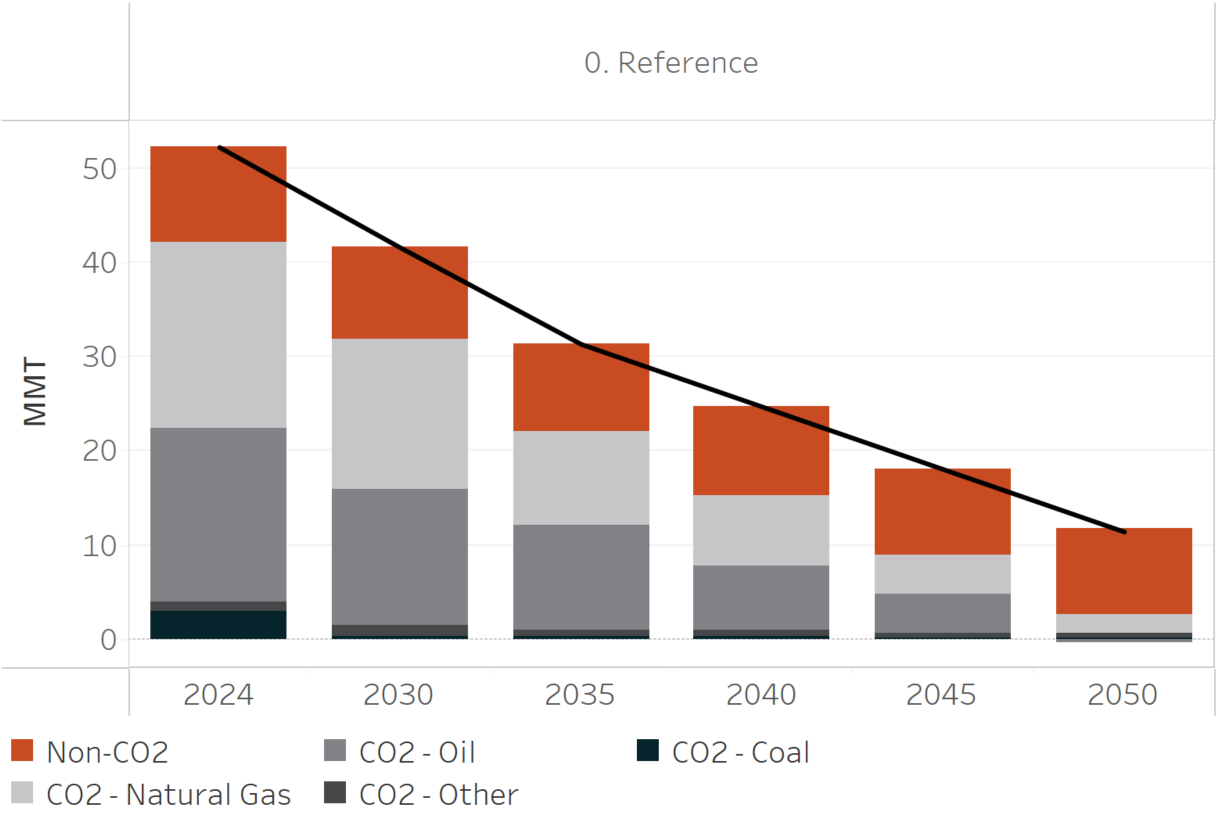
Air Quality Analysis

Reducing Emissions Brings Health Benefits

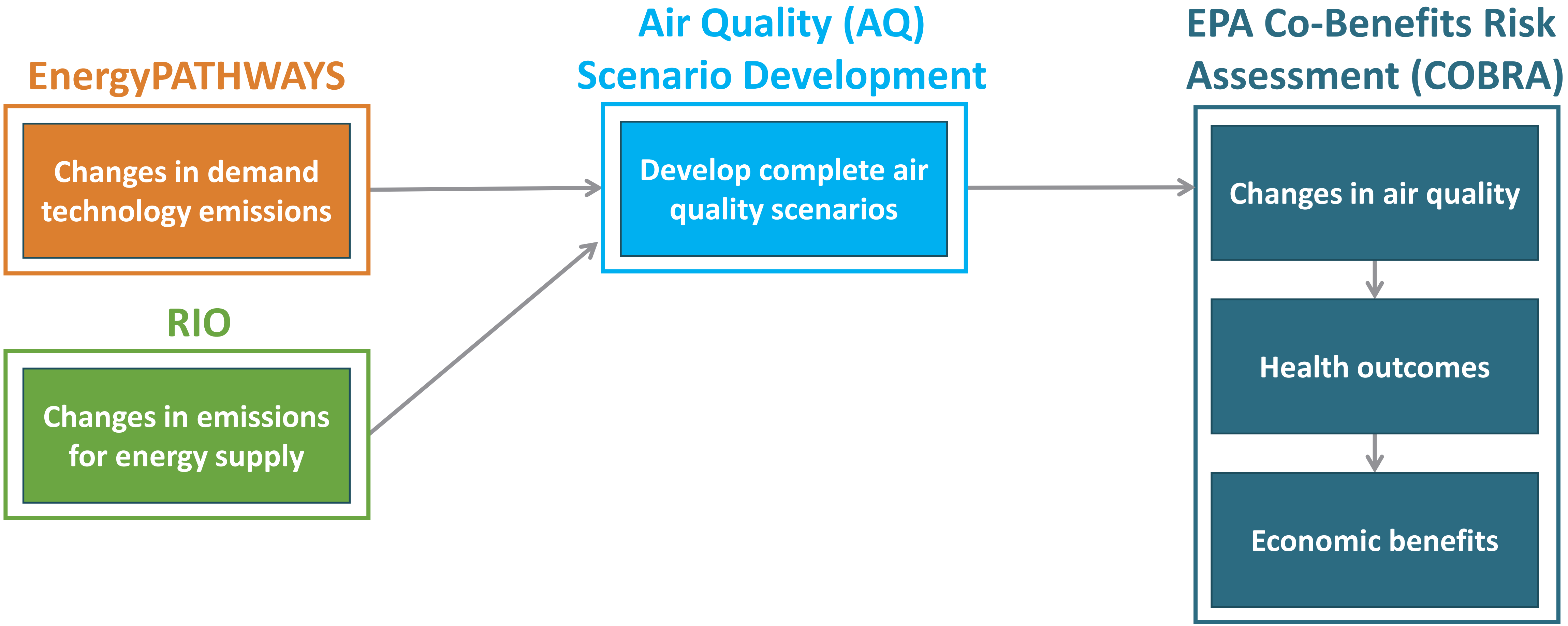
- In addition to the climate benefits of reducing greenhouse gas emissions, reducing pollutant emissions provides health benefits to Oregonians
- Air Quality analysis considers health impacts of changes in fine particulate matter (PM2.5) and secondary particulate matter such as nitrogen oxides (NOx) and sulfur oxides (SOx)

Greenhouse Gas Emissions from 1/31 Presentation by Type and Source



Note: Analysis was undertaken using the Climate Protection Program as proposed.

Air Quality Analysis Overview



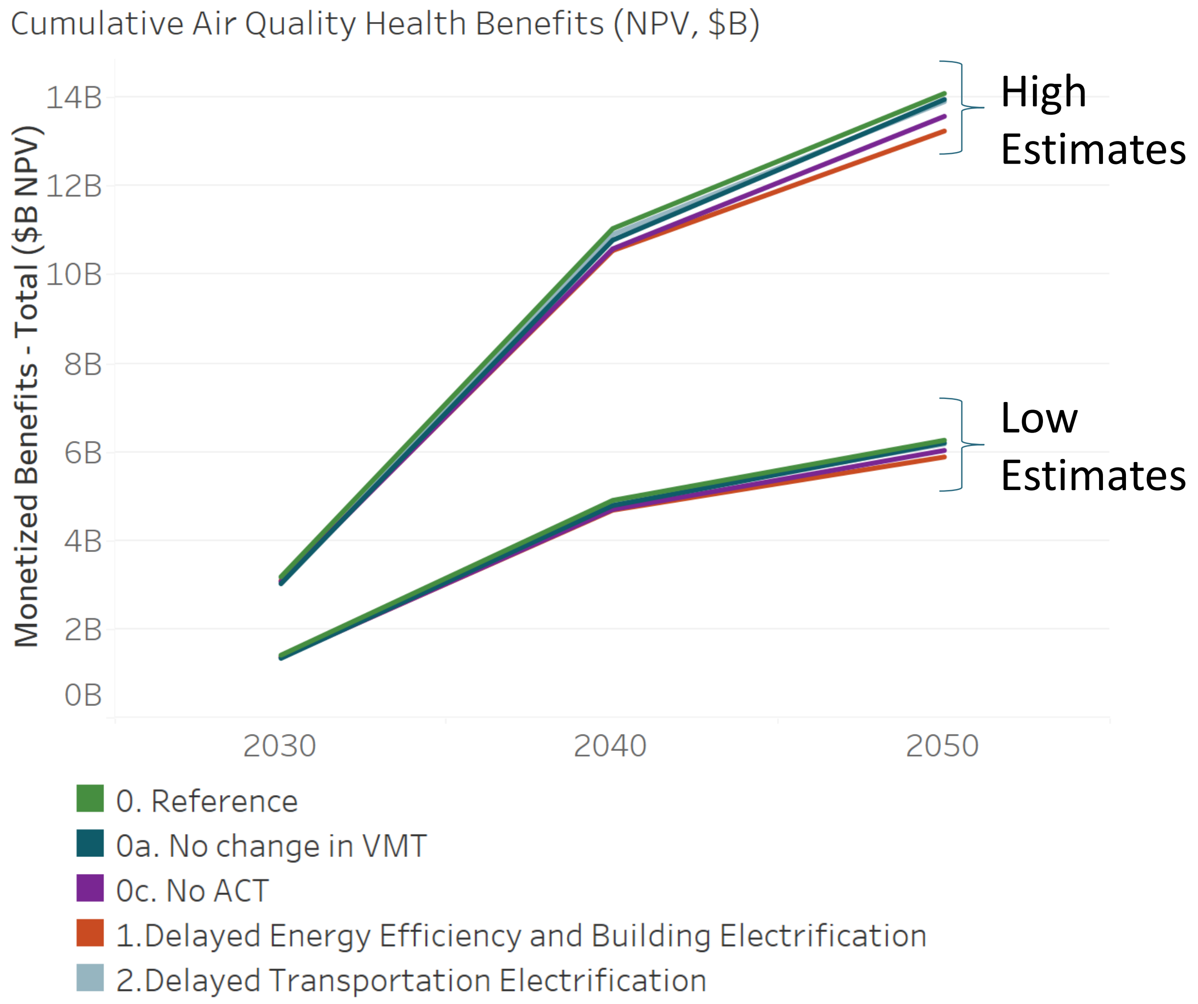
EPA COBRA: https://www.epa.gov/sites/default/files/2017-10/documents/cobra_training_eic_2017.pdf
More detailed methodology available in Appendix and in final Technical Report

Key Takeaways

- COBRA analysis indicates significant health benefits associated with achieving Oregon emissions and clean energy targets
  - Between $205M and $461M monetized benefits in 2030
  - Between $538M and $1211M monetized benefits in 2050
  - Cumulative present value benefits of $6.3B to $14.1B over the next 25 years
- Absolute benefits follow population by region, but per capita benefits are higher in the southern regions of the state
- Most monetized dollar health benefits are attributed to mortality based on the high value of a statistical life

Cumulative Benefits

- Benefits are relatively similar across scenarios
  - All achieve emissions reduction goals
- Slightly lower benefits when greater amounts of fuels are burned in buildings and industry or in vehicles
  - Delays in efficiency and electrification have worse health outcomes
- Cumulative benefits range from $6.3B to $14.1B present value
- Benefits relative to air quality in 2023



Present value calculated using a 2% societal discount rate

Impact on Health Metrics and Mortality

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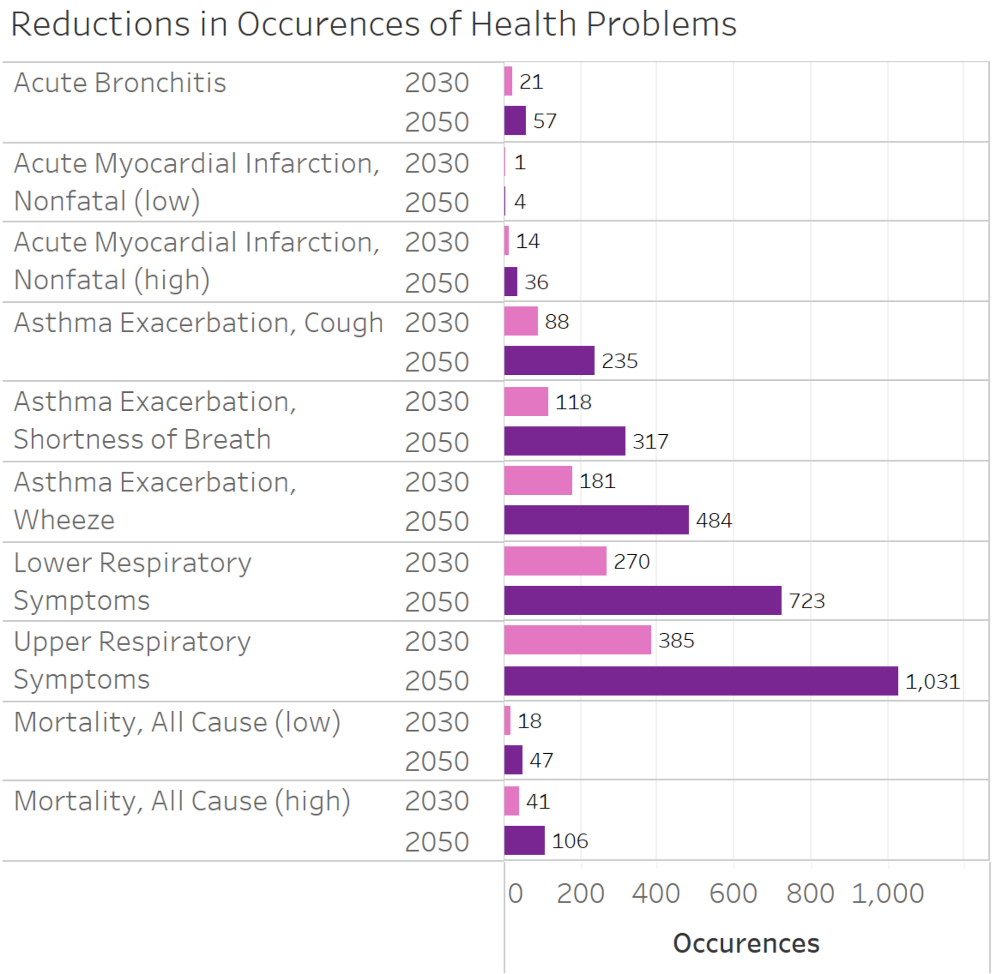
- Reduced occurrences of health problems due to reduced pollutant concentrations
- These result in economic benefits such as fewer missed workdays, fewer hospital admissions, and reduced mortality
- Reduced mortality is by far the largest economic benefit
  - Value of a statistical life (VSL) of $7.4M in 2006 dollars used by EPA
  - "How much people are willing to pay for small reductions in their risks of dying," EPA mortality risk valuation

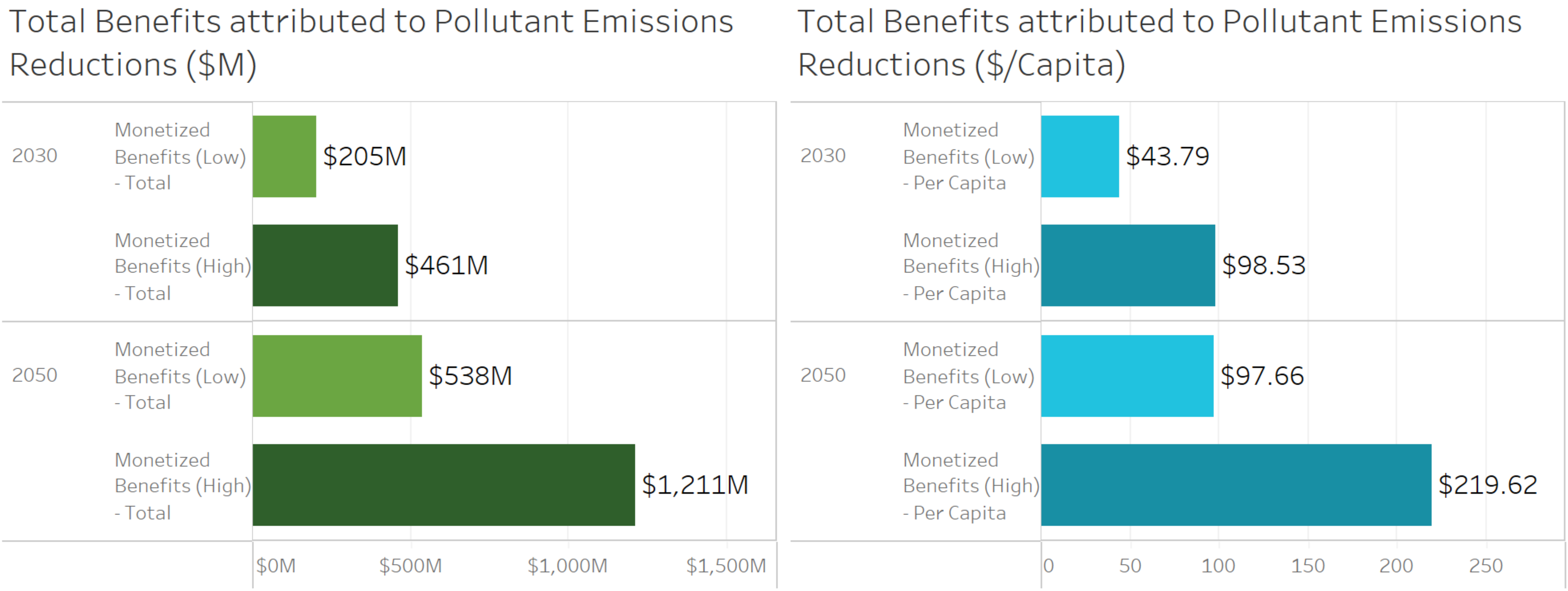


Impact on Lost Workdays, Hospital Admissions, and Mortality

- Outcomes include fewer days of work lost, hospital admissions, and mortalities

Outcomes	2030	2050
Fewer days of work lost per million people	403	918
Fewer hospital admits per million people	1.1	2.5
Fewer mortalities per million people (high)	8.7	19.3
Fewer mortalities per million people (low)	3.8	8.5

Benefits attributed to Annual Pollutant Emissions Reductions in the Reference Scenario



Total Health Benefits by Region in 2050: Reference

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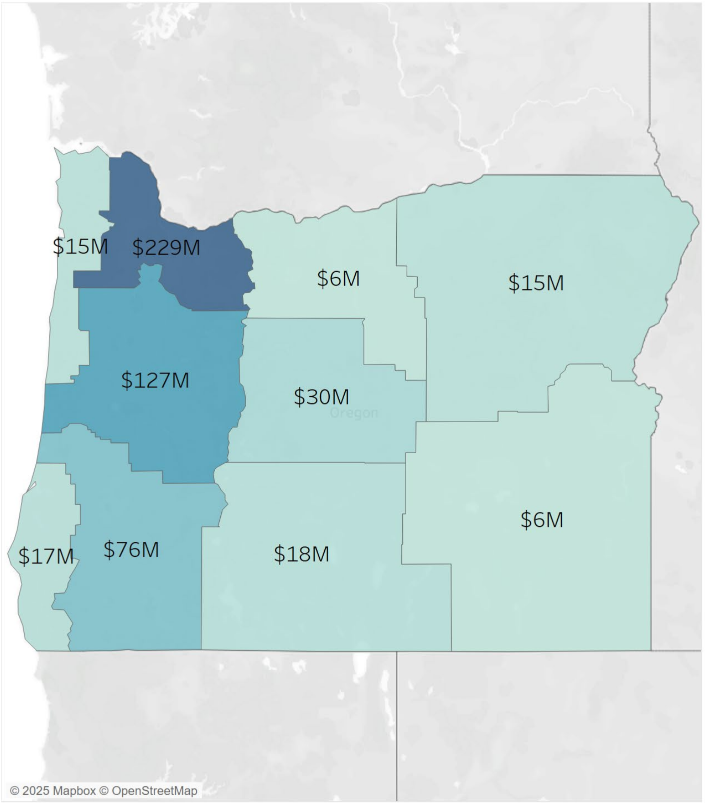
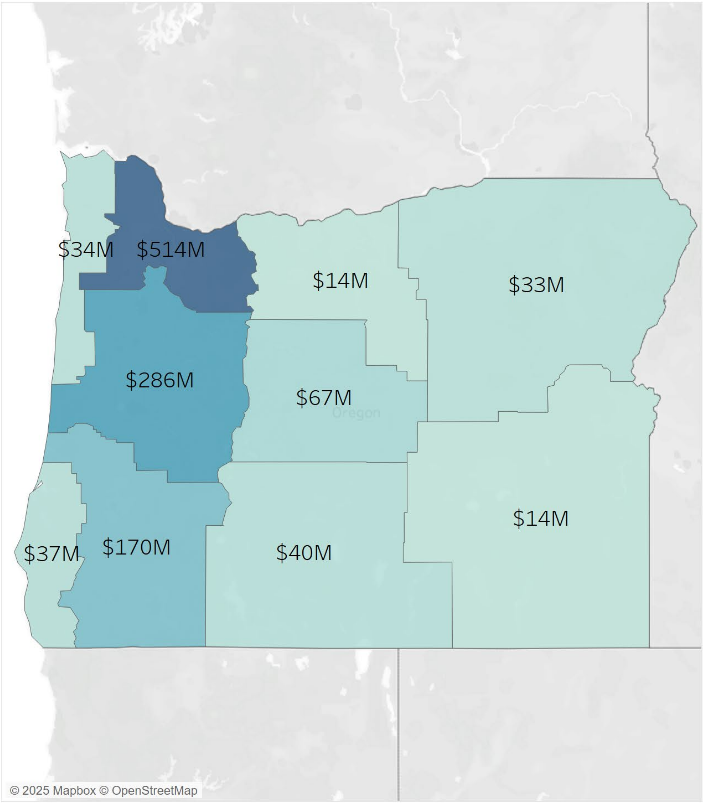
- Distribution of health benefits follows population
- Largest benefits in Portland metropolitan area
- Benefits relative to health impacts of particulate matter exposure in 2023
- Presented for AQ regions developed with the EJ and Equity working group

Total Health Benefits 2050 (Low)



Total Health Benefits 2050 (High)



Health Benefits per Capita by Region in 2050: Reference

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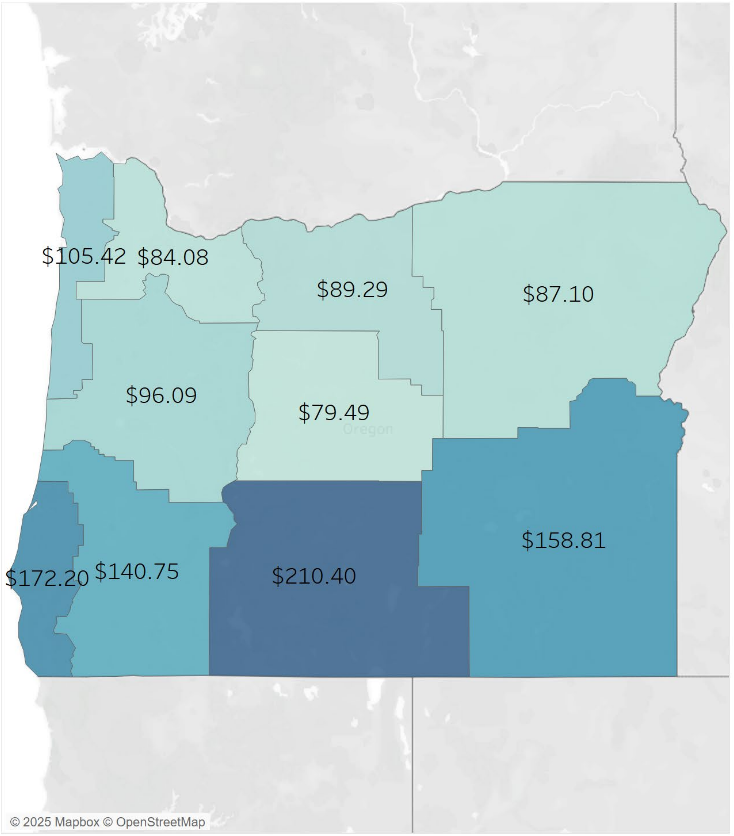
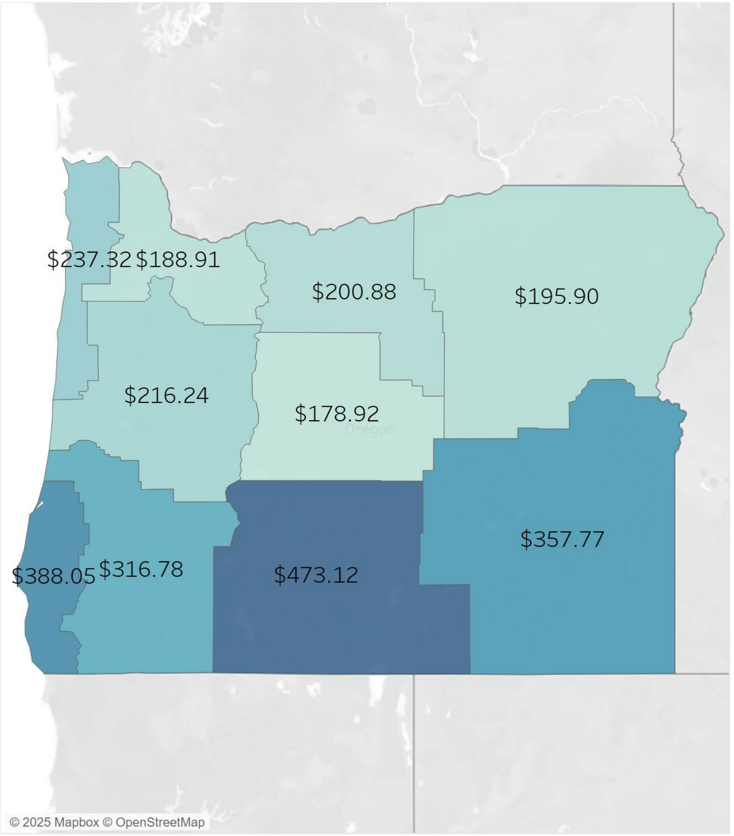
- Per capita benefits greater in the southern regions of the state
- Benefits relative to health impacts of particulate matter exposure in 2023
- ~99% of the benefits come from reduced mortality

Total Health Benefits per Capita 2050 (Low)



Total Health Benefits per Capita 2050 (High)



Particulate Matter Concentrations: Reference

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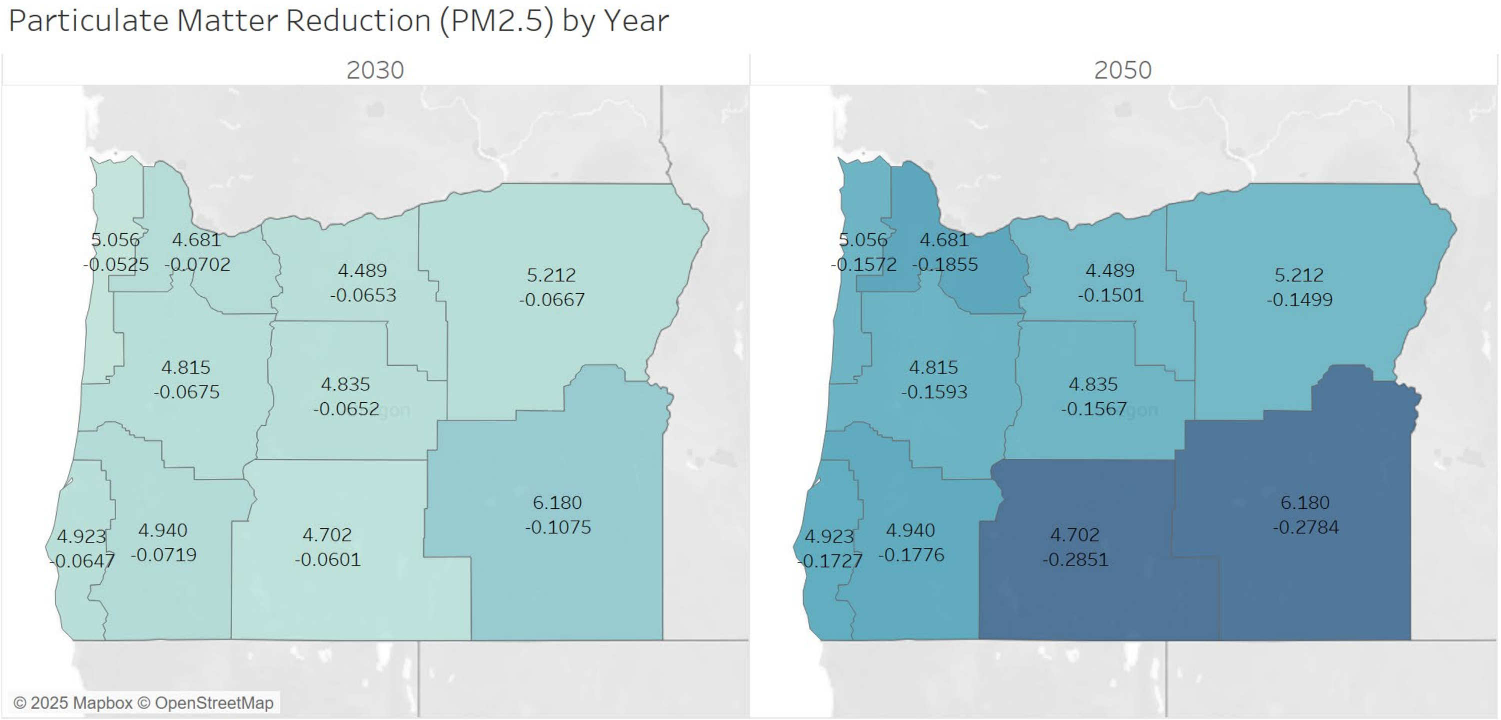
- COBRA calculates the change in PM2.5 concentrations and their impact on health outcomes
- The adjacent maps show the baseline PM2.5 concentrations in 2023 and the change in that baseline by 2030 and 2050
- The reduction in PM2.5 concentrations results in better health outcomes



Top: Baseline PM2.5 in 2023
Bottom: Change in PM2.5 from 2023 baseline

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Energy Wallet Analysis – Methodology

Energy Wallet Overview

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- Energy wallet examines a household's energy use and associated costs as they switch to an electric vehicle (EV) and heat pump
  - Includes household's use of electricity, natural gas, and gasoline
  - Includes all energy spending across fuels, as well the capital cost or savings of buying an EV or a heat pump (compared to buying other replacement technologies)
  - Analysis undertaken for five sample households

Energy Wallet Illustrates How Technology Adoption Affects Household Energy Costs

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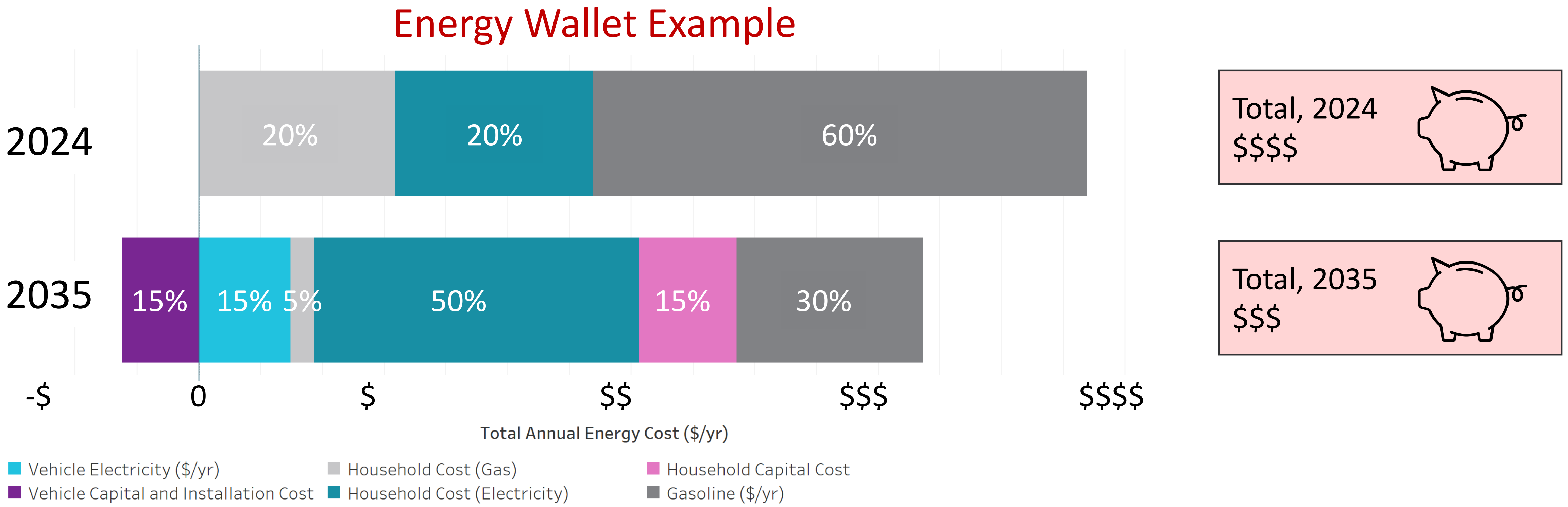
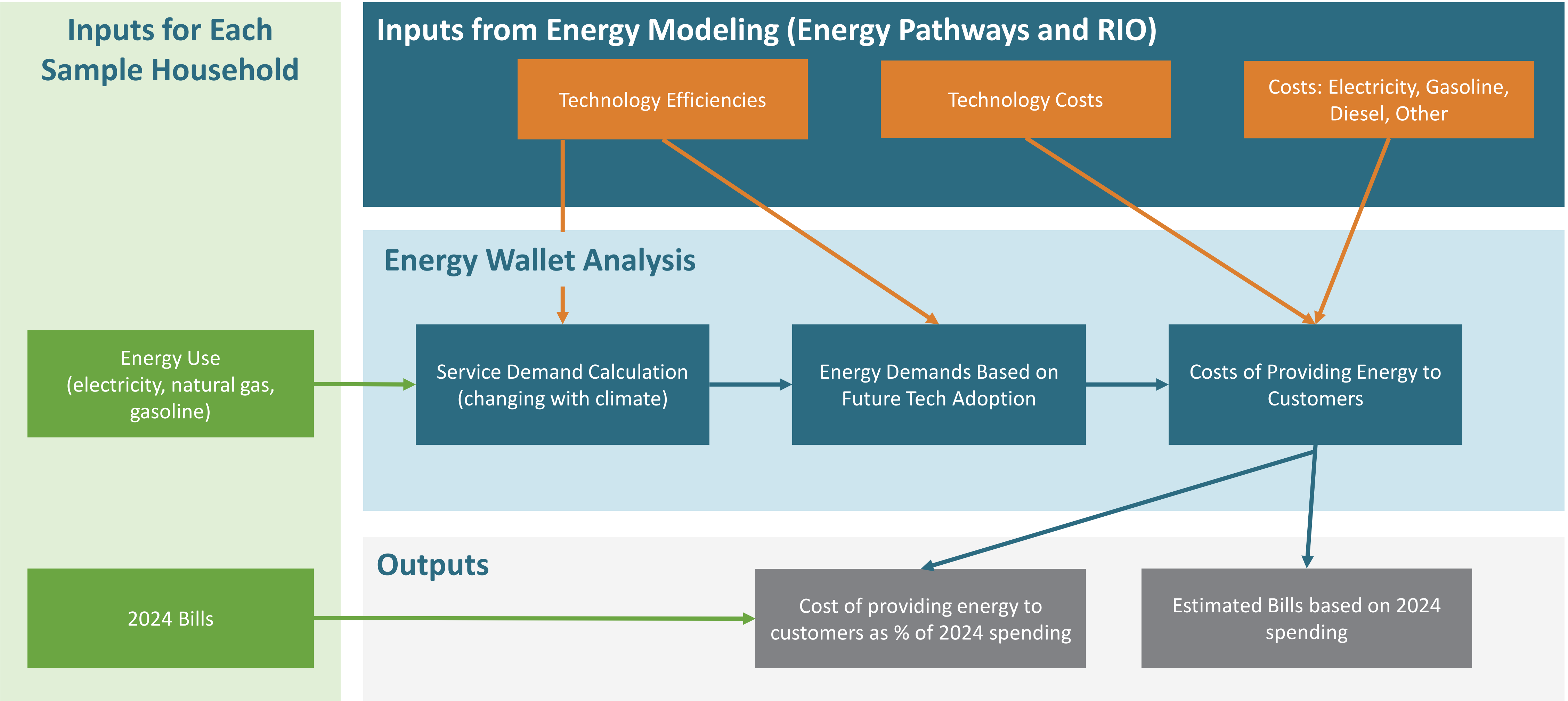
- Example household buys an EV and a heat pump in 2035. This changes their energy consumption and therefore costs. They must also pay the difference between EVs/heat pumps and conventional technologies



Key Takeaways

- All five sample households save money with vehicle electrification in most circumstances
- All five sample households save energy from electrification of home heating, but not all sample households save money from heat pump installation, absent policy support
- Multiple factors impact how great the savings could be from electrification of home heating and transportation
  - Energy prices, cost and access to technology based on household income, technological development, production and supply chain challenges
- Policies are important to enable access to cost savings
  - Education, incentive programs, infrastructure development, access to useable technology, and workforce development
- Upfront costs must be addressed to ensure equal access to the savings from electrification
  - Intentional, explicit policies that ensure environmental justice and equitable solutions are required

Energy Wallet Approach



Step 1. Defining Sample Households—Development Process

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Empathize	Define	Ideate	Prototype	Test
Working Groups— Active listening	**Identify Themes—** Understanding Needs	**Generate Ideas—** Develop Ideas for Possible Sample Households	**Identify Solutions—** Identify Sources and Data	**Partner Feedback—** Share Initial Customer Groups and Seek Feedback
(e.g., Environmental Justice & Equity, Buildings, Land Use & Natural Resources)	(e.g., energy efficiency, affordable energy)	(e.g., weatherization, rural)	(e.g., NEEA, Oregon's Ten-Year Plan)	(e.g., public comment period, working groups, advisory group)

Implement

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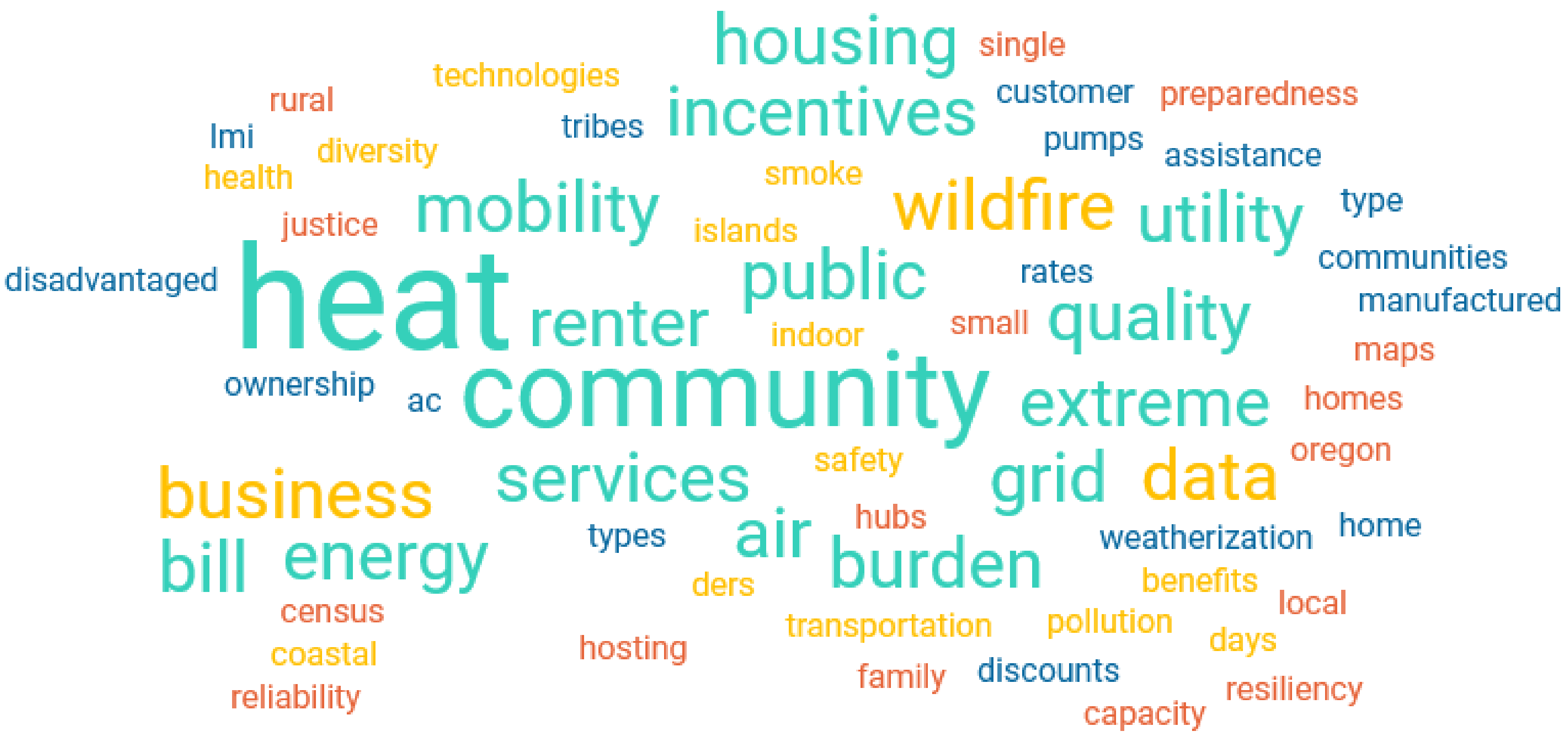
Step 1. Empathize—Word Bubble

- Example: Key themes heard in Phase 1 EJ & Equity Working Group sessions



Step 1. Define & Ideate—Understanding & Solving for the "Problem Statement"

We synthesized key themes from the Working Group sessions to develop a series of "problem" statements, outlining the issues and challenges partners aimed to solve with the sample households.

After collecting our findings, our next step was to develop ideas for possible sample households.

For example, partners expressed concerns about high energy costs for low-income families living in older, inefficient homes. Indoor air quality and safety were also high priorities.

Using this feedback, we explored how energy efficiency improvements could lower costs, enhance indoor air quality, and make homes safer.

This feedback served as a foundation for developing the "High Priority Area Homes" customer group.

Step 2. Identify Sources for Input Data to Develop Each Sample Household

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Data Inputs needed for Energy Wallet:

- Energy Consumption (electricity, natural gas) and associated costs
- Vehicle Miles Traveled (VMT)[1] and associated costs (gasoline)

From there, we worked backward to identify initial sample households that could be developed using publicly available data sources

- Initially, we identified the Northwest Energy Efficiency Alliance's (NEEA) 2022 Residential Building Stock Assessment (2022 RBSA) as a valuable starting point for defining sample households based on building type.
- This consideration is based on NEEA's extensive regional data, which includes, but is not limited to, building types, location, energy consumption, utility information, and equipment-level data.

1. VMT by county from the Housing and Transportation (H+T) Affordability Index: https://htaindex.cnt.org/

Step 3. Meet the Five Sample Households

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Household Characteristic	Jessica's	Stephanie's	Ruchi's	Alan's	Hugh's
					
Building Category	Single Family Detached	Single Family Detached	Single Family Detached	Single Family Manufactured	Multi-family
Region	Urban	Rural Cold Climate	High Priority Area	Rural	Urban
Ownership	Own	Own	Own	Rent	Rent, Below county AMI
Primary Heating Fuel Type	Natural gas	Natural gas	Electricity	Electricity	Electricity
Primary Heating System	Furnace	Furnace	Furnace	Furnace	Baseboard
Primary Cooling System	Central AC	None	Portable AC	Window AC	None
Water Heater Technology	Fossil Fuel Non-Condensing	Fossil Fuel Non-Condensing	Electric Resistance	Electric Resistance	Electric Resistance
Water Heater Fuel	Natural gas	Natural gas	Electricity	Electricity	Electricity
Area (sq ft)	3100	1855	1400	1520	-
Year	2012	2006	2007	1986	1977
Stove/Oven	Natural gas	Natural gas	Electric	Electric	Electric
Occupants	6	4	2	2	2
Vehicles	2 SUVs	2 SUVs	2 SUVs	2 Cars	1 Car

Step 3. Sample Households Energy Consumption

Annual Household Usage	Jessica’s	Stephanie’s	Ruchi’s	Alan’s	Hugh’s
					
Electricity (kWh)	**9,920**	**6,364**	**15,487**	**18,330**	**8,964**
Space heating	-	-	3,954	6,777	3,151
Water heating	-	-	2,754	2,759	1,712
Air conditioning	2,168	-	2,181	2,184	-
Other	7,752	6,364	6,599	6,610	4,101
Natural Gas (therms)	**821**	**1,023**	**-**	**-**	**-**
Space heating	430	712	-	-	-
Water heating	314	250	-	-	-
Other	76	61	-	-	-
Vehicle Miles Traveled (VMT)	**16,823**	**22,113**	**19,833**	**20,743**	**13,555**

Uncertainties Underpin the Analysis

Input to the Analysis	Uncertainty
Electricity rates: $0.10/kWh, $0.15/kWh, $0.20/kWh, $0.40/kWh • 2024 rates estimated to range between $0.10/kWh and $0.20/kWh. We also looked at a high electricity rate, double the highest estimate in 2024 at $0.40/kWh	• T&D infrastructure cost changes over time are uncertain and will have an effect on electricity rates • Electric vehicle economics are relatively insensitive to higher electric costs • Heat pump economics are more sensitive
Gas rates: $1/therm, $1.25/therm, $1.50/therm • 2024 rates estimated to range between $1/therm and $1.50/therm • Conservatively assumed no higher gas rates, presenting a lower bound on the economic benefits of heat pump adoption due to avoided gas bills	• Large uncertainties on future gas costs as volumes decrease • Will there be a managed decommissioning of gas infrastructure or will infrastructure costs remain similar to today, recovered from fewer and fewer natural gas sales? • How will costs be recovered? Cost recovery across electric rates? Through taxes? Fully though gas sales? Low-income rates?
Gasoline rates: $3.79/gallon • Held flat at today's gasoline price	• Large uncertainties on gasoline prices • Exposure to global market volatility • Refining and delivery network costs for lower gasoline volumes
Costs for appliances and vehicles: ACEEE and ICCT • Assumed average cost from databases, American Council for an Energy Efficient Economy (ACEEE) and the International Council on Clean Transportation (ICCT)	• Capital costs play a large role in customer economics • Large distribution around reported costs, particularly for heat pumps
Efficiencies: EPA and EIA • Assume miles per gallon (MPG) of internal combustion engine (ICE) vehicles increases in the future. Forecasted heat pump efficiency improvements	• Forecasted efficiency improvements in conventional internal combustion engine (ICE) vehicles and heat pumps have both technological and policy uncertainties

Cost Assumptions for EVs

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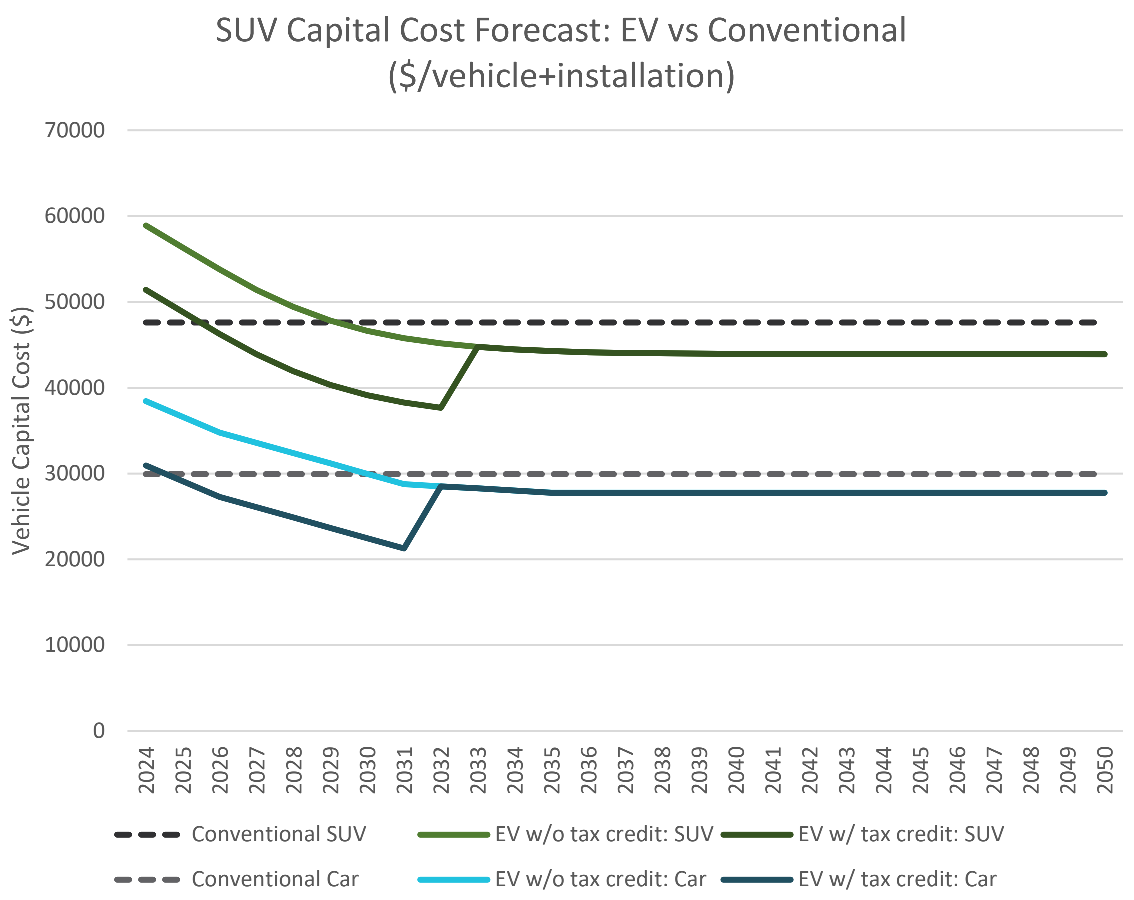
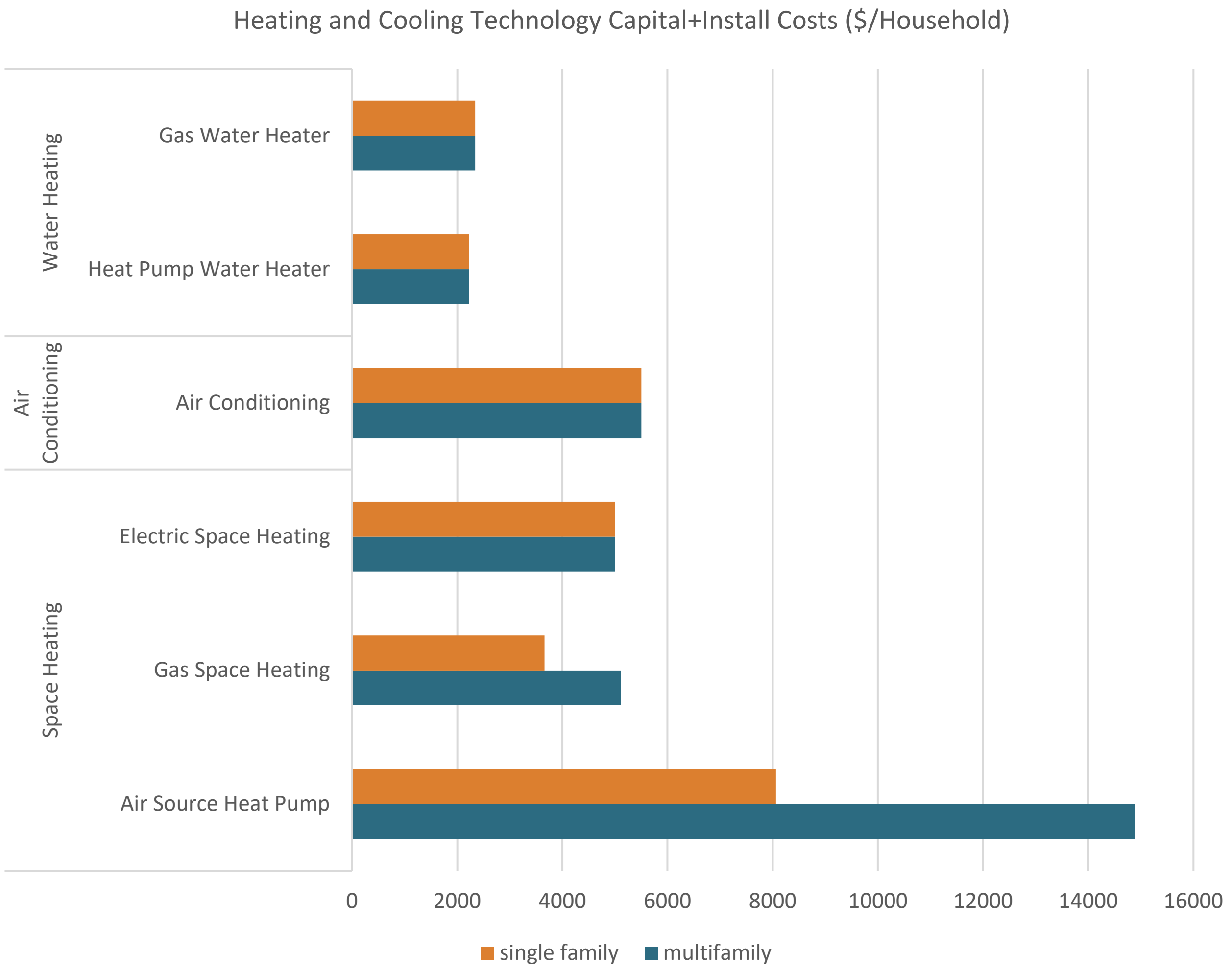
- Vehicle cost assumptions from ICCT
  - theicct.org/wp-content/uploads/2022/10/ev-cost-benefits-2035-oct22.pdf
- SUVs
  - Without Inflation Reduction Act (IRA) tax credits, the capital cost crossover point is forecasted for 2029
  - With IRA, the crossover point is forecasted for 2026
- Cars
  - Without IRA tax credits, the crossover point in 2030
  - With IRA, the crossover point is 2025



Cost Assumptions for Heat Pumps

- Heating and cooling technology costs from ACEEE
  - https://www.aceee.org/sites/default/files/pdfs/b2205.pdf
- Large uncertainties in installed costs for heating and cooling. We use these costs recognizing they can vary significantly household to household



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Vehicle Purchases

Fundamentals

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- Assumes gasoline prices at the pump remain flat at $3.79/gallon
- All technology replacements assumed to happen at the end of useful life
  - For example, households replacing a vehicle in 2030 assumed to have bought their previous one in 2016 assuming a 14-year lifetime
  - Replaced technology has the average efficiency from the year of purchase
- Where households have 2 SUVs or 2 cars, both contribute half of the total household VMT
- Vehicle and household technology financing assumes a 7% loan rate over seven years
- The following vehicle results assume no heat pump purchase
  - When heating and cooling systems come to the end of their lives, they are replaced with the same, but more efficient technology, because it’s newer

Transportation Electrification is the biggest opportunity for energy wallet savings

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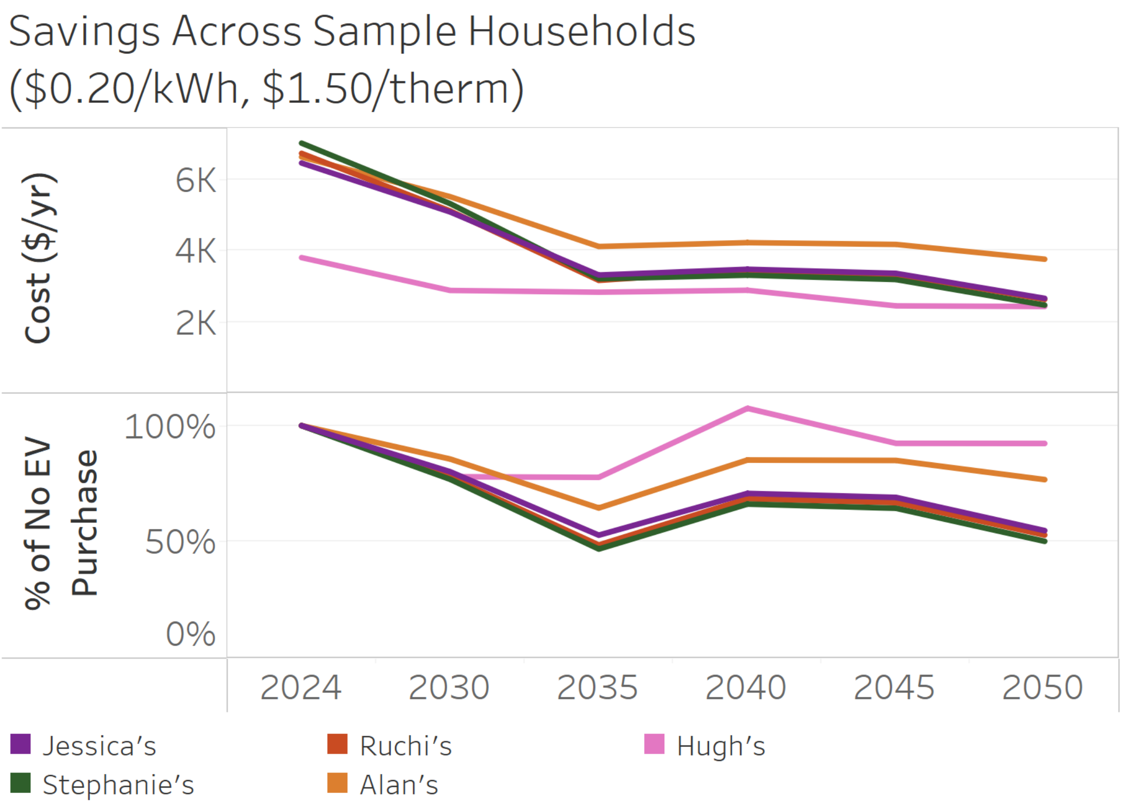
- With electricity at $0.20/kWh, all households experience savings if replacing their 2 vehicles with an EV in 2030 and 2035 (1 vehicle in 2030 for Hugh's household)
  - Assumes customers do not receive IRA credit for either vehicle
  - Overall energy related spending reduced by up to 52%. Includes the capital cost savings of buying an EV rather than an internal combustion engine vehicle
  - Assumes Hugh's charging happens 80% outside of the home at a rate of $0.43/kWh. Hugh's household could make higher savings with more home charging
- % of No EV Purchase compares energy costs to households retaining an ICE across all years



Vehicle electrification saves money even at higher electricity rates

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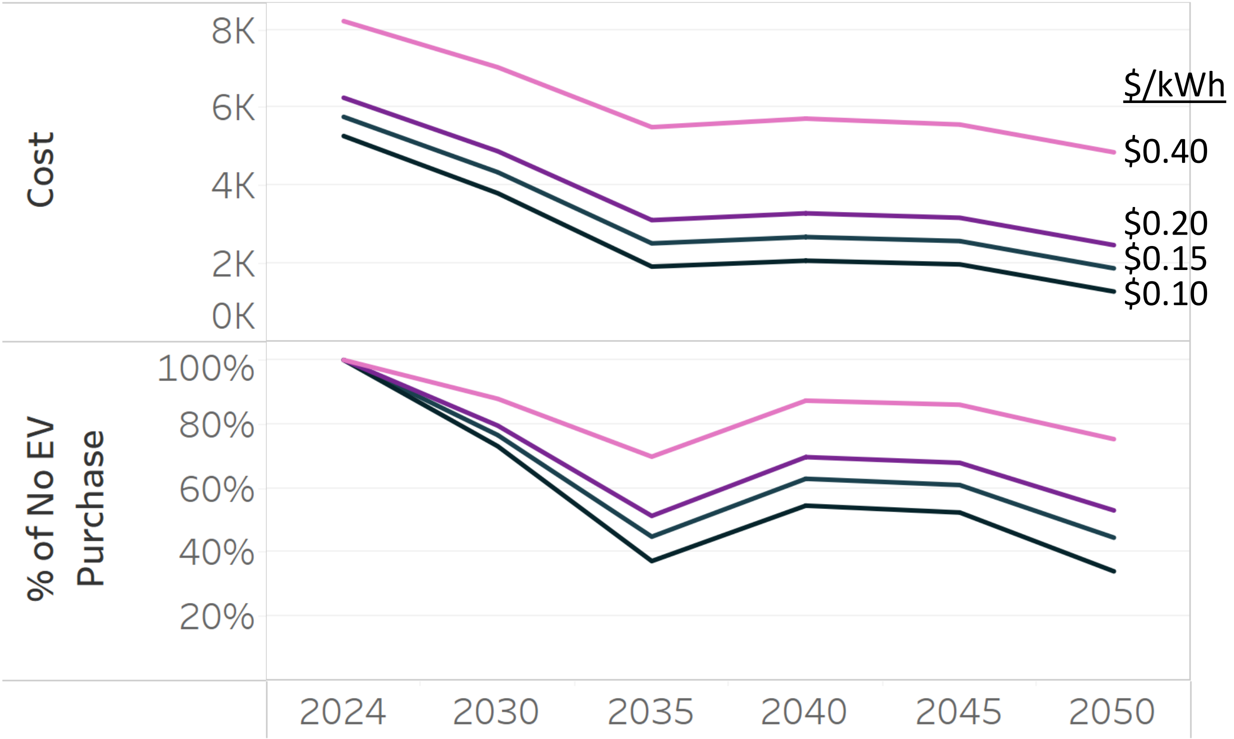
- Focusing on Jessica's single-family home, under varying electric rates she is still better off purchasing an EV than an ICE
- Caveats
  - Compares purchasing a new EV with a new ICE. This may not be the decision a customer makes
  - Cost assumptions on vehicle capital cost and gasoline prices are uncertain

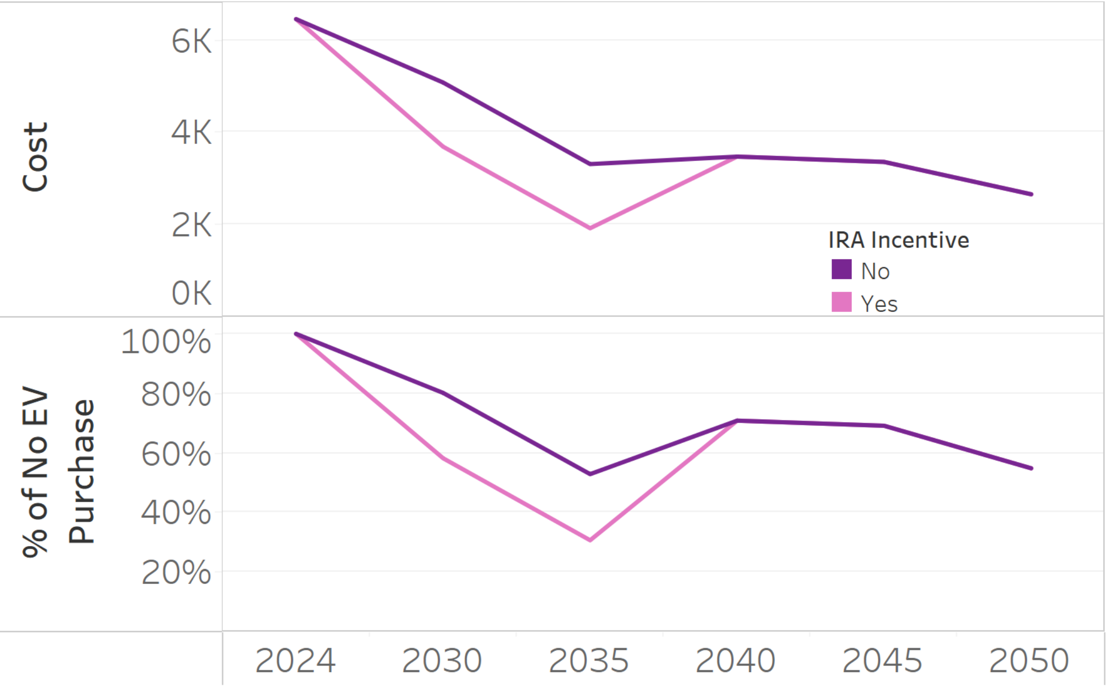
Jessica's savings of EV purchase in 2030 and 2035 with different electric rates



IRA tax incentives help with upfront capital cost

- Focus: Jessica buying one EV in 2030 and another in 2035, at an electric rate of $0.20/kWh and a gas rate of $1.50/therm
- Tax incentive has a large effect, though the EV purchases remain cost effective
- No vehicle cost sensitivities analyzed, but this shows that savings are sensitive to vehicle capital cost

Jessica's savings of EV purchase in 2030 and 2035 with different tax incentives



Vehicle electrification saves money for every household we analyzed

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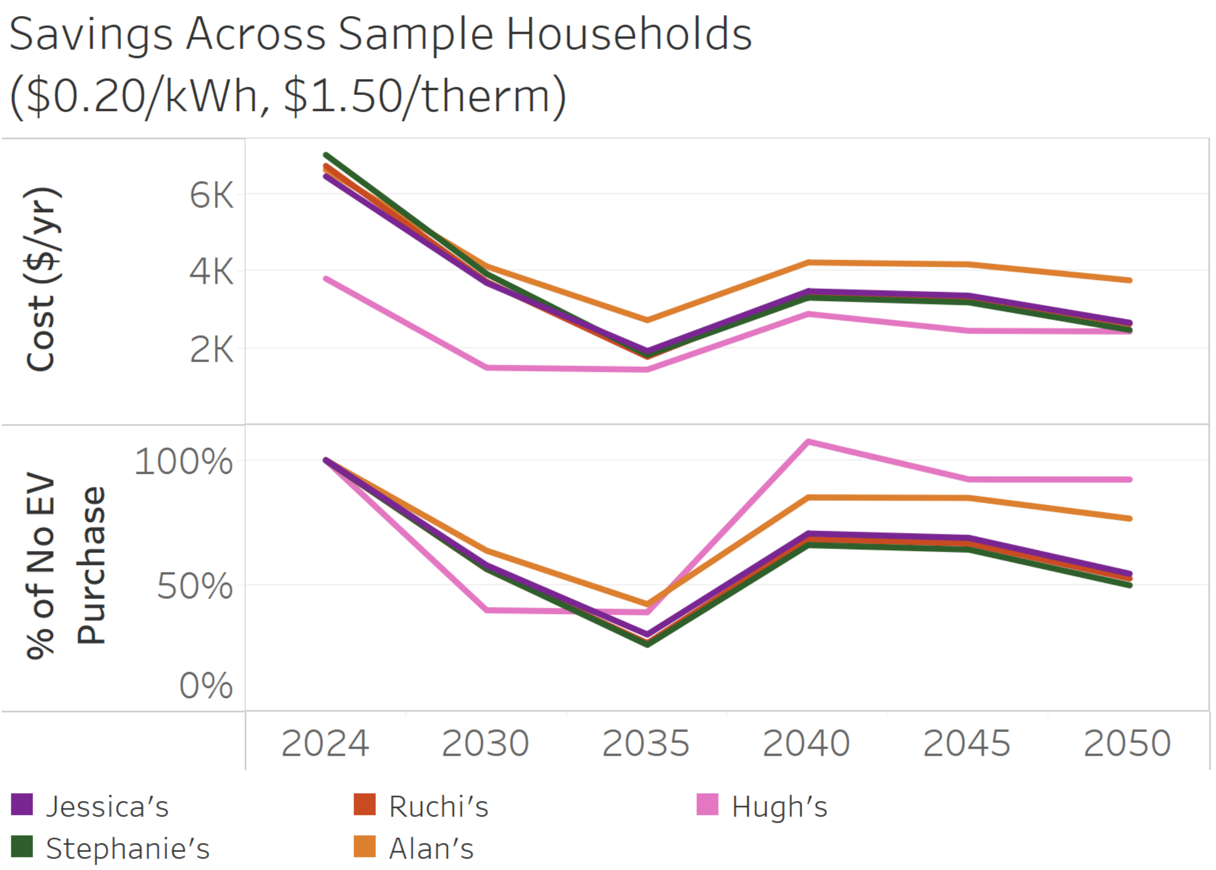
- Households with $0.20/kWh electricity, replacing with EVs in 2030 and 2035 (1 car in 2030 for Hugh), and receiving the IRA tax credit
  - Assumes a vehicle loan period of 7 years resulting in a difference of $2,190/yr in car payment in 2035 across 2 vehicles
- Hugh's energy spending at his rental unit is lower than others, and gasoline makes up more of his energy use, so the cost of charging (public or not) has outsized effects



The year of EV purchase matters

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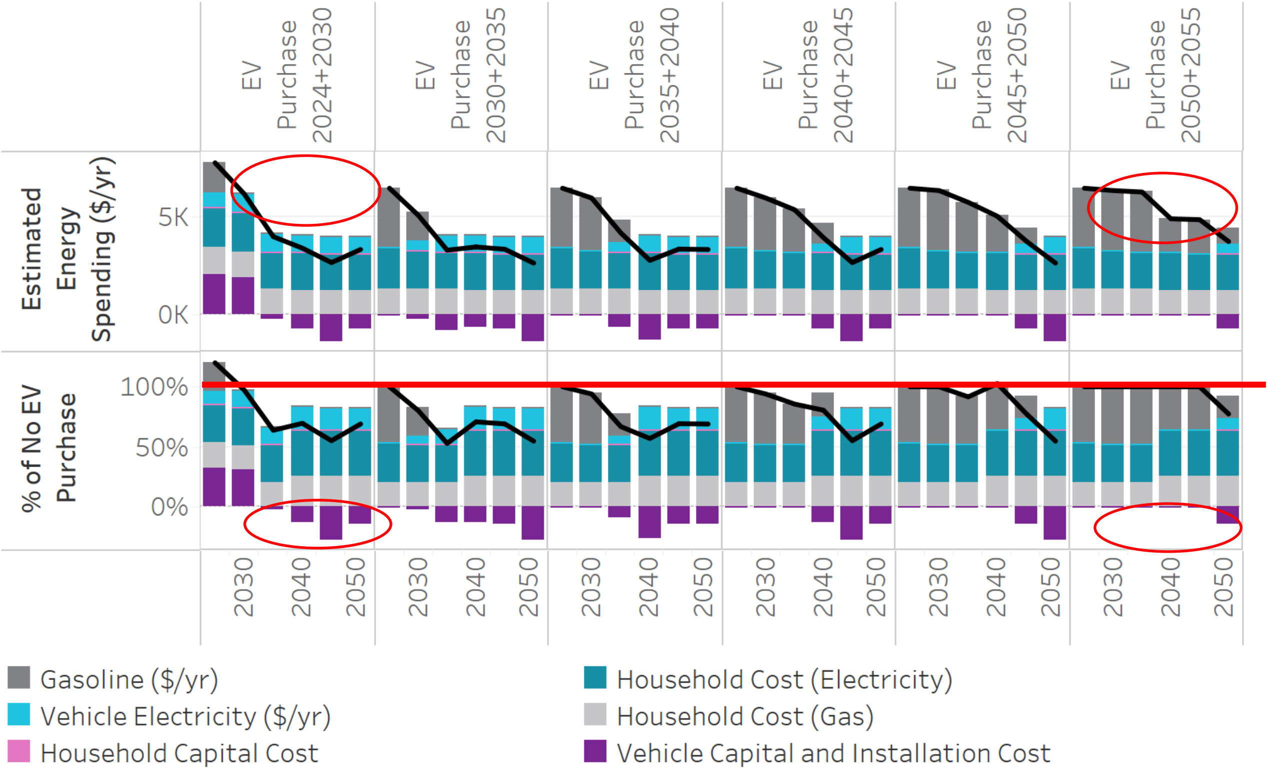
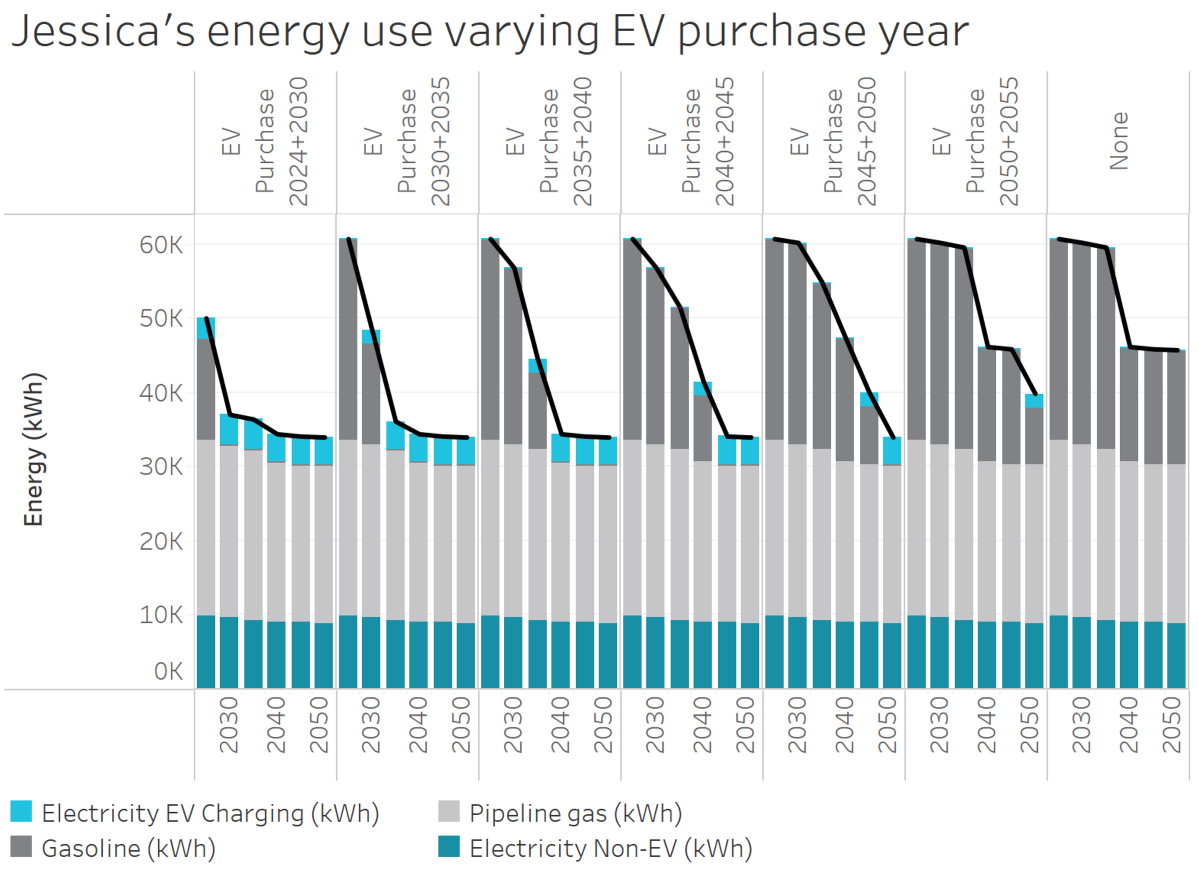
- Focus: Jessica's household at an electric rate of $0.20/kWh, $1.50/therm, no IRA tax incentive, and no heat pump purchase
- Replacing with an EV in 2030 and 2035 is most cost effective than replacing later
- Replacing with an EV in 2024 was not cost effective due to the currently higher EV capital costs
  - Whether this is possible depends on age of current vehicle and capital cost

Jessica's estimated energy spending based on EV purchase year ($0.20/kWh, $1.50/therm, No IRA)



EVs significantly reduce energy demand

- Electric motor efficiency significantly reduces customer demand for transportation energy
  - Assuming EV: 98 mpge vs ICE: 26 mpg in 2024, and EV: 119 mpge vs ICE: 31 mpg in 2030 for an SUV
- Reduced gasoline use from 2 EV SUV purchases cuts Jessica's total energy use by ~37% in 2035 and ~24% in 2050 relative to continuing to drive ICEs
- Hugh's demand reductions are even greater at up to 55%



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Heating and Cooling

Fundamentals

- All technology replacements assumed to happen at end of useful life
  - For example, households replacing a furnace in 2030 assumed to have bought their previous one in 2012 assuming an 18-year lifetime
  - Replaced technology has the average efficiency from the year of purchase
- Households can replace space heating, water heating, and air conditioning services with heat pumps
- Household technology financing assumes a 7% loan rate and a 7-year term
- The results in this section assume our households make no EV purchase between now and 2050
- Natural gas rates are assumed to remain flat between now and 2050 (at 3 different levels tested). This is conservative, likely forming a lower bound on benefits of heat pump adoption

Significant energy savings across all households regardless of heating technology and fuel

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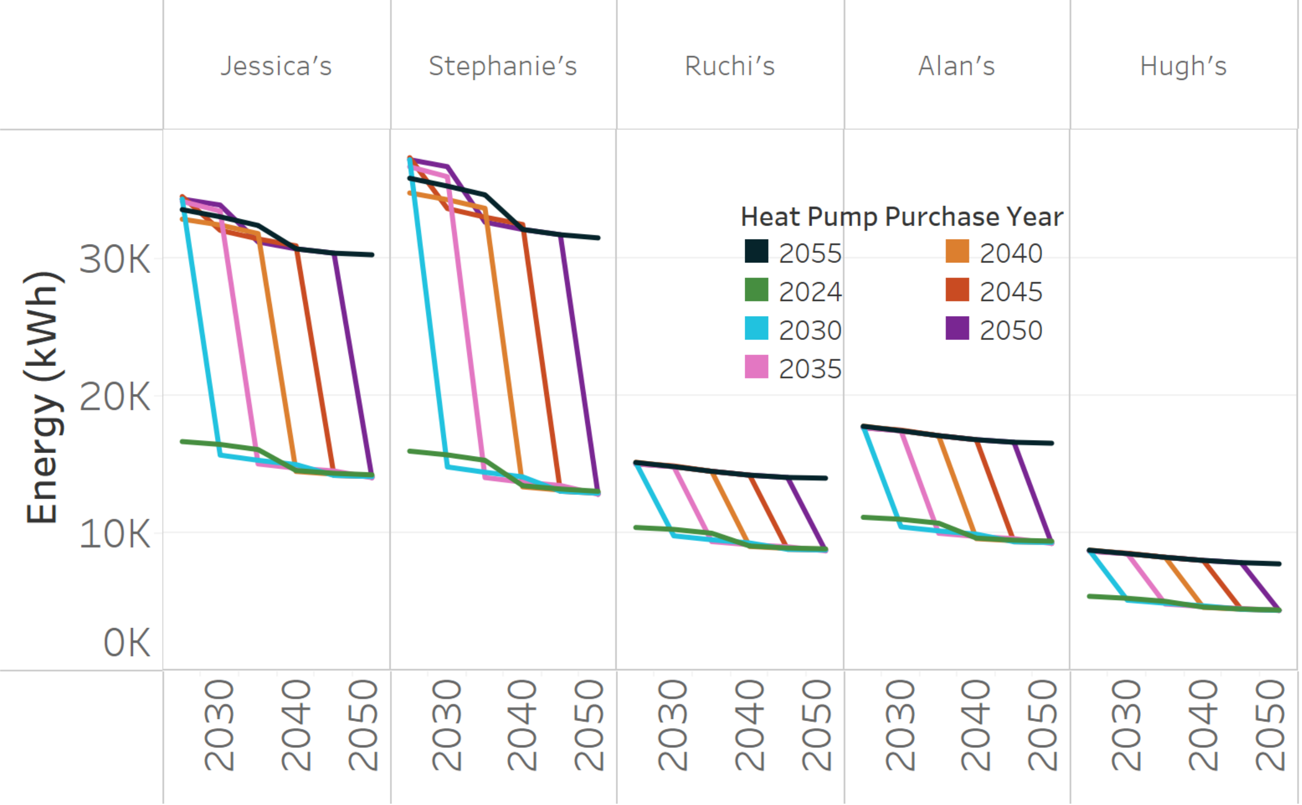
- Energy use for heating and cooling declines significantly regardless of the starting technology
- Newer vintage technologies have greater efficiency across technologies, contributing to a downward trend even with no HP purchase
- When a customer can install a heat pump depends on when their current equipment reaches end of life

Energy use excluding vehicles by year of heat pump purchase



Heating cost uncertainty: Savings of heat pumps are rate and technology dependent

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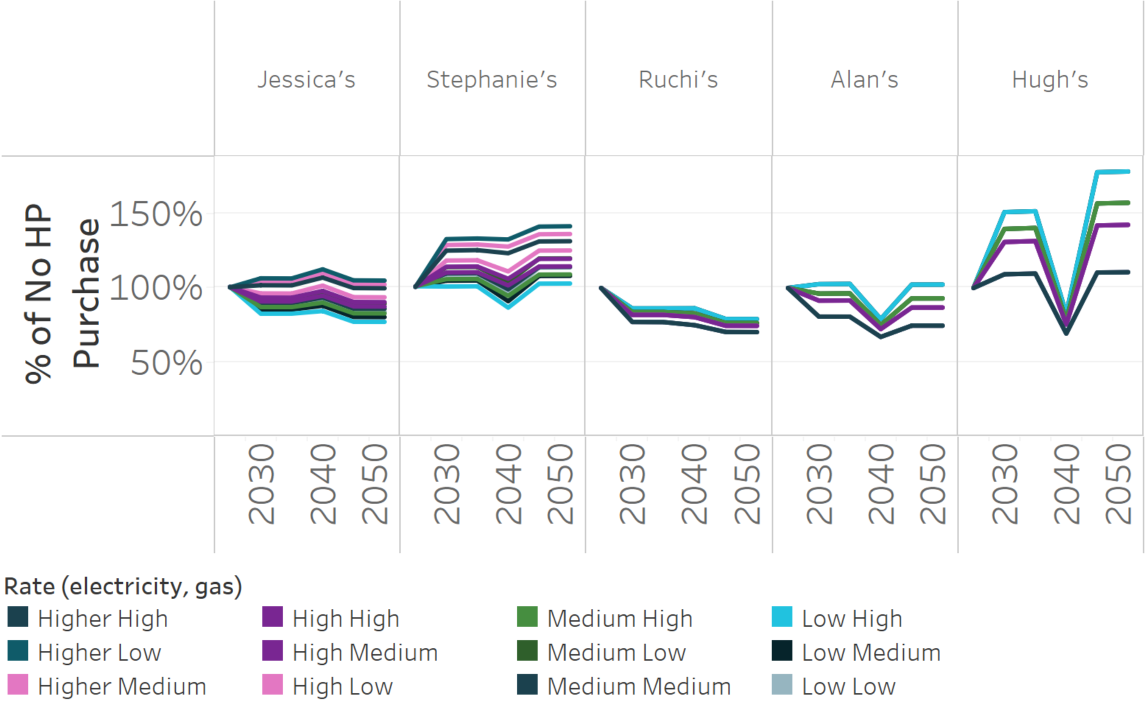
- Whether a heat pump saves a household money or not depends on rate, technology, and service demand
- Customers with electric heat save under all rates, the greatest savings under the highest electric rates
- Households with gas heating save the most under the lowest electric rates
  - Jessica's household saves in all but the "higher" electric rate
  - Stephanie's household does not have AC so doesn't receive the benefits of avoiding an AC purchase with a heat pump
- Hugh's rental unit has high costs for installation ($14,900/unit) and struggles to save even at the highest electric rates

2030 HP purchase estimated bills as % of no HP purchase (assumes no EV purchase)

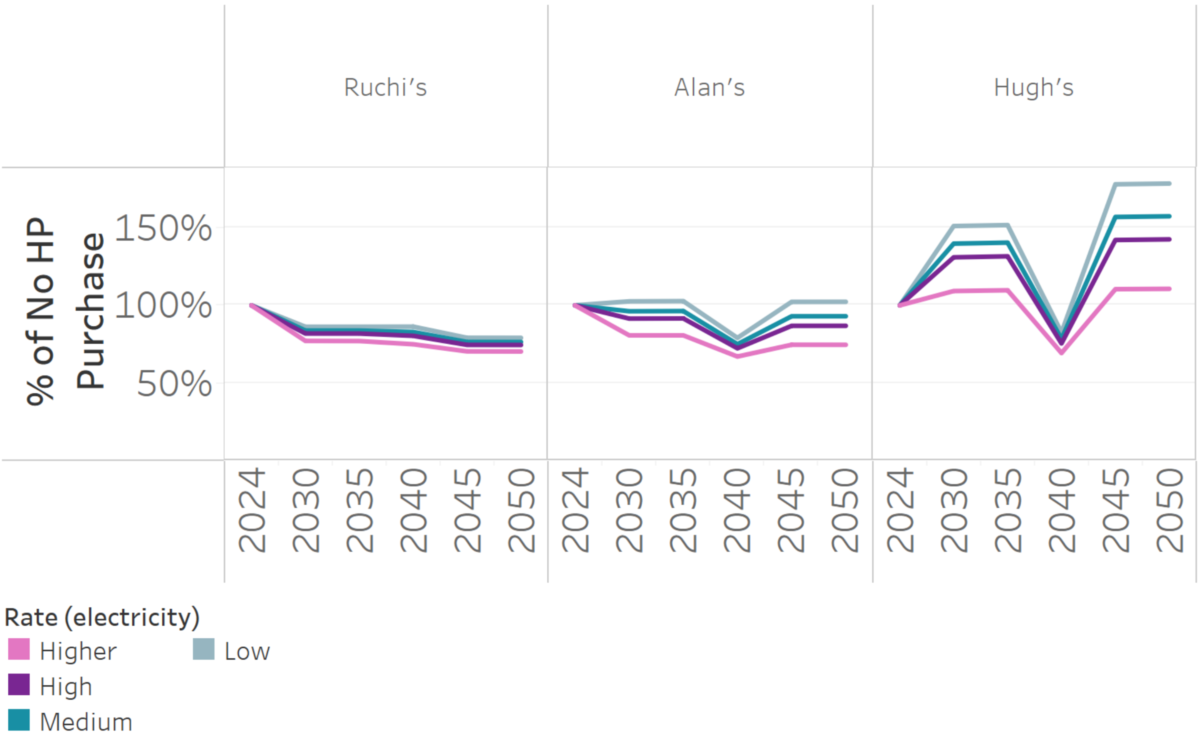


Note: Spike downwards is in years when customers do not have a loan payment to make on heat pump equipment

Households heating with electricity likely to save money with heat pumps

- Heat pump efficiency far exceeds that of resistance heating
- Assuming ACEEE average technology and installation costs, Ruchi's and Alan's households save money
  - This does not factor in the large distribution of costs that will vary household by household
- Multifamily ACEEE costs are much higher, assuming retrofit challenges in multifamily buildings, making all but the "higher" electricity rate more expensive for Hugh's household
  - Shows savings are sensitive to capital cost

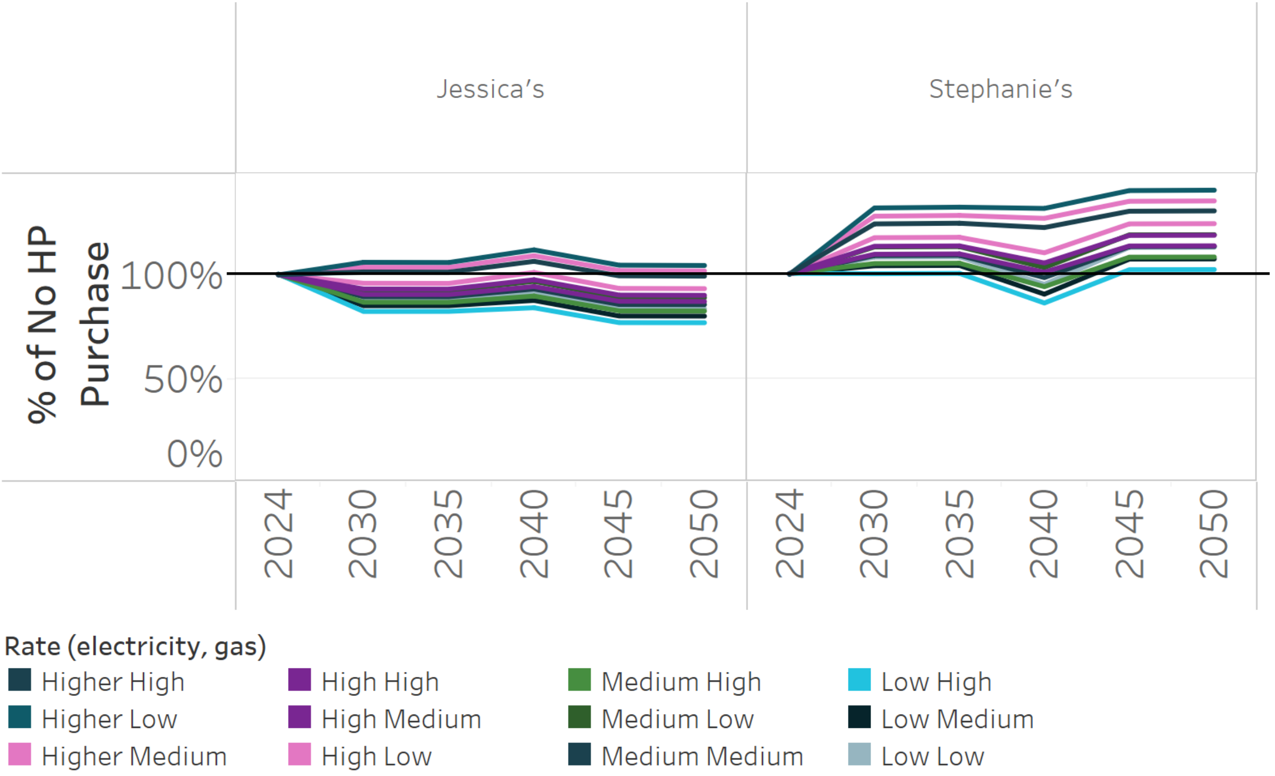
2030 HP purchase estimated bills as % of no HP purchase (assumes no EV purchase)



Savings for households with gas depend on rates

- Savings for homes with gas depend on both the gas rate and the electricity rate
- Households like Jessica's with both heating and AC save in most cases, assuming ACEEE costs
  - Higher gas rates/lower electricity rates are more favorable
- Households without AC like Stephanie's are less likely to save money when switching to heat pumps
  - However, homes without AC installing heat pumps will likely benefit from new AC service

2030 HP purchase estimated bills as % of no HP purchase (assumes no EV purchase)



What if electricity or gas rates are higher in the future?

- This analysis looked at a range of rates, including an electric rate that is double the high end of the estimated range of rates in Oregon in 2024
- There is considerable uncertainty on rates in the future, including how the fixed costs of gas service are recovered over fewer total gas sales
  - If these are recovered through increases in gas rates over time, savings from heat pumps will be greater and incentivize heat pump installations
  - Increases in gas rates may burden households that cannot afford the capital cost of a heat pump
- Households where heat pump installation costs are lower can protect against future gas price uncertainty with heat pump installation
  - Even in the case where electricity rates are double the estimated 2024 top end rate, and gas prices are low, costs for Jessica's household are similar to not purchasing a heat pump whereas the savings with higher gas rates and lower electric rates are significant

The large distribution of install costs will make heating benefits/costs household specific

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- This study uses ACEEE costs of $8,060 for a single-family home and $14,900 per unit for a multifamily home
  - These are averages from past installations; however, the range of costs is large
  - The most favorable homes have re-purposable equipment and construction that is easy to retrofit
  - The most favorable homes may be disproportionately represented in past installs
  - Some households pay significantly more for installed heat pumps
- Higher capital costs reduce the benefits
  - These benefits are household specific

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Conclusions

Conclusions

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- Purchasing an electric vehicle saves money in almost all cases
  - Even if electricity costs $0.40/kWh
  - Customers are better off purchasing an EV earlier vs later starting in 2030, even if households do not receive IRA tax credits
  - Policy that explores readiness for vehicle adoption with charger infrastructure as well as business models for customer financing could support EV adoption
- Heat pump adoption lowers energy use, but cost effectiveness is dependent on several factors
  - Relative electric and gas rates affect the decision. For Jessica's household with air conditioning and gas heating, heat pump adoption is cost effective in most cases modeled and protects against uncertain gas rate increases in the future at ACEEE costs
  - The broad range of heat pump installation costs affects cost effectiveness
- Upfront costs must be addressed to ensure equal access to the savings from electrification
  - Many buy their vehicles on the secondhand market. Stretching the lifetime of older vehicles and heating equipment may be more affordable than replacing
  - Intentional, explicit policies that ensure environmental justice and equitable solutions are required

Biggest challenges

- Vehicles
  - EV purchase prices are assumed to decrease over time whereas ICEs remain steady
    - This could be affected by technological development, trade policy, commodities markets etc.
  - Charging infrastructure is needed to make large scale adoption viable
    - Rate of builds have been slower than expected to date. Challenges with T&D infrastructure support
  - Capital costs of a new vehicle may not be the decision that many households are making
- Buildings
  - The range of capital costs is broad and building specific
  - Savings are dependent on uncertain future rates
  - High capital costs and split incentive problem for renter

Key Takeaways

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- All five sample households save money with vehicle electrification in most circumstances
- All five sample households save energy from electrification of home heating, but not all sample households save money from heat pump installation, absent policy support
- Multiple factors impact how great the savings could be from electrification of home heating and transportation
  - Energy prices, cost and access to technology based on household income, technological development, production and supply chain challenges
- Policies are important to enable access to cost savings
  - Education, incentive programs, infrastructure development, access to useable technology, and workforce development
- Upfront costs must be addressed to ensure equal access to the savings from electrification
  - Intentional, explicit policies that ensure environmental justice and equitable solutions are required

THANK YOU

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Appendix

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Air Quality

Benefits Analysis: Health Impacts

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- U.S. Environmental Protection Agency (EPA) CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA) Analysis
- Health impacts of particulate matter from air pollutants including nitrogen oxides (NOx), sulfur oxides (SOx), and direct fine particulate matter emissions (PM2.5)

Air Quality Results from Evolved Models

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EnergyPATHWAYS

Demand technology emission changes

- Database of emissions factors for NOx, PM2.5 and SOx from key technologies
  - Vehicles emission factors taken from EPA Motor Vehicle Emission Simulator
  - Supplemental vehicle emission data from OECD (2020), Non-exhaust Particulate Emissions from Road Transport: An Ignored Environmental Policy Challenge, OECD Publishing, Paris, https://doi.org/10.1787/4a4dc6ca-en.
  - Building technologies adapted from EPA's Air Emissions Inventories for point sources
- Calculates emissions based on technology activity

RIO

Energy supply emission changes

- Database of emissions factors for NOx, PM2.5, SOx and mercury from existing and new power plants
  - Existing plant emission factors taken from EPA Avoided Emissions and Generation Tool (AVERT) and eGRID 2019 data
  - Existing energy conversion technologies (e.g., boilers for steam) are adapted from EPA's Air Emissions Inventories for point sources
  - New power plant data is a combination of NREL ATB data and National Electric Energy Data System data
- RIO calculates emissions based on least cost dispatch

EPA Co-Benefits Risk Assessment (COBRA)

Develop Scenario

Construct air quality scenario

- Combines data from results and inputs bundled with COBRA to develop AQ scenarios
  - Pollutant results address many but not all categories for COBRA
  - COBRA inputs are scaled or adjusted for missing data categories, with changes made to reflect how each pathway evolves differently.

COBRA

Changes in Air Quality (Particulate Matter) → **Health Outcomes** → **Economic Benefits**

Changes in Air Quality (Particulate Matter)

- Reduced form air quality model called the Source-Receptor (S-R) Matrix
  - Estimates ambient concentrations of PM by county
- Estimates contribution from each pollutant source to air quality of each county

Health Outcomes

- Concentration response functions
  - Adult and infant mortality
  - Non-fatal heart attacks
  - Respiratory and Cardiovascular hospital admissions
  - Acute bronchitis and respiratory symptoms
  - Asthma exacerbations and emergencies
  - Restricted activity and work loss days

Economic Benefits

- Economic costs of health impacts
  - Value of statistical life (VSL)
  - Cost of illness
  - Hospital charges
  - Willingness to pay
    - Symptoms of illness
    - Restricted activity
    - Lost workdays

EPA COBRA: https://www.epa.gov/sites/default/files/2017-10/documents/cobra_training_eic_2017.pdf

Epidemiological Studies Behind COBRA Functions

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- COBRA's concentration response functions are based on epidemiological studies of health outcomes when populations are exposed to changes in PM2.5
- More details can be found in the COBRA user guide and documentation at the following link (source of adjacent table)
  - https://www.epa.gov/system/files/documents/2021-11/cobra-user-manual-nov-2021_4.1_0.pdf

Endpoint	Author	Age
Mortality, All Cause	Krewski et al. (2009)	30-99
Mortality, All Cause	Lepeule et al. (2012)	25-99
Mortality, All Cause	Woodruff et al. (1997)	Infant
Acute Myocardial Infarction, Nonfatal	Peters et al. (2001)	18-99
Acute Myocardial Infarction, Nonfatal	Pope et al. (2006)	18-99
Acute Myocardial Infarction, Nonfatal	Sullivan et al. (2005)	18-99
Acute Myocardial Infarction, Nonfatal	Zanobetti and Schwartz (2006)	18-99
Acute Myocardial Infarction, Nonfatal	Zanobetti et al. (2009)	18-99
HA, All Cardiovascular (less Myocardial Infarctions)	Bell et al. (2008)	65-99
HA, All Cardiovascular (less Myocardial Infarctions)	Moolgavkar (2000b)	18-64
HA, All Cardiovascular (less Myocardial Infarctions)	Peng et al. (2008)	65-99
HA, All Cardiovascular (less Myocardial Infarctions)	Peng et al. (2009)	65-99
HA, All Cardiovascular (less Myocardial Infarctions)	Zanobetti et al. (2009)	65-99
HA, All Respiratory	Zanobetti et al. (2009)	65-99
HA, All Respiratory	Kloog et al. (2012)	65-99
HA, Asthma	Babin et al. (2007)	0-17
HA, Asthma	Sheppard (2003)	0-17
HA, Chronic Lung Disease	Moolgavkar (2000a)	18-64
Emergency Room Visits, Asthma	Mar et al. (2010)	0-99
Emergency Room Visits, Asthma	Slaughter et al. (2005)	0-99
Emergency Room Visits, Asthma	Glad et al. (2012)	0-99
Acute Bronchitis	Dockery et al. (1996)	8-12
Asthma Exacerbation, Cough	Mar et al. (2004)	6-18
Asthma Exacerbation, Cough	Ostro et al. (2001)	6-18
Asthma Exacerbation, Shortness of Breath	Mar et al. (2004)	6-18
Asthma Exacerbation, Shortness of Breath	Ostro et al. (2001)	6-18
Asthma Exacerbation, Wheeze	Ostro et al. (2001)	6-18
Minor Restricted Activity Days	Ostro and Rothschild (1989)	18-64
Lower Respiratory Symptoms	Schwartz and Neas (2000)	7-14
Upper Respiratory Symptoms	Pope et al. (1991)	9-11
Work Loss Days	Ostro (1987)	18-64

COBRA Methodology

- Reports the benefits attributed to emissions reductions in a single year versus 2023 (the latest year of air quality historical data in the COBRA model)
  - Reporting 2030 and 2050 here
  - Future gas generation additions are assumed to go into the same counties that have existing natural gas capacity for power plants
  - Benefits are attributed to the emissions reductions over 2023 experienced by the population in 2030 and 2050
- Fewer hospital visits, lost workdays, incidences of illness are determined for the year in which the emissions reductions are experienced
- Mortalities attributed to the emissions in a particular year are assumed to occur over the following 20 years
  - Benefits of emissions reductions are the present valued of reduced mortalities over that time period
  - All attributed to the emissions reductions experienced within a single year
- This analysis does not address indoor air quality changes from the energy transition or the effect on air quality of changing wildfire frequency

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Energy Wallet

Additional Data Sources to Supplement NEEA RBSA

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Vehicle Miles Traveled (VMT)	VMT by county from the Housing and Transportation (H+T) Affordability Index: https://htaindex.cnt.org/
Area Median Income (AMI)	Oregon Housing & Community Services' 2024 Area Median Income: https://www.oregon.gov/ohcs/compliance-monitoring/Documents/rents-incomes/2024/2024-County-Area-Median-Income-Summary.pdf
Region Type (Urban/Rural)	USDA definition of rural/urban: https://eligibility.sc.egov.usda.gov/eligibility/welcomeAction.do (map layer available: https://rdgdwe.sc.egov.usda.gov/arcgis/rest/services/Eligibility/Eligibility/MapServer/11). Zip codes that intersect with an urban area are considered urban. Sites classified as "urban" in the NEEA dataset may be classified as "rural" in this analysis and vice versa.
Heating Zone	Bonneville Power Administration "Regional States Climate Zone Assignments by Utility“: https://www.bpa.gov/-/media/Aep/energy-efficiency/interim-solution-2-files/pnw-heating-zones.pdf
High Priority Area Index	As defined in Oregon's 10-Year Plan: https://www.oregon.gov/energy/Get-Involved/Documents/2018-BEEWG-Ten-Year-Plan-Energy-Burden.pdf

Typical Homeowner – Input Summary

Typical Homeowner	
	Annual Usage
Electricity (kWh)	**9919.7**
Space heating	0.0
Other Electricity	9919.7
Water heating	0.0
Air conditioning	2167.7
Other	7752.0
Natural Gas (therms)	**820.8**
Space heating	430.3
Other Natural Gas	390.5
Water heating	314.4
Other	76.1
VMT	16823

Site Details	
Building Type	Single Family
Building Category	Single Family Detached
Ownership	Own
Primary Heating Fuel Type	Natural gas
Primary Heating System	Furnace
Primary Cooling System	Central AC
Water Heater Technology	Fossil Fuel Non-Condensing
Water Heater Fuel	Natural gas
Area (sq ft)	3100
Year	2012
Stove	Natural Gas
Oven	Natural Gas
EV charger	None
Large unusual load	None
Occupants	6

Rural Cold Climate – Input Summary

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Rural Cold Climate	
	Annual Usage
Electricity (kWh)	**6364.2**
Space heating	0.0
Other Electricity	6364.2
Water heating	0.0
Air conditioning	0.0
Other	6364.2
Natural Gas (therms)	**1023.0**
Space heating	712.0
Other Natural Gas	311.0
Water heating	250.4
Other	60.6
VMT	22113

Site Details	
Building Type	Single Family
Building Category	Single Family Detached
Region Type	Rural
Ownership	Own
Primary Heating Fuel Type	Natural gas
Primary Heating System	Furnace
Primary Cooling System	None
Water Heater Technology	Fossil Fuel Non-Condensing
Water Heater Fuel	Natural gas
Heating Zone	2
Area (sq ft)	1855
Year	2006
Stove	Natural Gas
Oven	Natural Gas
EV charger	None
Large unusual load	None
Occupants	4

High Priority Area Homes – Input Summary

High Priority Area Homes	
	Annual Usage
Electricity (kWh)	**15487.4**
Space heating	3953.8
Other Electricity	11533.6
Water heating	2754.3
Air conditioning	2180.5
Other	6598.8
Natural Gas (therms)	**0.0**
Space heating	0.0
Other Natural Gas	0.0
Water heating	0.0
Other	0.0
VMT	19833

Site Details	
Building Type	Single Family
Building Category	Single Family Detached
High Priority Area Home Index	3
Ownership	Own
Primary Heating Fuel Type	Electicity
Primary Heating System	Furnace
Primary Cooling System	Portable AC
Water Heater Technology	Electric Resistance
Water Heater Fuel	Electricity
Area (sq ft)	1400
Year	2007
Stove	Electric Coils
Oven	Electric Radiant
EV charger	None
Large unusual load	None
Occupants	2

Low-Income Multifamily Renter – Input Summary

Low-Income Multifamily Renter	
	Annual Usage
Electricity (kWh)	**8963.8**
Space heating	3151.4
Other Electricity	5812.4
Water heating	1711.6
Air conditioning	0.0
Other	4100.7
Natural Gas (therms)	**0.0**
Space heating	0.0
Other Natural Gas	0.0
Water heating	0.0
Other	0.0
VMT	13555

Site Details	
Building Type	Multi-family
Building Category	Low-Rise (1-3)
Ownership	Rent
Below Area Median Income	Yes
Primary Heating Fuel Type	Electricity
Primary Heating System	Baseboard
Primary Cooling System	None
Water Heater Technology	Electric Resistance
Water Heater Fuel	Electricity
Area (sq ft)	Unknown
Year	1977
Stove	Electric Coils
Oven	Electric Radiant
EV charger	None
Large unusual load	None
Occupants	2

Manufactured Home – Input Summary

EVOLVED ENERGY RESEARCH

Manufactured Home	
	Annual Usage
Electricity (kWh)	**18329.6**
Space heating	6777.3
Other Electricity	11552.3
Water heating	2758.7
Air conditioning	2184.0
Other	6609.5
Natural Gas (therms)	0.0
Space heating	0.0
Other Natural Gas	0.0
Water heating	0.0
Other	0.0
VMT	20743

Site Details	
Building Type	Single Family
Building Category	Manufactured
Ownership	Rent
Below Area Median Income	Yes
Primary Heating Fuel Type	Electricity
Primary Heating System	Furnace
Primary Cooling System	Window AC
Water Heater Technology	Electric Resistance
Water Heater Fuel	Electric
Area (sq ft)	1520
Year	1986
Stove	Electric Glasstop
Oven	Electric Radiant
EV charger	None
Large unusual load	None
Occupants	2