State of Oregon

Joint Task Force on Resilient Efficient Buildings

Report on Modeling of Policies

November 21, 2022

SSG

Contents

APPENDICES

Disclaimer

This analysis has been undertaken to identify and evaluate policies related to building codes and building decarbonization for new and existing buildings and to support policy recommendations by the Joint Task Force on Resilient Efficient Buildings created by Senate Bill 1518 (2022).

Reasonable skill, care and diligence have been exercised to assess the information provided for this analysis, but no guarantees or warranties are made regarding the accuracy or completeness of this information. This document, the information it contains and the information and basis on which it relies, is subject to changes that are beyond the control of the authors. The information provided by others is believed to be accurate, but has not been verified.

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Terms and Abbreviations

BAP	Business as Planned
BAU	Business as Usual
CDD	Cooling degree days
COBRA	CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool
CPP	Climate Protection Program
DEQ	Department of Environmental Quality
ESS	Energy Systems Simulator
GDP	Gross domestic product
GHG	Greenhouse gas
HB 2021	House Bill 2021
HDD	Heating degree days
IRA	Inflation Reduction Act
kWh	Kilowatt hour
MtCO2e	Metric tonne of CO2 equivalent
MW	Megawatt
MWh	Megawatt hour
Negawatts	A watt of energy that is not used as a result of energy conservation or the use of energy-efficient products
NREL	National Renewable Energy Laboratory
NG	Natural gas
PV	Photovoltaic
RNG	Renewable natural gas
Roadmap to 2035	Oregon Global Warming Commission’s Greenhouse Gas Reduction Plan
SB 1518	Senate Bill 1518, Establishes Task Force on Resilient Efficient Buildings
SCC	Social cost of carbon
SSG	Sustainability Solutions Group
sqft	Square feet (ft2)
tCO2e	Tonnes carbon dioxide equivalent

Notes and limitations

The Energy Systems Simulator (ESS) modeling described in this report uses an integrated, multi-fuel, multi-sector, energy systems, emissions and finance model designed specifically for projects of this nature. ESS was previously populated with Oregon-specific data and calibrated for the state of Oregon as part of the Oregon Global Warming Commission's Roadmap to 2035. In this project, ESS was used to support the Joint Task Force on Resilient Efficient Buildings' analysis to:

- Evaluate policies related to building codes and building decarbonization for new and existing buildings;
- Assess the impact of these policies on additional benefits, such as increasing energy efficiency, improving resilience against climate change, improving public health and air quality, reducing the percentage of household income that goes toward energy costs and mitigating displacement and toward mitigating other impacts that result from wildfires, heat waves and other climate change events; and,
- Assess impacts of policies related to the upfront and longer-term economic, environmental, climate and health costs, savings and benefits, along with lifecycle emissions and the social cost of carbon.

The analysis undertaken in this study does not:

- Evaluate the impact of the policies on market costs of housing or the State's GDP;
- Evaluate the costs of climate change, and its associated impacts on the State's building stock;
- Assess opportunities for demand response in the building stock;
- Assess GHG emissions from refrigerants (e.g., refrigerant leakage);
- Recommend a specific scenario or pathway; and,
- Assess the details of the implementation of other State policies or regulations.

Executive Summary

This report assesses the possible changes in energy use, greenhouse gas (GHG) emissions, and associated co-benefits resulting from the policies considered by the Task Force on Resilient Efficient Buildings (Task Force).

An Energy Systems Model

Modeling is a powerful tool to explore cause and effect of complex systems, such as current and future energy consumption and GHG emissions from residential and commercial buildings. The Energy Systems Simulator (ESS) is a model designed specifically for exploring the impacts of the policies being considered by the Task Force.

Local Data

ESS has been populated with data specific to Oregon and calibrated to observed energy consumption for each County across the state, to ensure a detailed representation of energy and GHG emissions from residential and commercial buildings.

Guidance from the Joint Task Force on Resilient Efficient Buildings

The Joint Task Force on Resilient Efficient Buildings (the "Task Force") identified 25 policy concepts, which was further narrowed to a total of nine policies. Upon assessment by the Sustainability Solutions Group (SSG), six of these could be modeled in ESS:

1. Setting building performance standards;
2. Promoting, incentivizing, and/or subsidizing energy efficiency and heating/cooling efficiency increases;
3. Decarbonization of institutional/public buildings;
4. Promoting, incentivizing, and/or subsidizing heat pumps;
5. Assessing and disclosing material-related emissions; and,
6. Enacting energy-efficient building codes.

SSG used scenario analysis as an approach to assess the impacts of the policy concepts, where a scenario is a description of a possible future, but not necessarily the desired or even likely outcome.

The Task Force decided to model high and low ambition implementations of each policy concept, which were evaluated as individual scenarios. These scenarios were then combined into five integrated scenarios, which capture the interplay between different policy concepts.

Each scenario was evaluated by the model for its impact on GHG emissions and energy use, as well as the impacts on household energy costs, abatement costs, air pollution levels, employment, resilience and the social cost of carbon. The impact of the five integrated scenarios on hourly electricity demand was also evaluated.

Findings

1. **Many of the policies are "no regrets":** Most of the policies generate net financial savings.
2. **Household energy costs are reduced:** Relative to 2019, policies decrease household costs by between 2.6% and 37% by 2050, using conservative projections on energy costs.
3. **Several policies and all integrated scenarios can achieve the GHG target:** The building performance policies and the heat pump policies achieve a proportionate allocation of Oregon's GHG target of 45% below 1990 levels by 2035.[1] All five integrated scenarios also achieve this reduction.
4. **Capital costs of the more ambitious policies are less than 1% of Oregon's GDP:** The most ambitious form of Policy 2 requires average annual capital investments of approximately $2 billion, 0.74% of Oregon's GDP.
5. **Embodied carbon is the largest opportunity for emissions reductions:** The most ambitious form of Policy 5 (embodied carbon) results in average annual reductions of 3.3 million MtCO2e. Embodied GHG emissions are accounted for differently than operational emissions, so these reductions do not directly contribute to achieving Oregon's GHG target.
6. **Electricity demand will increase in the BAP scenario:** Population growth increases electricity demand from the residential and commercial sectors in the absence of any policies considered by the Task Force.
7. **The policies reduce electricity demand from residential and commercial buildings:** Compounding efficiency benefits limit the impact of heat pumps on peak demand in the winter. For example, a poorly insulated house with baseboard heating that gets retrofitted (50% thermal reduction), and has a heat pump installed will need only 1/6 of the electricity when compared to prior energy demand. Further, as these changes reduce electricity demand from electric baseboard heating, Oregon would have a reservoir of "available" electricity freed up for new electric loads from new or existing buildings or other sectors.
8. **The financial results are sensitive to energy costs:** The results are sensitive to energy costs. For example, the analysis assumes a 2022 cost of $13.48/MMBTU for natural gas, while the cost in August, 2022 was $18.98/MMTBU, a 41% increase.

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[1] Office of the Governor (2020). Executive Order No 20-04. Retrieved from: https://drive.google.com/file/d/16islO3GTqxVihqhhlcjGYH4Mrw3zNNXw/view

Increases in natural gas costs will strengthen the financial benefits of the scenarios that increase adoption of heat pumps. Conversely, increases in electricity costs will lower the financial benefit of these scenarios.

9. **The policies reduce the implementation risks for the House Bill 2021 (HB 2021) and the Climate Protection Program (CPP):** By reducing electricity demand and GHG emissions from natural gas, the policies reduce the burden for utilities to achieve their respective GHG targets/caps.
10. **Retrofits are more expensive but reduce electricity demand:** Deep energy retrofits are capital intensive but are instrumental in reducing peak demand. The economic value of the avoided electricity generation capacity that follows from the avoided demand, or "negawatts", is not included in this analysis.
11. **Retrofits provide significant co-benefits:** Building retrofit policies provide the most jobs (i.e. policy 2c and 2d) and increase the resilience of homes. They also result in public health co-benefits.
12. **Combining policies result in compounding benefits:** The abatement cost of the most ambitious retrofit policy (2c) is $560/MtCO2e. When combined with the most ambitious heat pump policy, which has an abatement cost of -$130/MtCO2e, the combined abatement cost is $42/MtCO2e.
13. **Highest and best use of RNG:** Renewable natural gas (RNG) is used in the Building Performance Standard, alongside heat pumps. Given that RNG availability is constrained in Oregon, it makes sense to preserve this fuel for activities that require combustion, such as industrial applications.
14. **Accounting for the Social Cost of Carbon (SCC) increases the financial benefit of policies:** The value of the avoided damages from investments in mitigating the impacts of climate change as a result of the policies assessed range from -$4 million per year to -$255 million per year. New estimates of the Social Cost of Carbon (SCC) would increase these numbers by a factor of four.
15. **Policies need targets:** Policies can take many flavors with different outcomes for energy, emissions, and additional co-benefits. Targets and parameters that define specific components of a policy, such as the applicable building stock, for example, are necessary in order to achieve these targets.
16. **The scenarios analyzed are guideposts, not prescriptions.** None of the policy scenarios are prescribed as the preferred pathway, however they provide directional guidance on what would happen if a policy achieves a particular outcome.

1. Introduction

In 2022, the Oregon State Legislature enacted Senate Bill 1518 (SB 1518), which established the Resilient Efficient Buildings Task Force ("Task Force"). SB 1518 directed the Task Force to identify and evaluate policies related to building codes and building decarbonization for new and existing buildings that would enable the state to meet its greenhouse gas (GHG) emissions reduction goals while maximizing additional co-benefits. The legislation also directed the Task Force to consider the costs, savings, and benefits of recommended policies as related to residential, commercial, and industrial buildings. Senate Bill 1518 directed the Task Force to make policy recommendations to the interim committees of the Legislative Assembly before the 2023 regular session.

2. Method

2.1 Modeling Approach

Sustainability Solutions Group (SSG) employed the Energy Systems Simulator (ESS), a model that has been calibrated and populated with current and future climate policies and initiatives for the State of Oregon. ESS uses bottom-up accounting for energy supply and demand, including renewable resources, conventional fuels and energy consuming technology stocks (e.g., vehicles, appliances, dwellings, buildings, industry, etc.). For this project, the analysis focuses specifically on the residential and commercial building stocks.

The ESS applies a physical economy approach to provide coherent scenarios that explore the long-term impacts of ongoing energy transitions. To measure energy costs and GHG emissions, ESS traces the flows and transformations of energy from sources (e.g., power plants, photovoltaic solar) through energy currencies (e.g., electricity, hydrogen), to end uses (e.g., space heating). An energy balance is achieved by accounting for efficiencies, conservation rates, and trades and losses at each stage in the journey from source to end use. ESS is used to analyze energy and GHG emissions associated with customized policies over time and includes modeled financial information that can inform budgetary decision-making related to energy and emissions reduction actions.

The ESS is calibrated using observed datasets, while future projections are driven by population change and employment growth. The strengths of this modeling approach are as follows:

- **Bottom-up:** ESS tracks the physical stocks of equipment and buildings with GHG emissions (e.g., dwellings, offices etc.), how these stocks are used, and how the GHG emissions are produced. These stocks evolve as the population grows or the economy expands. This level of detail allows us to evaluate the impacts of programs at a high sectoral and geographical resolution, assuming that the stocks can be located in a physical space.
- **Geography:** ESS can report on impacts both at the state level and at the sub-geographical level (i.e., county).

- **Transformation:** While systems dynamics models are constrained by physical systems (i.e., the turnover of housing stocks), this modeling approach is not limited to cost constraints. This flexibility is critical for evaluating transformative change in the energy system which requires departures from historical patterns, or historically-derived coefficients.
- **Transparency:** The modeling logic and assumptions are extensively defined and documented in the modeling tool, which can be freely accessed. Further, it is standard practice for the team to document the method and assumptions in a Data, Methods, and Assumptions Manual (Appendix 4).
- **Economic impacts:** ESS calculates marginal abatement costs for each program or action and evaluates economic indicators, such as operating and capital impacts.
- **Public health outcomes:** ESS tracks changes in air pollutant emissions, which can be translated into health costs or avoided health costs.

Over the course of this project, the modeling approach evolved accordingly to address specific requests from the Task Force members, where possible. These requests and the responses made by SSG and its modeling team are included in Appendix 3.

2.2 The Context

SSG recently developed a fully calibrated, multi-sector model for the Oregon Global Warming Commission's Greenhouse Gas Reduction Plan ("Roadmap to 2035"), which was applied to this project.

2.2.1 POPULATION, EMPLOYMENT AND HOUSEHOLDS

Population is projected to increase from 4.2 million in 2020, to 5.4 million people by 2050,[2] an average annual growth rate of 0.8%. As a result, the number of households are projected to grow from 1.65 million to 2.1 million, and employment is projected to increase from 2.1 million to 2.6 million, between 2019 and 2050 (Figure 1).

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[2] Population Research Center (2021). Population Forecasts by County. Retrieved from: https://www.pdx.edu/population-research/population-forecasts

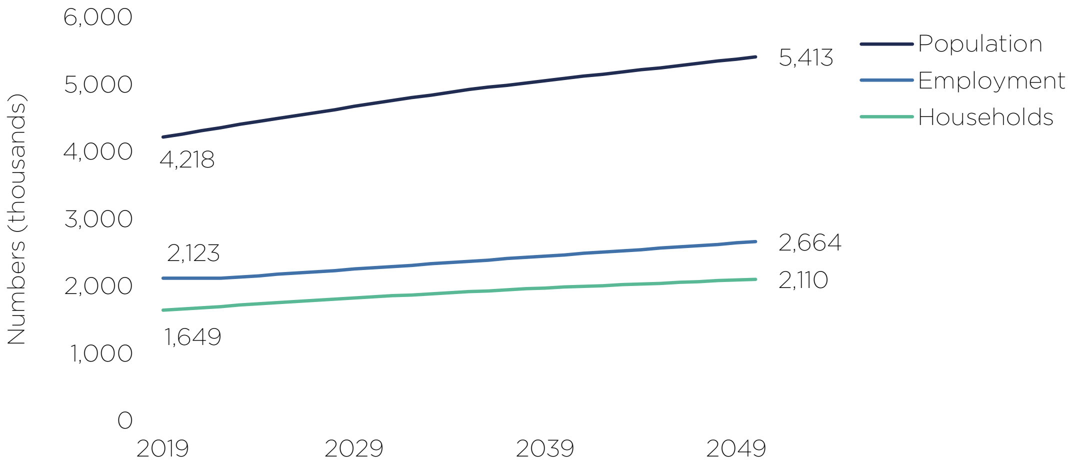

Figure 1. Trends in population, households and employment for the State of Oregon, 2019 to 2050

The projected changes in population and employment will result in increased demand for new residential and commercial space, respectively. Between 2019 and 2050, the projected growth in residential floor space will grow by nearly one billion square feet, while non-residential floor space will expand by 255 million square feet (Table 1). This information is an important consideration for the breakdown of modeling inputs specifying between existing buildings and new buildings in the design of targeted policies.

Table 1. Current and future growth of residential and non-residential floor space, 2019 to 2050

	RESIDENTIAL FLOORSPACE (MILLION SQFT)	NON RESIDENTIAL FLOORSPACE (MILLION SQFT)
Existing (2019)	2,930	2,120
New (by 2050)	970	255
Total (by 2050)	**3,900**	**2,375**
% change	133%	112%

2.2.2 SPATIAL DISTRIBUTION

The ESS tracks buildings, energy consumption, and emissions for each County in Oregon, and is able to capture the dynamics, such as different building types and characteristics and climatic conditions, for different geographies in Oregon, as illustrated in Figure 2 through Figure 5.

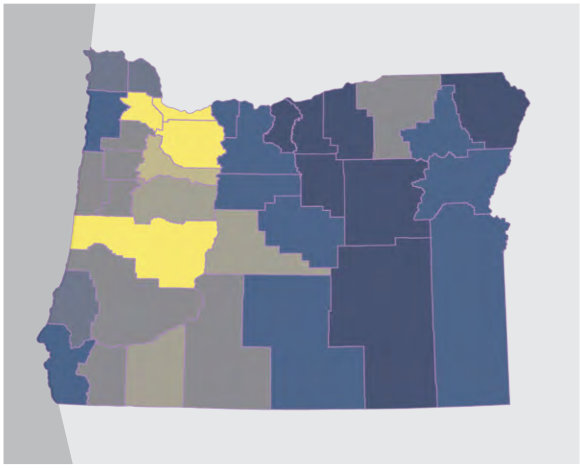

Figure 2. GHG emissions from residential buildings by County, 2019

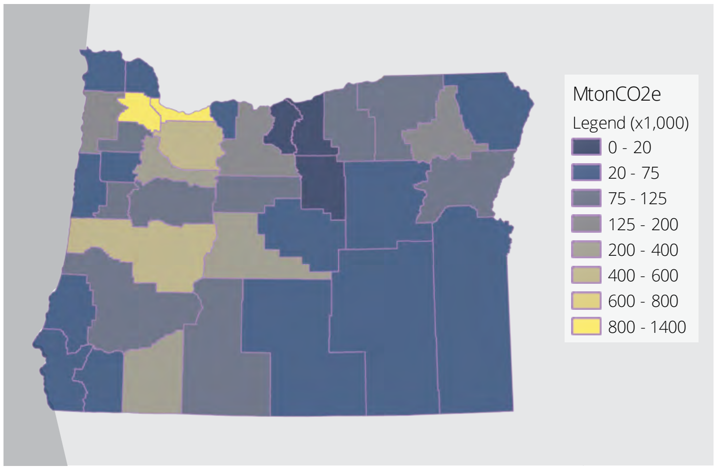

Figure 3. GHG emissions from commercial buildings by County, 2019

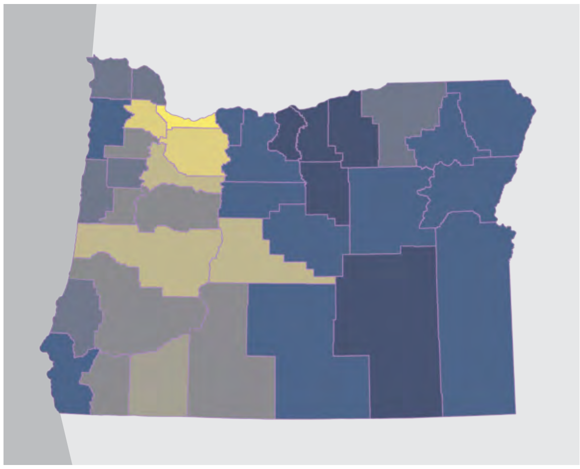

Figure 4. Energy consumption from residential buildings by County, 2019

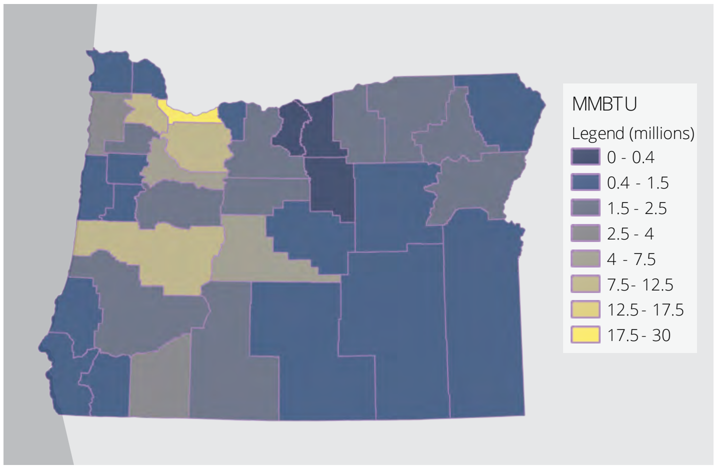

Figure 5. Energy consumption from commercial buildings by County, 2019

2.2.2 REFERENCE SCENARIOS

Two scenarios were developed based on the Oregon Global Warming Commission's Roadmap to 2035 (the "Roadmap to 2035") analysis.3 A Business as Usual (BAU) scenario illustrates the impact of population and employment growth on energy consumption and GHG emissions, without any additional policies or initiatives. A Business as Planned (BAP) scenario includes policies and programs that are in rule, funded, and/or legislatively required as well as market trends (Table 2).

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[3] Oregon Global Warming Comission (2022). Roadmap to 2035. Retrieved from: https://www.keeporegoncool.org/tighger

Table 2. BAU and BAP Scenarios

BAU ASSUMPTIONS	BAP ASSUMPTIONS
• Population growth • Employment growth • Transportation fuel standards • Heating and cooling degree days	• BAU Assumptions • HB 2021 • Climate Protection Program (CPP) • Clean Fuels Standard • Increased EV Light-Duty Sales • Advanced Clean Trucks • Energy Efficiency Standards for Appliances • Manufactured Home Replacement • Solar + Storage Rebate Program • Heat Pump Rebate Programs • Community Renewable Energy Program • Healthy Homes Repair Fund

Box #1: HB 2021 and CPP

House Bill 2021 (HB 2021) requires retail electricity providers to reduce GHG emissions associated with electricity sold to Oregon consumers to 80 percent below baseline emissions levels by 2030, 90 percent below baseline emissions levels by 2035, and 100 percent below baseline emissions levels by 2040.

The Climate Protection Program (CPP) sets a declining limit, or cap, on GHGemissions from fossil fuels used throughout Oregon, including diesel, gasoline, natural gas and propane used in transportation, residential, commercial and industrial settings.

The economy-wide analysis projects that GHG energy consumption per capita would decline by 30% under the BAP scenario, relative to the BAU scenario, by 2050 (Figure 6), and that GHG emissions per capita would decline by 75%, by 2050 (Figure 7).

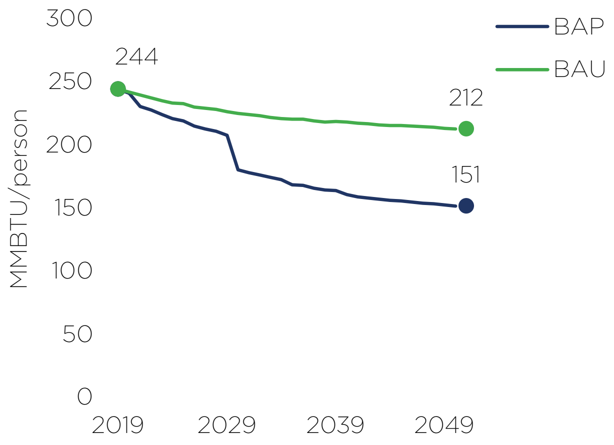

Figure 6. Per capita energy consumption for BAP and BAU scenarios, all energy sources

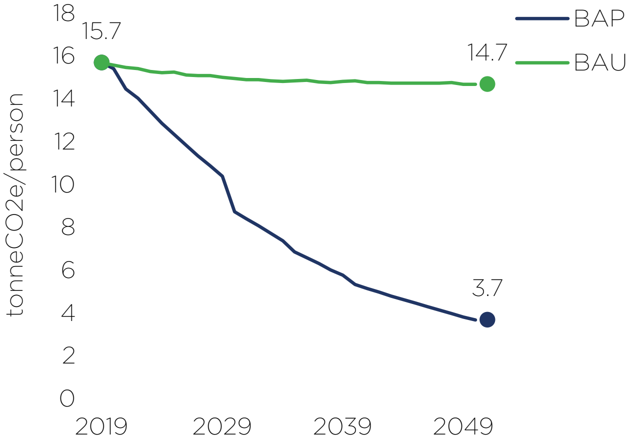

Figure 7. Per capita GHG emissions for BAP and BAU scenarios, all emissions sources

2.2.3 GHG EMISSIONS AND ENERGY CONSUMPTION IN THE REFERENCE SCENARIO

Energy consumption in the buildings sector follows a similar trajectory in the BAU and BAP scenarios (Figures 8 and 9), but GHG emissions decline precipitously as a result of the implementation of the the HB 2021 and the CPP, which result in emissions reductions from electricity, and from natural gas consumption, respectively (Figures 10 and 11).

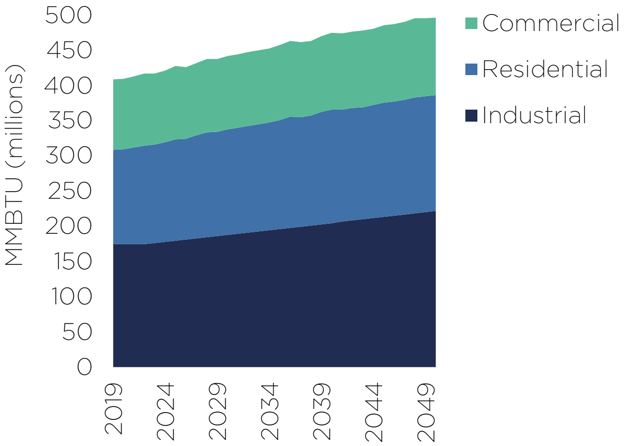

Figure 8. Annual energy consumption from buildings, BAU scenario, by sector

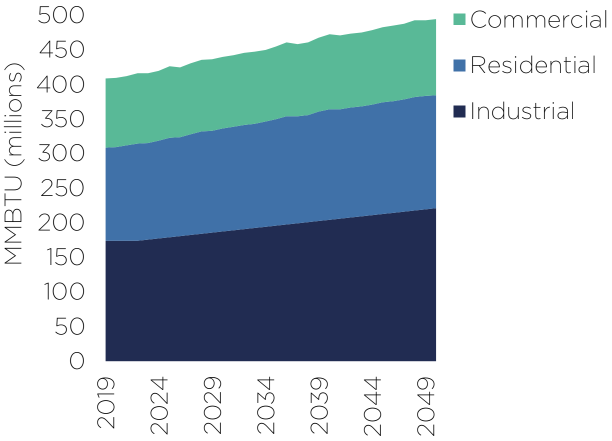

Figure 9. Annual energy consumption from buildings, BAP scenario, by sector

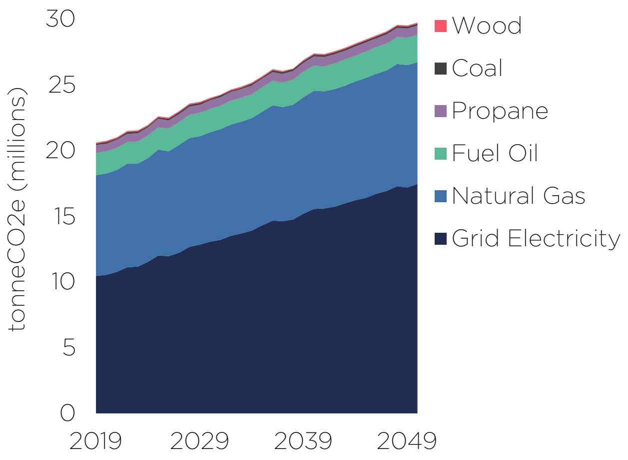

Figure 10. Annual GHG emissions from buildings, BAU scenario, by fuel

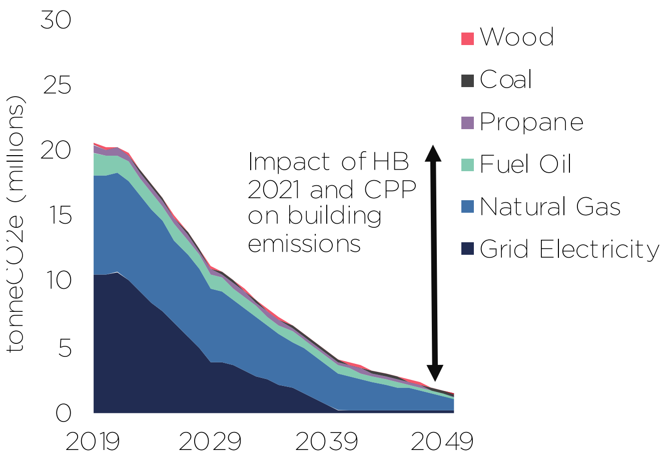

Figure 11. Annual GHG emissions from buildings, BAP scenario, by fuel

In comparison, the HB 2021 policies were modeled assuming total GHG emissions from electricity will be 80% below baseline emissions levels by 2030, 90% below baseline emissions levels by 2035 and 100% below baseline emissions levels by 2040.[4] The CPP was represented by assuming GHG emissions from fossil fuels would be reduced 50% by 2035, and 90% by 2050. For the purposes of modeling, the CPP was implemented as a GHG cap on natural gas, reducing emissions in alignment with the CPP Bill. Some policy measures under the CPP may actually result in reductions in energy consumption, but these were not specified because there are multiple pathways in which the CPP may be implemented, including the policies under consideration by the Task Force.

Figure 12 illustrates GHG emissions by end-use from buildings in the BAU scenario. In 2020, major sources were industrial processes (32%), space heating (30%), water heating (15%), lighting (10%) and plug loads (10%); In addition space cooling accounted for 2%, appliances accounted for 1%; and, heat pumps constitute 8% of the total (Figure 12). In terms of energy consumption, electricity was 42%, and natural gas 35%, of the total energy consumed (Figure 13).

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[4] House Bill 2021, Relating to clean energy; and prescribing an effective date, Regular Session, 81st Oregon Legislative Assembly

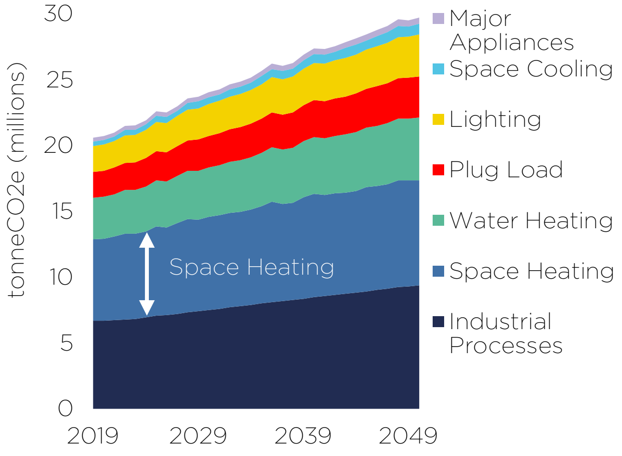

Figure 12. GHG emissions by end-use in the BAU scenario, buildings sector

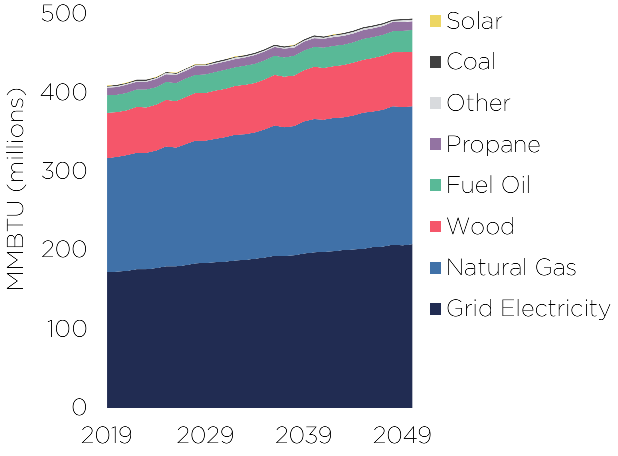

Figure 13. Energy consumption by fuel type in the BAU scenario, , buildings sector

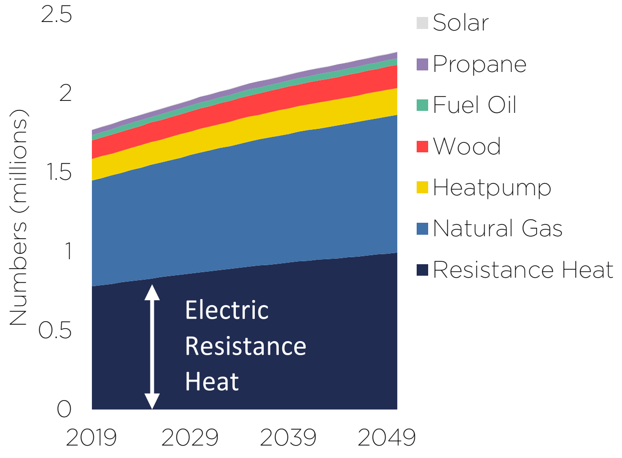

Figure 14. Number of heating systems by type in the BAU scenario, buildings sector

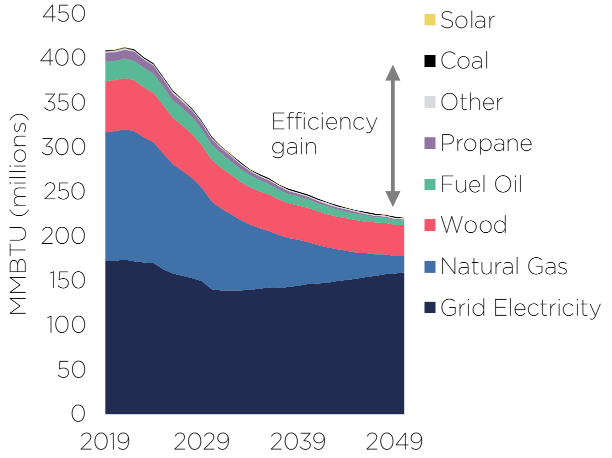

Figure 15. Annual energy consumption in buildings by fuel in the Electrification scenario for the Roadmap to 2035.

A deeper dive into space heating demonstrates that 44% of space heating systems in the reference scenario are electric resistance heating, roughly equal to the number of natural gas furnaces as illustrated in Figure 14. Replacing the electric resistance heaters with heat pumps could reduce electricity consumption by on-third due to the efficiency of this technology. Extensive building retrofits or weatherization could further reduce consumption of other sources of energy. These opportunities for decreased electricity consumption would mitigate the demands of electrification of heating and transportation on the existing electrical grid, illustrated in the electrification scenario evaluated for the Roadmap to 2035, which includes both extensive deployment of heat pumps and deep building retrofits.

2.3 Policies

The Task Force narrowed a preliminary list of 25 policy concepts to nine in a survey. Upon assessment by SSG, six of these nine policies could be modeled in ESS. The policies which were modeled are as follows:

1. Building performance standards;
2. Promote, incentivize, and/or subsidize energy efficiency and heating/cooling efficiency increases;
3. Decarbonize institutional/public buildings;
4. Promote, incentivize, and/or subsidize heat pumps;
5. Assess and disclose material-related emissions; and,
6. Enact energy-efficient building codes.

The remaining three policies were evaluated qualitatively:

7. Align energy efficiency programs with the State's climate goals;
8. Modify Energy Trust of Oregon's mission; and,
9. Promote, incentivize, and/or subsidize air purification systems.

2.3.1 POLICY DETAILS

The Task Force used a survey to identify parameters for up to four variations of each policy concept. The parameters specified the scope of the implementation for each policy concept as described in Appendix 1. The Task Force decided to model high and low ambition implementation pathways for each policy concept with variations in respect to the size of commercial buildings that were included. For example, the Building Performance Standards policy was evaluated targeting bookends of a 5% reduction and a 40% reduction in GHG emissions by 2035 below 2035 levels.

Each implementation of the policy concept was modeled as an independent scenario and was evaluated against the BAP scenario.

Box #2: What is a Scenario?

Scenarios are alternative descriptions of different possible futures that help the Task Force consider the implications of these future possibilities for planning and decision-making today. Scenarios are not predictions. Rather, they are stories about how the world could change over some specified time in the future.

A scenario is distinguishable from a vision and forecast in two ways:

a scenario is a possible future – it need not be desirable, thus it is not a vision, and, it need not be likely, thus it is not a forecast; **a scenario emphasizes a process of change**, not just a point in the future.

Many people assume that the future will closely resemble the present; however, scenarios are not grounded principally in a continuation of past trends or data. Rather, they involve plausible visions of the ways that relevant uncertainties might evolve in the future.

CHARACTERISTICS OF SCENARIOS

Plausible. The scenario must be believable.

Relevant to the key strategic issues and decisions at hand. If the scenario would not cause a decision-maker to act differently compared to another scenario, there is little use in considering it.

Challenging to today's conventional wisdom. It should make one think about different possibilities and options.

Divergent from each other. Together, the scenarios should "stretch" the thinking about the future environment, so that the decisions take account of a wider range of issues.

Balanced. It is useful to ensure that a group of scenarios strike a good psychological balance between challenges and opportunities, and between risks and potential benefits.

2.3.3 Policy Implementation

The selected policies were modeled using the implementation assumptions provided in Table 3.

Table 3. Policy Implementation Assumptions

POLICY	IMPLEMENTATION APPROACH
1. Building performance standards	A building performance standard requires new and existing buildings to reduce GHG emissions by a specific percent, implemented using a GHG intensity (GHGs/floor area). SSG selected the most cost-effective measures from the Roadmap to 2035 analysis in order to achieve the GHG reductions using the order of: heat pumps for space conditioning, water heating, and RNG. RNG potential was limited to 40.5 tBTU in policy 1c and 1d, because the availability of RNG is constrained in Oregon5 and is therefore best used in industries that require this type of fuel. This policy was applied to residential and commercial buildings.

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[5] (2019). Renewable Sources OF Natural Gas: Supply and Emissions Reduction Assessment. American Gas Foundation. https://gasfoundation.org/wp-content/uploads/2019/12/AGF-2019-RNG-Study-Full-Report-FINAL-12-18-19.pdf

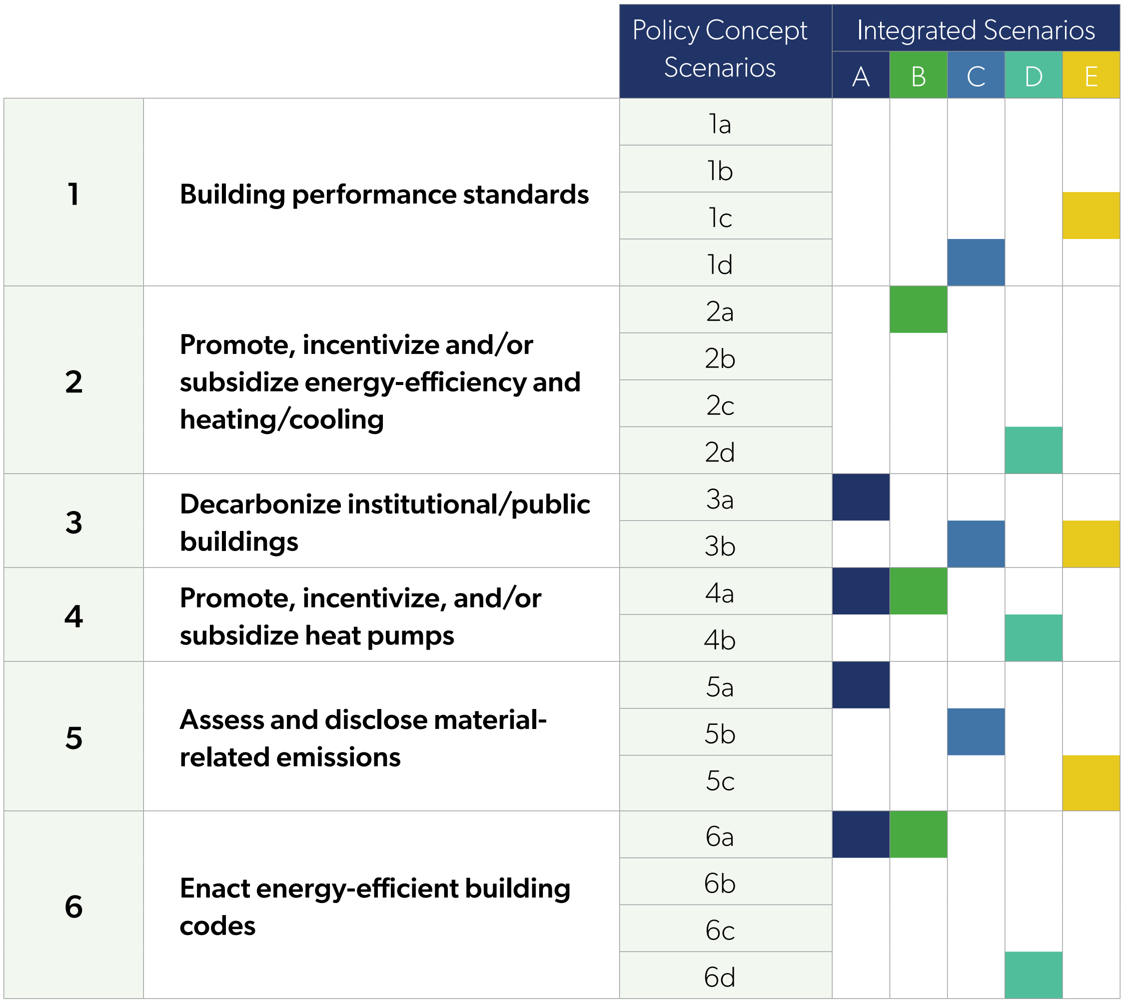
POLICY	IMPLEMENTATION APPROACH
2. Promote, incentivize, and/or subsidize energy efficiency and heating/cooling efficiency increases	This policy concept stimulates building retrofits to improve the thermal envelope. This policy was applied to residential and commercial buildings.
3. Decarbonize institutional/public buildings	Existing institutional and public buildings are retrofitted while new buildings are constructed to net zero energy performance.
4. Promote, incentivize, and/or subsidize heat pumps	The policy concept stimulates the uptake of air source and ground source heat pumps in new and existing residential and commercial buildings. 30% of new/existing homes or buildings were assumed to maintain natural gas as a backup energy source.
5. Assess and disclose material-related emissions	The policy concept results in decreased embodied emissions in new construction. Annual embodied carbon emissions, opportunities for reductions and associated costs were provided by DEQ, reflecting the impacts of three strategies. The first comprises using environmental product declarations (EPDs) as a tool to measure and disclose material production impacts and set GHG limits over time. There are numerous policy precedents already for this in the US. Examples include California, Colorado, and the Federal General Services Administration (GSA). The second strategy involves measuring and disclosing the whole lifecycle emissions of a building during the design process to employ a broader array of strategies to reduce embodied carbon. The policy precedents for whole building LCA include City of Vancouver BC, and US Federal GSA (buildings). The third strategy includes adaptive reuse of existing buildings. This strategy primarily applies to the reuse and renovation of an existing building as a means to offset a certain percentage of new construction. This policy was applied to new residential and commercial buildings.
6. Enact energy-efficient building codes	Building codes include energy performance requirements for new construction and renovations. An assumption was that between 2%-8% of the existing building stock was renovated each year.

2.3.3 Integrated Scenarios

Individual scenarios were combined into integrated scenarios, in order to capture the interplay among different policy concepts. For example, building retrofits reduce the demand for energy consumption so that smaller heat pumps can be installed and the operating energy for those heat pumps is lower. Five integrated scenarios were developed in order to evaluate these dynamics, described in Table 4 and illustrated in Figure 16.

Table 4. Integrated Scenarios

NAME	A	B	C	D	E
Theme	Go slow, focus on large buildings	Medium efficiency, focus on large buildings	Medium GHG reductions, non-prescriptive	Maximum efficiency	Maximum GHG reductions, non-prescriptive
Scenarios	6a. Enact energy-efficient building codes 4a. Promote, incentivize, and/or subsidize heat pumps 3a. Decarbonize public buildings 5a* Assess and disclose material-related emissions	2a. Promote, incentivize and or subsidize energy efficiency and heating/cooling 4a. Promote, incentivize, and/or subsidize heat pumps 6a. Enact energy-efficient building codes	Building Performance Standard 1d Decarbonize public buildings 3b Assess and disclose material-related emissions 5b*	Promote, incentivize and or subsidize energy efficiency and heating/cooling 2d Promote, incentivize, and/or subsidize heat pumps 4b Enact energy-efficient building codes 6d	Building Performance Standard 1c Decarbonize public buildings 3b Assess and disclose material-related emissions 5c*



		Policy Concept Scenarios	Integrated Scenarios				
			A	B	C	D	E
1	**Building performance standards**	1a					
		1b					
		1c					■
		1d			■		
2	**Promote, incentivize and/or subsidize energy-efficiency and heating/cooling**	2a		■			
		2b					
		2c					
		2d				■	
3	**Decarbonize institutional/public buildings**	3a	■				
		3b			■		■
4	**Promote, incentivize, and/or subsidize heat pumps**	4a	■	■			
		4b				■	
5	**Assess and disclose material-related emissions**	5a	■				
		5b			■		
		5c					■
6	**Enact energy-efficient building codes**	6a	■	■			
		6b					
		6c					
		6d				■	

Figure 16. Illustration of the policy concept scenarios and the integrated scenarios

2.3.5 Peak Electricity Demand Analysis

Peak electricity demand can generally be reduced by introducing policies that increase energy efficiency, and is generally increased by adding new end-uses such as heating, cooling and transportation. With this in mind, the Impacts of policies on peak demand was evaluated in the analysis of the integrated scenarios.

In order to assess the impact of the selected policies on hourly electricity demand, an 8760 hour electricity demand model was integrated with the ESS model developed for Oregon. The integrated scenarios were tested in this model.

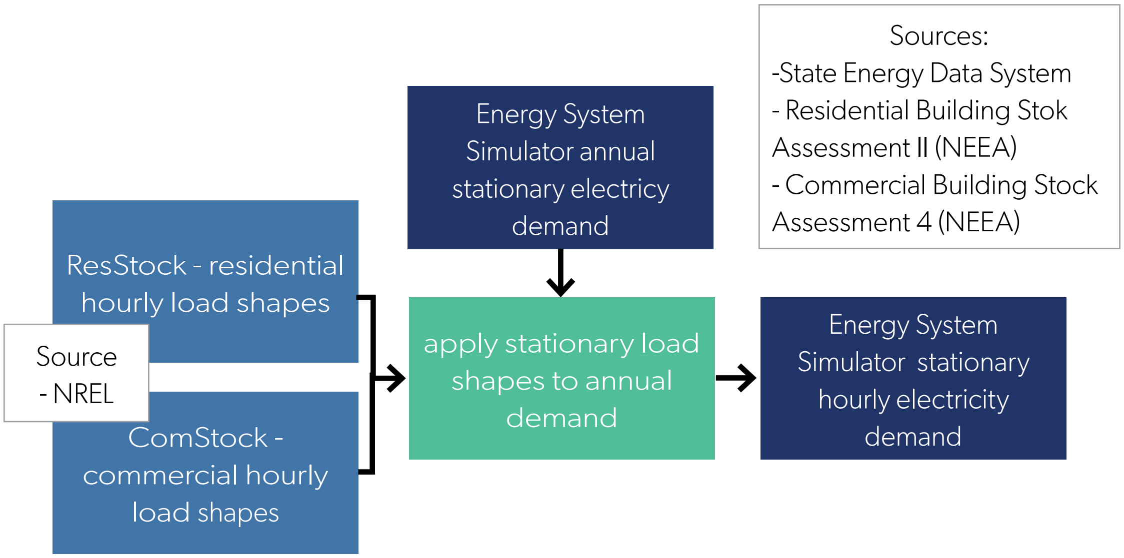


Figure 17. Annual electricity demand to hourly demand process

National Renewable Energy Laboratory (NREL)'s ResStock and ComStock models were used to develop hourly profiles by county, which were applied to annual demand to generate total electricity demand on an hourly basis from residential and commercial buildings in Oregon.

Box #3: Restock and Comstock

ResStock and ComStock are physics-based simulation models developed to represent the energy use and energy saving potential of residential and commercial building stocks with high granularity at national, regional, and local scales.6

The hourly analysis completed for this study built a bottom-up representation of electricity demand for the residential and commercial sectors only. It does not model total electricity demand (all sectors) for the State of Oregon or the Western Interchange. This analysis enables policy-makers to compare how different building-related policies will impact the hourly electricity demand in Oregon. It also includes capturing sub-regional climatic variation in heating and cooling hourly demand profiles, and the impacts of climate change on decreased heating demand.[7]

The model uses an average coefficient of performance (COP) of 2.75 for air source heat pumps,[8] In periods of extreme cold, the COP may decline below this level. However, the COP applied

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[6] US Department of Energy (2022). End-Use Load Profiles for the U.S. Building Stock; Methodology and Results of Model Calibration, Validation, and Uncertainty Quantification. Retrieved from: https://www.nrel.gov/docs/fy22osti/80889.pdf

[7] The uses heating degree days and cooling degree days from RCP 4.5 for each Count. For more details, see: https://crt-climate-explorer.nemac.org/

[8] The COP averages were derived by calculating applying actual performance of a cold weather heat pump to hourly temperature data for a northern climate city.

here was a reasonable assumption given that (a) the inclusion of a share of hybrid heating systems which enable natural gas to provide heating for periods of extreme cold for some homes and buildings; (b) the COP of cold weather air source heat pumps continues to improve in cold temperatures;[9] and, (c) no demand response measures were applied (e.g., shifting water heating demand).

2.4 The Reference Scenario

The BAP scenario from the Roadmap to 2035 was used as the reference scenario for evaluation of the selected policy concepts. HB 2021 was included in the BAP scenario, however the CPP was omitted. HB 2021 impacts the GHG emissions from electricity, which is an energy carrier not an energy source and can be decreased by changing the mix of electricity generation, which is not considered within the scope of this study. The pathway for the CPP, however, impacts the types of fuels and technologies used in buildings, and therefore could not be included in the reference scenario in order to avoid double counting.

2.4.1 THE TREATMENT OF THE CLIMATE PROTECTION PROGRAM (CPP)

The CPP sets a declining limit or cap on GHG emissions from fossil fuel use in transportation, residential buildings, and commercial and industrial settings throughout Oregon (e.g., including diesel, gasoline, natural gas and propane).

Natural gas utilities, which are the primary fossil fuel entities impacted by the mandate of the Task Force, must achieve emissions reductions in alignment with the CPP's GHG reductions caps (i.e., 50% by 2035 and 90% by 2050 from a 2017-2019 average emissions baseline). However, the actions to achieve these targets are not determined by the CPP. The covered entities (i.e., utilities) must achieve the emissions reductions in the context of other factors including population growth, evolving public policy (as is being evaluated by the Task Force), and market trends, which may decrease or increase the efforts required.

In order to illustrate the impact of the CPP, charts were prepared to represent the GHG impact of each scenario in the context of CPP implementation. Not all natural gas consumption is within the purview of the Task Force (i.e., natural gas consumed in industry and transportation was not included in this analysis), so the CPP caps were applied proportionately to natural gas consumed in the residential and commercial sectors. The impact of the CPP on GHG emissions is shown below as wedges; if the selected policy achieves more GHG emissions reductions, the CPP wedge is smaller (FIgure 18); if the selected policy achieves less GHG emissions, the CPP wedge is larger (Figure 19). The resulting visual makes no conclusions on how the CPP will be achieved,[10] but does show its impact on GHG emissions.

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[9] For example" US Department of Energy (2022). DOE Announces Breakthrough in Residential Cold Climate Heat Pump Technology. Retrieved from: https://www.energy.gov/articles/doe-announces-breakthrough-residential-cold-climate-heat-pump-technology

[10] The natural gas utilities' Integrated Resource Plans describe pathways to achieve the CPP caps. For example, see: Northwest Natural (2022). 2022 Northwest Natural 2022 Integrated Resource Plan. Retrieved from: https://www.nwnatural.com/about-us/rates-and-regulations/resource-planning

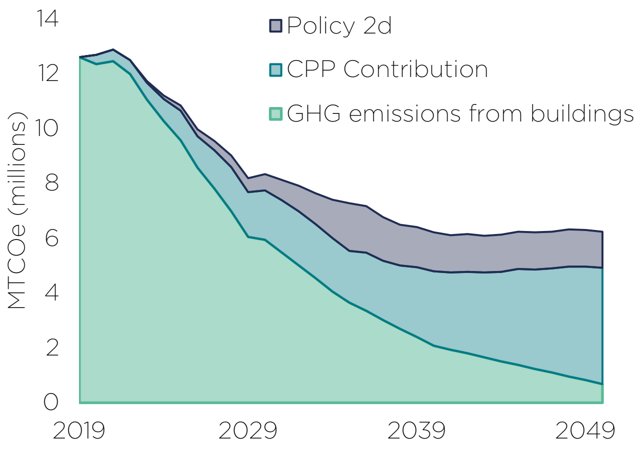

Figure 18. Impact of Policy 2D and CPP relative to the BAP scenario, GHG emissions from residential and commercial buildings

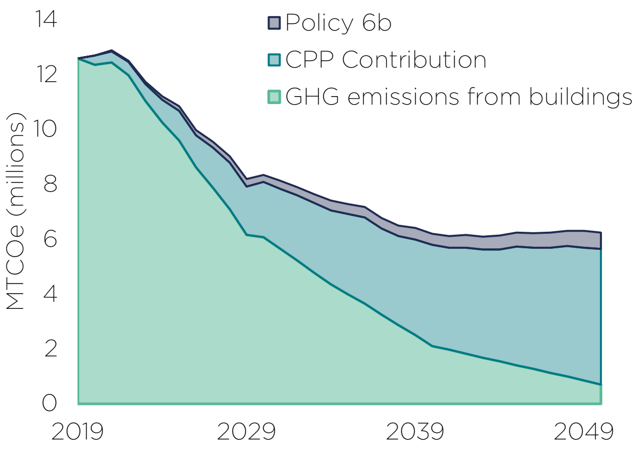

Figure 19. Impact of Policy 6b and CPP relative to the BAP scenario, GHG emissions from residential and commercial buildings

2.5 Financial Analysis

The financial impacts of each scenario were calculated by applying capital costs when investments are made and applying cost intensities for energy and maintenance costs over the lifetime of the investment.

2.5.2 FINANCIAL METHODS

Four aggregate categories were used to track the financial performance of the policies in this analysis: capital expenditures, energy savings (or additional costs, operation and maintenance savings), and revenue generation (associated with renewable energy production facilities and some transit actions). Cost projections for capital and operating are described in a Financial Cost Catalog (Appendix 5).

Financial impacts were calculated in comparison to the BAP scenario. The financial analysis tracked the projected costs and savings of each scenario that go above and or below the projected BAP costs.

The abatement cost was calculated by dividing the net present value (NPV) by the cumulative GHG emissions reduced of the lifetime of the policy. The NPV is the sum of the present value of the capital investment and the present value of the future stream of costs, savings and revenue generated by the policy. Present value is calculated by applying a social discount rate to costs or savings in future years. For the purpose of this analysis, a social discount rate of 3% was applied.[11]

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[11] Interagency Working Group on Social Cost of Carbon (2010). Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866. Retrieved from: https://www.epa.gov/sites/default/files/2016-12/documents/scc_tsd_2010.pdf

2.5.2 INFLATION REDUCTION ACT (IRA)

The impact of the IRA was not included in the financial analysis. IRA will provide funding in different forms that will support aspects of the policy concepts being evaluated by the Task Force. As a result, funding programs in the IRA will improve the financial results for the policy concepts being evaluated. Examples of IRA funding programs that are relevant to the Task Force's policies include:[12]

- The Home Energy Performance-Based Whole-House Rebates (HOMES) provides between $2,000 and $8,000 for energy efficiency retrofits.
- The High-Efficiency Electric Home Rebate Program Rebate provides up to $14,000 for low and moderate income homes.

Table 5. 5High-Efficiency Electric Home Rebate Program Rebates

APPLIANCE	REBATE AMOUNT
Heat pump for space heating and cooling	$8,000
Electric stove, cooktop, range, or oven or clothes dryer	$840
Heat pump hot water heater	$1,750
Electric wiring	$2,500
Electric load service center (breaker box)	$4,000
Insulation, air sealing and ventilation	$1,600

- IRA-25C, a tax credit provides up to $1,200 per year for energy efficiency upgrades and up to $2,000 per year for electric heat pump water heaters and electric heat pumps. IRA-45L also provides a tax credit of $5,000 if a single-family or manufactured home is certified zero energy ready.

There are limitations to stacking the funding programs and more program details are still being developed, however, the overall financial benefits from the policy concepts will be enhanced by IRA.

2.6 Additional Benefits

SB 1518 requires that the analysis of new policies and initiatives consider "maximizing additional benefits".[13] The list of additional benefits includes increasing energy efficiency, improving resilience against climate change, improving public health and air quality, reducing the percentage of household income that goes toward energy costs, and mitigating displacement and other impacts that result from wildfires, heat waves and other climate change events. SB 1518

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[12] IRA funding programs were described in a presentation to ODOE: Rinaldi, K. (2022). Inflation Reduction Act (IRA): Big Picture. AnnDyl Policy Group.

[13] 81st Oregon Legislative Assembly (2022). Senate Bill 1518. p.2 Retrieved from: https://olis.oregonlegislature.gov/liz/2022R1/Downloads/MeasureDocument/SB1518

also requires consideration of upfront and longer-term economic, environmental, climate and health costs, savings and benefits, along with lifecycle emissions and the social cost of carbon.

2.6.1 ECONOMIC IMPACT, COSTS AND SAVINGS

ESS uses a lifecycle approach to calculate economic costs and benefits of each policy concept, including incremental capital, operating and maintenance costs. The lifetime of stocks including homes, buildings, heat pumps and hot water systems are provided in Table 6.

Table 6. Lifetime of stocks in ESS

STOCKS	LIFETIME (YEARS)
Homes (singles and apartments)	40
Buildings	50
Heat pumps	15
Hot water system	10

2.6.2 RESILIENCE

The Intergovernmental Panel on Climate Change (IPCC) defines climate resilience as "the capacity of social, economic, and environmental systems to cope with hazardous events, trends or disturbances, responding or reorganizing in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation."[14]

The number of homes retrofitted is used as a proxy indicator of increased resilience. Retrofits improve building envelopes so that they can better regulate temperature and therefore protect inhabitants in periods of extreme weather,[15] which the US Green Building Council has defined as passive survivability or thermal safety.[16] Thermal safety is defined as maintaining thermally safe conditions during a power outage that lasts four days during peak summertime and wintertime conditions.[17]

Energy retrofits can result in improved thermal comfort and lower energy costs, resulting in fewer reported financial difficulties , increased resident satisfaction, and more social interactions.[18]

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[14] Field, C. B. (Ed.). (2014). Climate change 2014–Impacts, adaptation and vulnerability: Regional aspects. Cambridge University Press.

[15] Ribeiro, D., Mackres, E., Baatz, B., Cluett, R., Jarret, M, Kelly, M., Vaidyanathan, S. (2015). Enhancing community resilience through energy efficiency. Report U1508. Retrieved from: https://aceee.org/sites/default/files/publications/researchreports/u1508.pdf.

[16] USGBC. Passive survivability and back-up power during disruptions. LEED BD+C: New construction. Retrieved from: https://www.usgbc.org/credits/passivesurvivability.

[17] What constitutes thermally safe varies in various buildings, and can also be dependent on humidity and other factors. See LEED pilot webpage for more information: https://www.usgbc.org/node/9836068?return=/pilotcredits/all/all

[18] Poortinga, W., Rodgers, S. E., Lyons, R. A., Anderson, P., Tweed, C., Grey, C., … Winfield, T. G. (2018). The health impacts of energy performance investments in low-income areas: a mixed-methods approach. Public Health Research, 6(5), 1–182. https://doi.org/10.3310/phr06050

2.6.3 PUBLIC HEALTH AND AIR QUALITY

In order to evaluate impacts on health and air quality, SSG used the EPA's CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA).19 COBRA estimates the economic value of the health benefits associated with reductions in emissions of particulate matter (PM2.5), sulfur dioxide (SO2), nitrogen oxides (NOX), ammonia (NH3), and volatile organic compounds (VOCs). Reductions in these pollutants were assessed using the ESS model, and then used as inputs into the COBRA Tool.

COBRA uses health impact functions to estimate how changes in outdoor air quality impacts instances of specified health outcomes (e.g., premature mortality, heart attacks, asthma exacerbation, lost work days). The change in instances for each health outcome is multiplied by a monetary value attributed to each outcome (e.g., the average cost of going to the emergency room for asthma symptoms or the cost of a lost work day) to determine the monetized health impacts.[20]

SSG also assessed possible options to evaluate the impacts of the policy scenarios on indoor air quality. However, it was determined that the complexity of parameters, including the introduction of new building envelope materials, ventilation and combustion would require a dedicated analysis that was outside the scope of the current study.

2.6.4 HOUSEHOLD EXPENDITURES

Household expenditures on energy can result in energy poverty, which can have a range of impacts. For example, households experiencing energy poverty or energy insecurity face challenges such as "pay the rent or feed the kids", "heat or eat", or "cool or eat".[21] In particular, energy insecurity disempowers low-income residents such as single parents, the elderly, persons with disabilities, and others with low or fixed incomes,[22] resulting in stresses such as utility-related debt, shutoffs, inefficient heating systems, antiquated appliances, and extreme home temperatures with the potential of resulting in significant health impacts.[23] Children may experience nutritional deficiencies, higher risks of burns from non-conventional heating sources, higher risks for cognitive and developmental behavior deficiencies, and increased incidences of carbon monoxide poisoning.[24]

Household expenditures on energy are calculated by multiplying the fuel consumption for each dwelling type by the relevant fuel cost intensity. The net change in household energy expenditures provides the difference in costs between the policy concept scenario and the BAP scenario.

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[19] EPA (2022). CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool. Retrieved from: https://www.epa.gov/cobra

[20] For more details on COBRA, see: EPA (2021). User's Manual for the Co-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA). Retrieved from: https://www.epa.gov/system/files/documents/2021-11/cobra-user-manual-nov-2021_4.1_0.pdf

[21] Cook, J. T., Frank, D. A., Casey, P. H., Rose-Jacobs, R., Black, M. M., Chilton, M., … Cutts, D. B. (2008). A brief indicator of household energy security: Associations with food security, child health, and child development in US infants and toddlers. PEDIATRICS, 122(4), e867–e875. https://doi.org/10.1542/peds.2008-0286

[22] Hernández, D. (2013). Energy insecurity: A framework for understanding energy, the built environment, and health among vulnerable populations in the context of climate change. American Journal of Public Health, 103(4), e32–e34. https://doi.org/10.2105/AJPH.2012.301179

[23] Hernández, D., & Bird, S. (2010). Energy burden and the need for integrated low-income housing and energy policy. Poverty & Public Policy, 2(4), 5–25. https://doi.org/10.2202/1944-2858.1095

[24] Ibid.

2.6.5 ECONOMIC IMPACT - EMPLOYMENT

The impact on employment was calculated using direct multipliers wherein a dollar of commodity or service output generates X number of person-years of employment (Table 7). Indirect jobs were not included in the analysis to avoid possible double counting. Person years of employment in the policy concept scenario were subtracted from person years of employment in the BAP scenario; as a result, if the number is negative, it represents a loss of employment; and, if positive, it represents an increase in employment.

Table 7. Employment multipliers[25]

CATEGORY	PERSON YEARS OF EMPLOYMENT
HVAC equipment manufacturing	4.6
Construction	5.5

2.6.6 SOCIAL COST OF CARBON (SCC)

The Social Cost of Carbon (SCC) is a measurement of the long-term socio-economic costs associated with emitting an additional ton of carbon dioxide.[26] The SCC is calculated using the quantifiable socio-economic costs and benefits of a tonne of carbon dioxide emitted to the atmosphere, that incorporates assumptions around future conditions such as population size, economic growth, rate of climate change, and the projected impacts of climate change.

The SCC from the Interagency Working Group on Social Cost of Greenhouse Gases was used for this analysis, with a 3% discounting rate (Figure 20).[27]

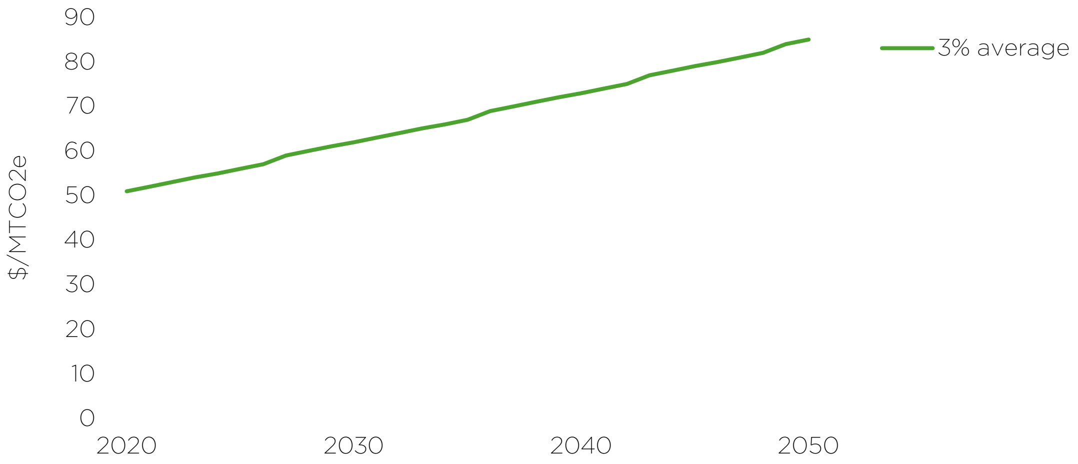

Figure 20. Social Cost of Carbon from the Interagency Working Group on Social Cost of

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[25] Bivens, J. (2019). Updated employment multipliers for the U.S. economy. Economic Policy Institute. https://www.epi.org/publication/updated-employment-multipliers-for-the-u-s-economy/

[26] ODOE (2020). Primer on the Social Cost of Carbon.

[27] Interagency Working Group on Social Cost of Greenhouse Gases (2021). United States Government Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990 Retrieved from: https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf

Greenhouse Gases, (3% discounting rate)

Subsequent to the completion of the modeling undertaken for this study, new values for the SCC were released by the EPA that have expanded the estimated damages caused by climate change.[28] As a result of the timing, SSG was unable to incorporate the updated SCC into the current analysis, however, it is important to note that if it had been used, then the socio-economic benefit of actions taken to reduce GHG emission would be of greater value.

2.7 Uncertainty

Models which explore the future are intrinsically uncertain, given that the future is unknowable. The ESS provides a powerful tool to allow analysts to explore cause and effect in a system that is calibrated to current conditions.

The scenarios evaluated in this analysis are not predictions of what will happen, they explore possible futures of what might happen if other conditions and/or assumptions are in place. This analysis of cause and effect provides insight on the possible impacts of policy concept scenarios. The use of integrated multiple scenarios provides further insight on how integrated variations in policies can impact possible outcomes.

2.8 Transparency

The ESS model and its approach are available for download to ensure that the method and framework is fully transparent.[29] In addition, a detailed description of the method is included in the Data, Methods and Assumptions Manual (Appendix 4).

3. Analysis

The results from the ESS modeling are presented in several policy scorecards and policy summary charts.

3.1 The Scorecard

Scorecards were prepared for each policy concept. The scorecards include indicators for GHG emission reductions, and for the additional benefits (i.e., co-benefits), which are presented using a consistent format across all policy concepts to ensure comparability (Figure 21). An indicator bar illustrates the relative impact of the policies on GHG emissions at a glance; complete shading of the bar indicates the policy which had the greatest emissions reduction while no

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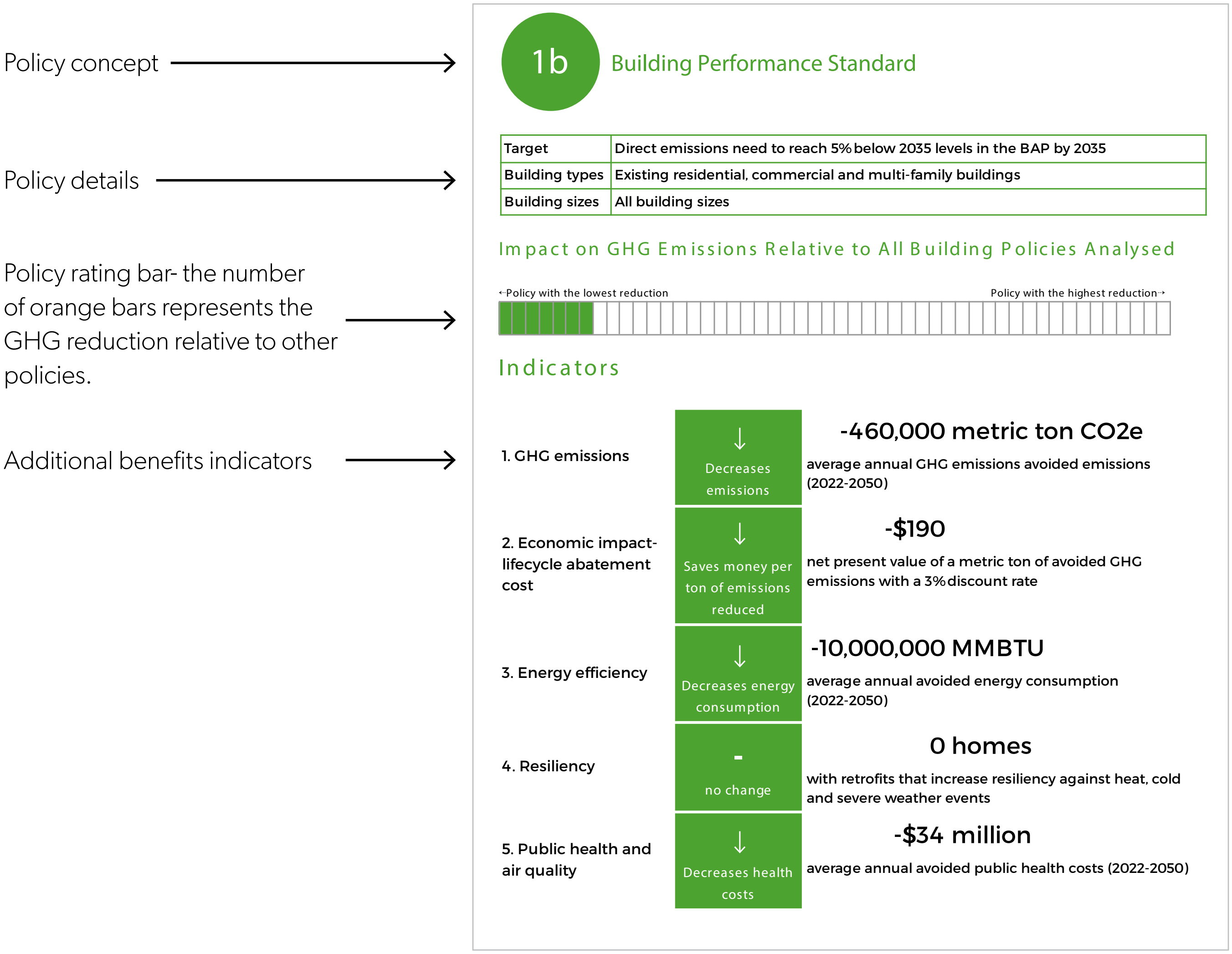
[28] EPA (2022). Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances. Retrieved from: https://www.epa.gov/system/files/documents/2022-11/epa_scghg_report_draft_0.pdf

[29] The ESS can be downloaded at: https://github.com/whatIfTechnologies/ESS_public

shading indicates the policy with lowest emissions reduction (Figure 21). A series of charts show cumulative impacts between 2022 and 2050, as well as annual curves over the same time period (Figure 22). A complete set of scorecards is included in Appendix 3.



Policy concept

Policy details

Policy rating bar- the number of orange bars represents the GHG reduction relative to other policies.

Additional benefits indicators

1b Building Performance Standard

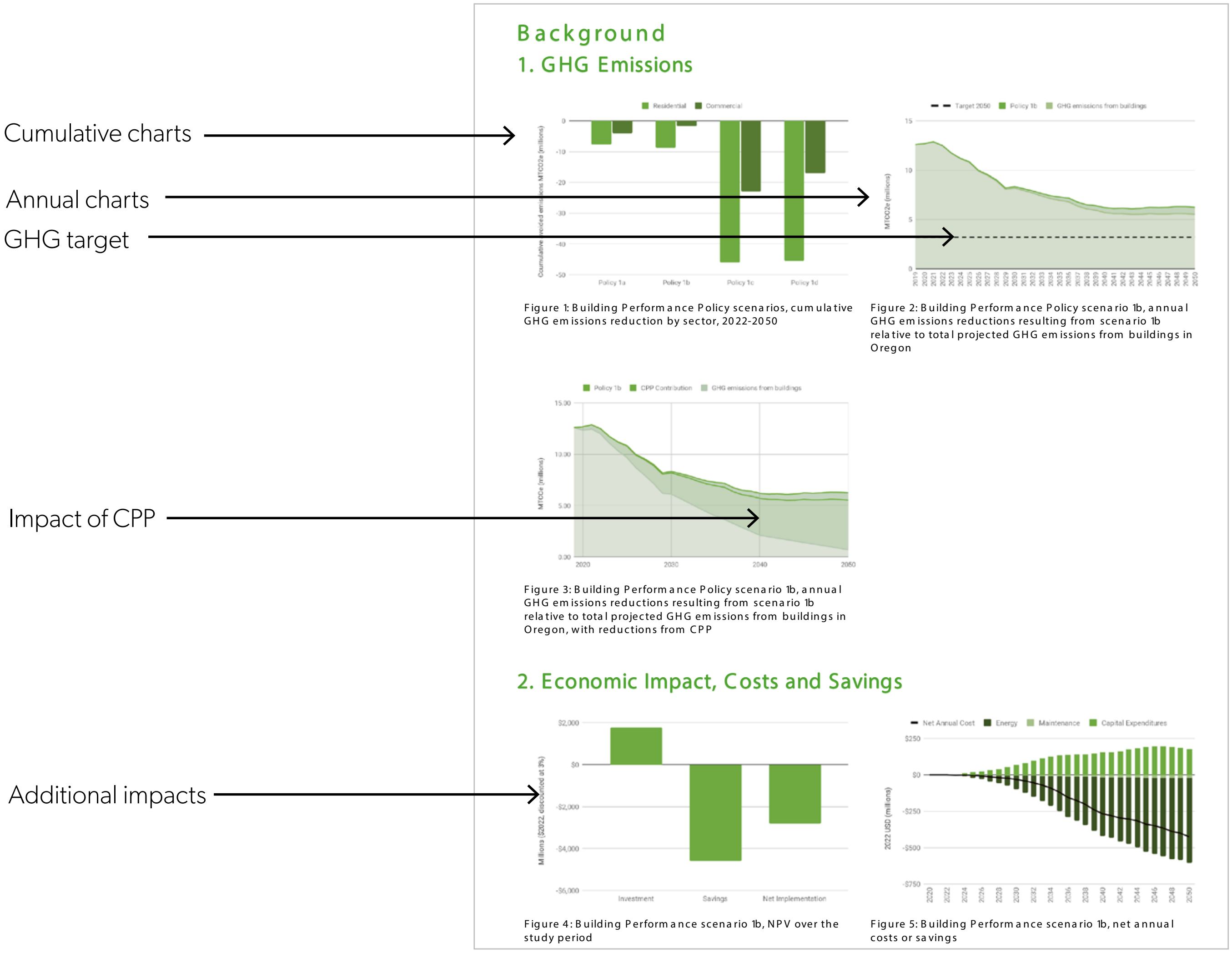
Target	Direct emissions need to reach 5% below 2035 levels in the BAP by 2035
Building types	Existing residential, commercial and multi-family buildings
Building sizes	All building sizes

Impact on GHG Emissions Relative to All Building Policies Analysed

Indicators

1. GHG emissions	↓ Decreases emissions	**-460,000 metric ton CO2e** average annual GHG emissions avoided emissions (2022-2050)
2. Economic impact- lifecycle abatement cost	↓ Saves money per ton of emissions reduced	**-$190** net present value of a metric ton of avoided GHG emissions with a 3% discount rate
3. Energy efficiency	↓ Decreases energy consumption	**-10,000,000 MMBTU** average annual avoided energy consumption (2022-2050)
4. Resiliency	- no change	**0 homes** with retrofits that increase resiliency against heat, cold and severe weather events
5. Public health and air quality	↓ Decreases health costs	**-$34 million** average annual avoided public health costs (2022-2050)

Figure 21. Page 1 of the policy scorecards



Background

1. GHG Emissions

Figure 1: Building Performance Policy scenarios, cumulative GHG emissions reduction by sector, 2022-2050

Figure 2: Building Performance Policy scenario 1b, annual GHG emissions reductions resulting from scenario 1b relative to total projected GHG emissions from buildings in Oregon

Figure 3: Building Performance Policy scenario 1b, annual GHG emissions reductions resulting from scenario 1b relative to total projected GHG emissions from buildings in Oregon, with reductions from CPP

2. Economic Impact, Costs and Savings

Figure 4: Building Performance scenario 1b, NPV over the study period

Figure 5: Building Performance scenario 1b, net annual costs or savings

Figure 22. Page 3 of a policy scorecard

3.2 Policy Concepts

The policy concepts apply to different aspects of the building stock with a range of physical interventions as determined by the Task Force. Figure 23 illustrates the policies according to categories including new buildings, existing buildings or both; and, whether the policy is focused on: energy efficiency, technologies such as heat pumps, an unspecified approach, or material-related GHG emissions. The figure illustrates which policies overlap (i.e., policy 2 and 6 on existing buildings; depending how it is implemented, policy 1 and policies 4 and/or 6).

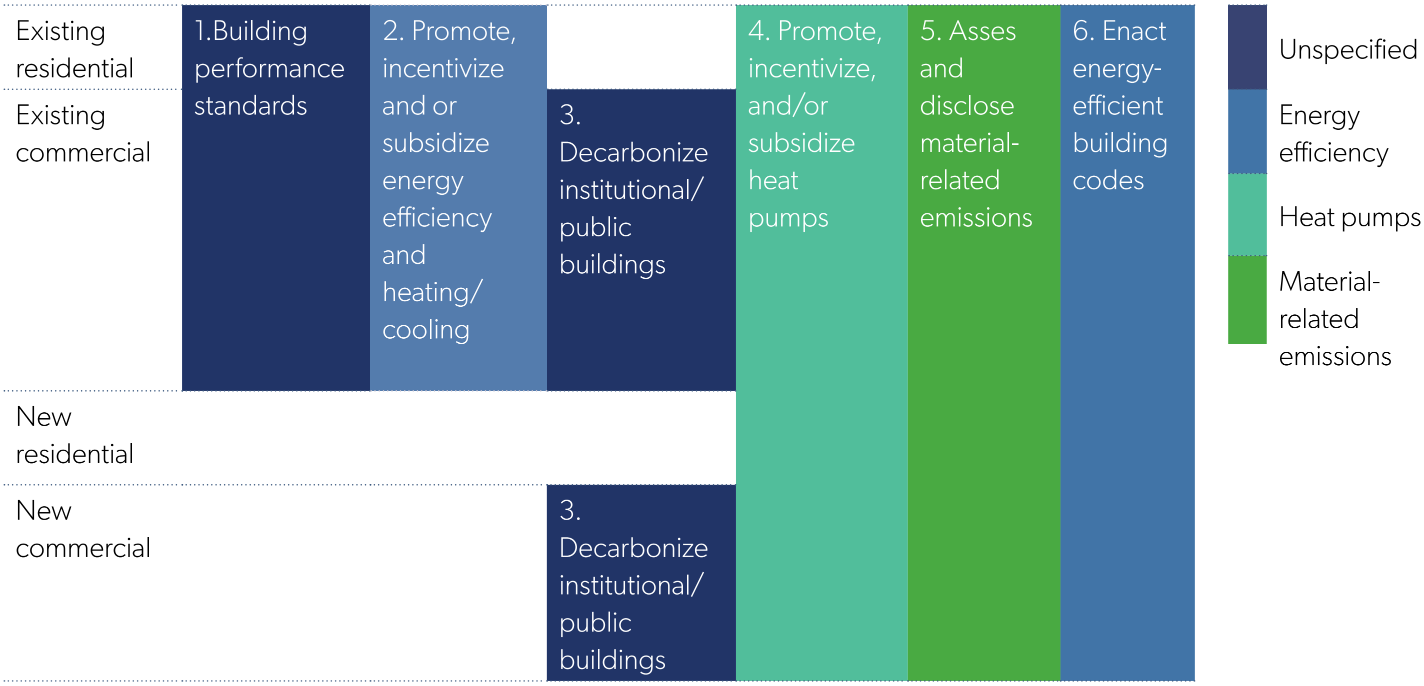


Figure 23. Mapping the policy impacts

The following sections summarize the results from the scorecards for all policy concepts againstGHG emissions and each category of additional benefits. The details of each policy concept are described in Appendix 1.

3.2.1 GHG EMISSIONS

The modeled outputs for GHG emissions reductions by policy concept are shown in Figure 24. The conversion to heat pumps in the State's building stock, Policy 4b, by 2035 resulted in average annual reductions of 3.6 million MtCO2e.[30] Policies 1c and 1d, the most ambitious implementation of the Building Performance Standards, achieved 82% and 77% of the reductions of Policy 4b, respectively. A combination of heat pumps and RNG was modeled as the pathway to achieve the Building Performance Standard GHG intensity requirements.

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[30] Note that this is an indicator, and modeled GHG reductions follow a curve that starts slowly and accelerates over time as the rate of adoption increases. S-curves are used to describe the diffusion of innovations in which a technology is adopted by pioneers, it then becomes mainstream experiencing rapid growth, before slowing down.

Carve outs for smaller buildings in the commercial sector (the policy only applies to buildings ⇢ 35,000 ft2) reduced the average annual emissions reduction by 5% in Policy 1 and by 7% in Policy 5 (the policy only applies to buildings ⇢ 50,000 ft2). There are no carve outs for residential buildings in either policy.

Efficiency improvements in Policy 2 reduced energy consumption without fuel switching, and achieved one-quarter of the average annual reductions of Policy 4b.

GHG reductions resulting from Policy 3 are relatively small, (even in the ambitious implementation pathway they are-176,000 MtCO2e/year), because of the size of public sector building stock in Oregon. This policy can be useful to stimulate net zero new construction and deep retrofits.

Policy 6 was effective for new buildings. Implementation for the larger existing building stock was limited by the rate of renovations, which is the trigger for building energy efficiency improvements in this policy concept.

Policy 5 can unlock a previously untapped source of GHG emissions reductions, namely embodied GHGs. Average annual reductions in embodied GHG emissions in Policy 5b wee 3.3 million MtCO2e for both commercial and residential buildings; these GHG emissions reductions are not included in the building sectors in Oregon's GHG emissions inventory but in the case in which materials used in buildings are produced in Oregon, these emissions may be included in other sectors such as industry.

Policies 1c, 1d, 4a and 4b achieve Oregon's GHG target proportionately applied to residential and commercial buildings as stand alone policies; the other policies do not. As indicated above. GHG emissions reductions resulting from Policy 5 are not included in the same ledger.

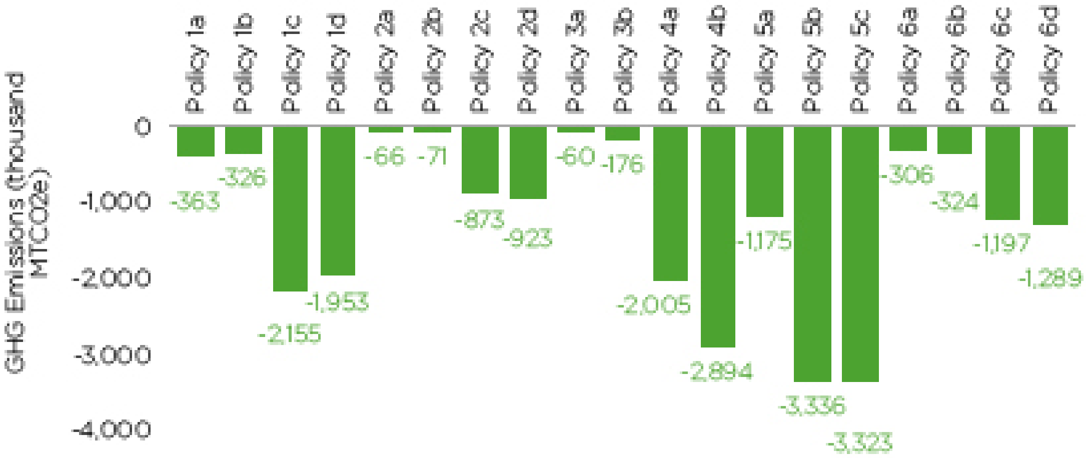

Figure 24. Average annual GHG emissions reductions for each of the Policy Concepts

3.2.2 ADDITIONAL BENEFITS

The modeled outputs for additional benefits included: a) energy efficiency; b) number of households with increased resilience; c) decline in public health costs; d) decrease in household energy costs; e) abatement costs; f) employment and g) avoided damage from climate change (social cost of carbon). All of the modeled Policy Concepts demonstrate outcomes that reduce energy consumption, with the exception of Policy 5, because it addressed embodied GHG emissions in building materials and other embodied construction-related emissions such as transportation (Figure 25).

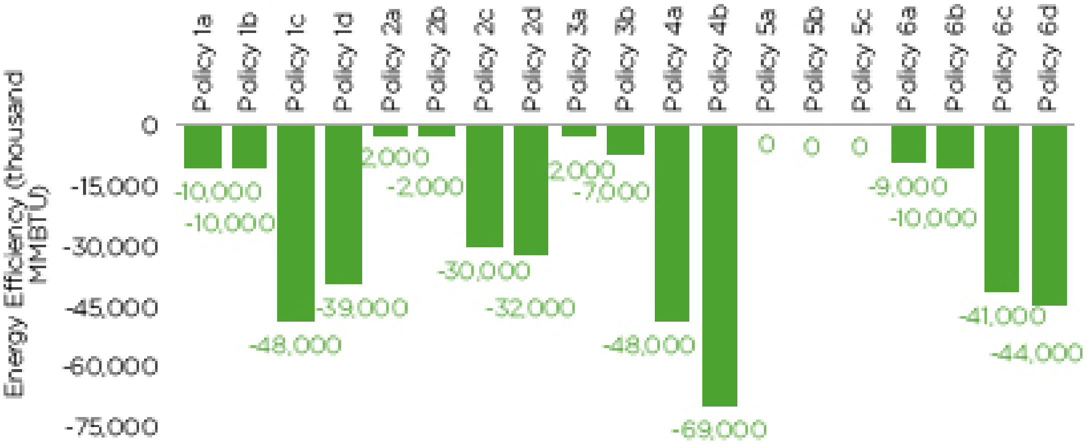

Figure 25. Average annual avoided energy consumption (2022-2050)

Not all of the policies resulted in home retrofits , which is the proxy indicator for increased household resilience. Policy 2 and Policy 6 specifically focused on home retrofits with different targeted rates of uptake. In addition, Policy 4, which focused on heat pump installation, would result in additional households having access to cooling during heat waves, however, this benefit was not analyzed in the modeling.

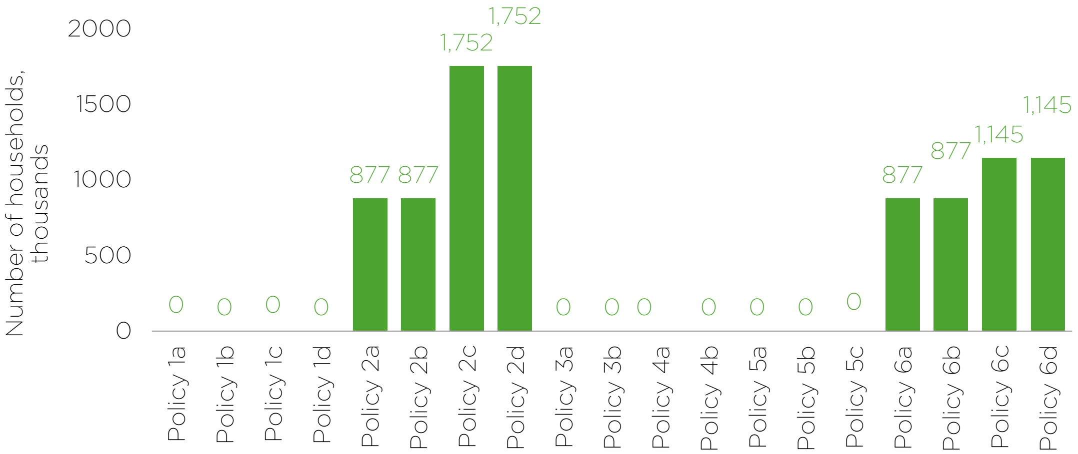

Figure 26. Number of household retrofits that increase resiliency against heat, cold and severe weather events (2022-2050)

All of the Policy Concepts resulted in decreased health-related costs of air pollution because of reduced air particulates from displaced wood combustion as well as other sources of combustion (Figure 27).

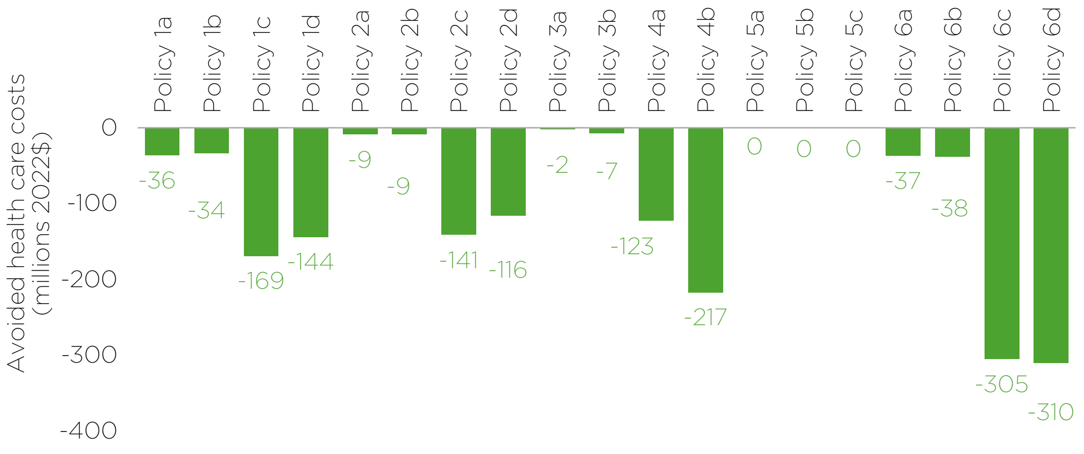

Figure 27. Change in public health costs related to air quality (2022-2050)

Policies 1,2,4 and 6 reduced household energy expenditures between 2022 and 2050, with the most significant reductions resulting from the maximum ambition of Policy 4b (-37%), followed by Policy 6d (-31%) and Policy 1d (-24%) (Figure 28). Policies 3 and 5 did not impact household energy expenditures. The greater reduction, in Policy 4b, was primarily a result of the displacement of electric resistance heating with heat pumps, which results in a drop in electricity costs. The lower ambition implementation of Policy 2 increased household energy expenditures, indicating that deeper energy savings (e.g., -50% as in Policies 2c and 2d) deliver greater financial benefits to households than shallower reductions (e.g., -15% as in Policies 2a and 2b), because shallower reductions do not keep up with increasing energy costs.

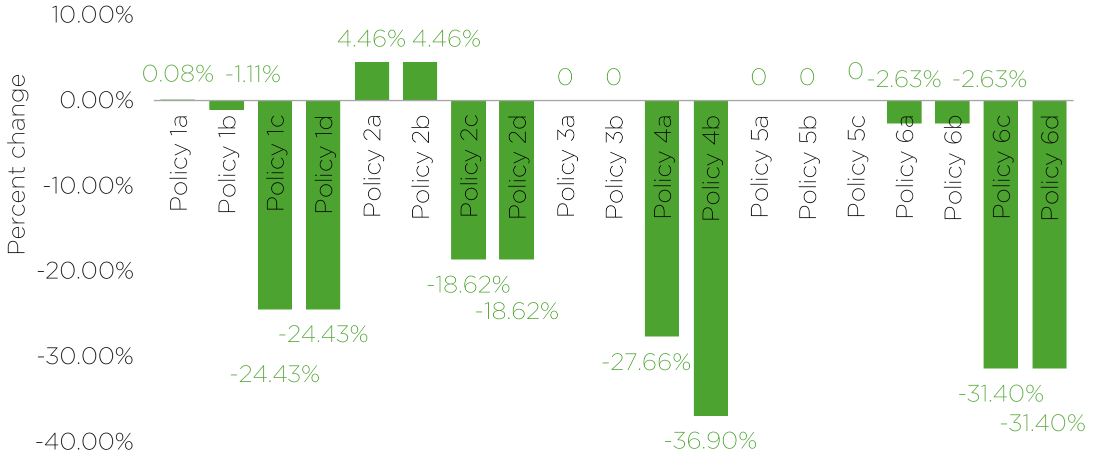

Figure 28. Change in household energy costs from 2022-2050

The policies evaluated result in an incremental capital costs relative to the BAP scenario. Average annual capital investments varied for each of the Policy Concepts with the greatest investments peaking at around $1.5 billion to $2 billion from the high costs of building retrofits (Figure 29).[31]

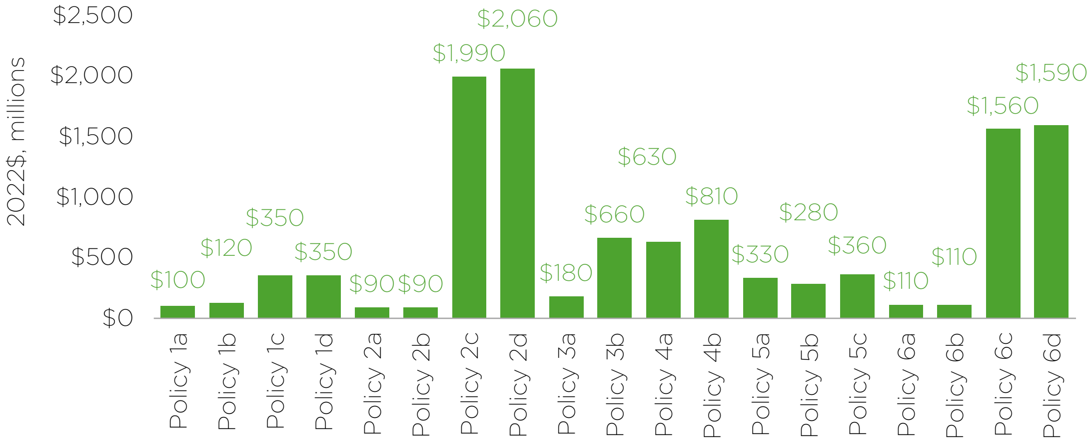

Figure 29. Average annual capital investment (2022-2050), undiscounted

The net present value (NPV) is a sum of the costs and savings for each of the policies over the period between 2022-2050. Policies 1c, 1d, 2a, 2b, 4a, 4b, 6a and 6b generated net savings, while the other policies generated costs. In general, IRA funding would reduce the costs and increase the savings for the policies across the board, but the specific impacts were not calculated. Further cost reductions may also be achieved through economies of scale for heat pumps and building retrofits that also were not included in the modeling.

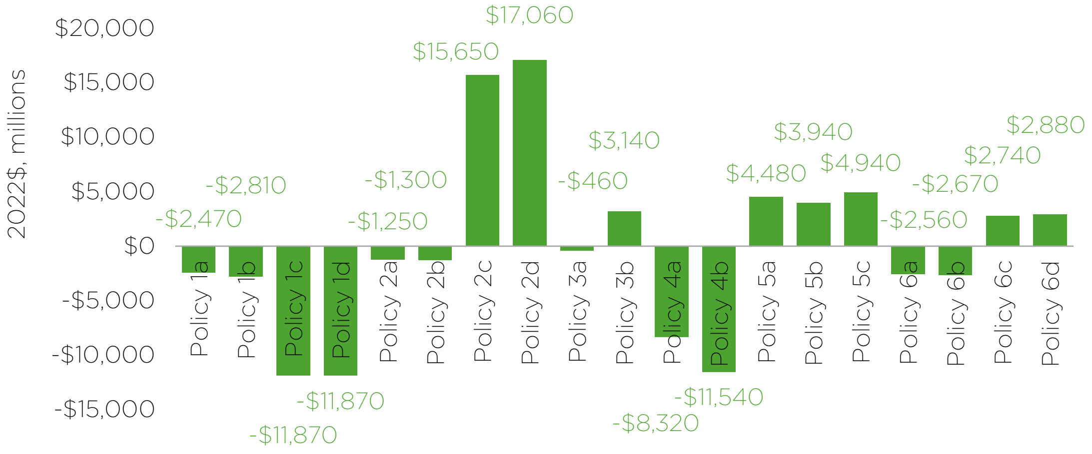

Figure 30. Cumulative net costs discounted at 3% (2022-2050)

Policies 1a, 1b, 1c, 1d, 2a, 2b, 3a, 4a, 4b, 6a and 6b are no-regrets policies in that they generate cost savings for each Mt of GHG emissions reduced. Policies 2c, 2d and 3b can be targeted for innovation or combined with policies which save money, as they have a cost of more than $500/MtCO2e. Policies 5a, 5b, 5c, 6c and 6d also have net costs/MtCO2e, which could be mitigated by introducing incentives or subsidies.

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[31] Bureau of Economic Analysis (2020). Gross Domestic Product by State and Personal Income by State, 2nd Quarter 2022. Retrieved from: https://www.bea.gov/sites/default/files/2022-09/stgdppi2q22-a2021.pdf

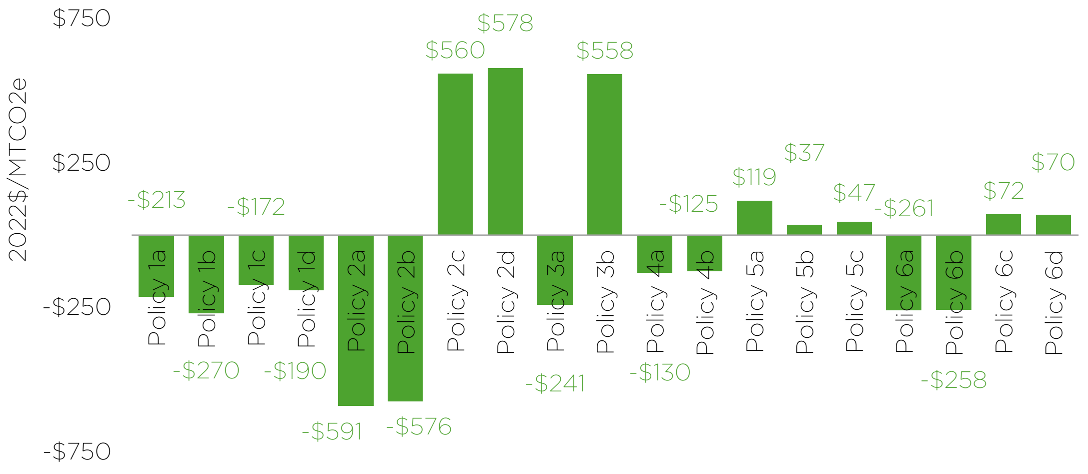

Figure 31. Lifecycle abatement cost (2022-2050)

Policies 2c and 2d result in the greatest number of person years of employment, totalling an average of 10,000 per year. The remainder of the policies generate between 500 and 3,300 of person years of employment per year. Note that the adoption curves of the policy start slowly so that the years of employment accelerate towards the end of the period.

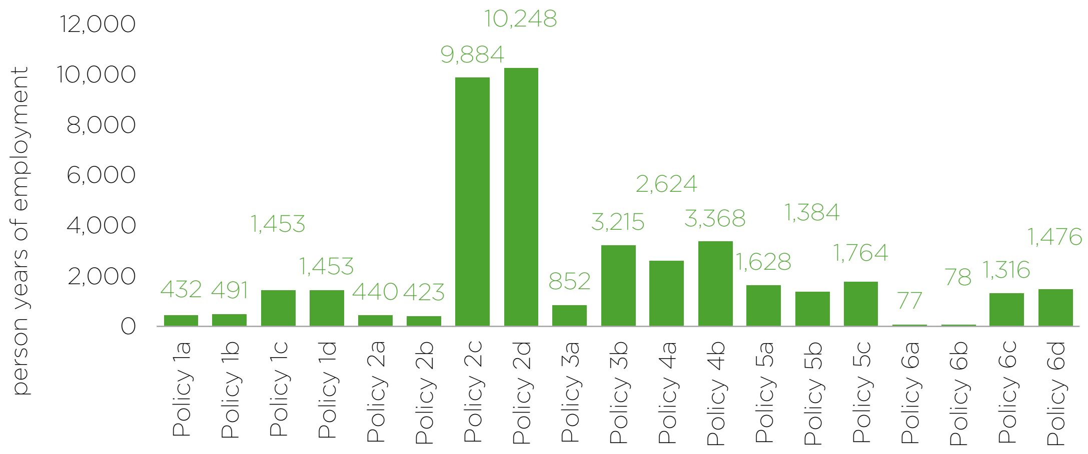

Figure 32. Average annual person years of employment (2022-2050)

The value of avoided damage from the impacts of climate change was assessed as proportional to the GHG emissions reduced. Policy 5c had the greatest value for avoided damage with an average total of $255 million per year (Figure 33).

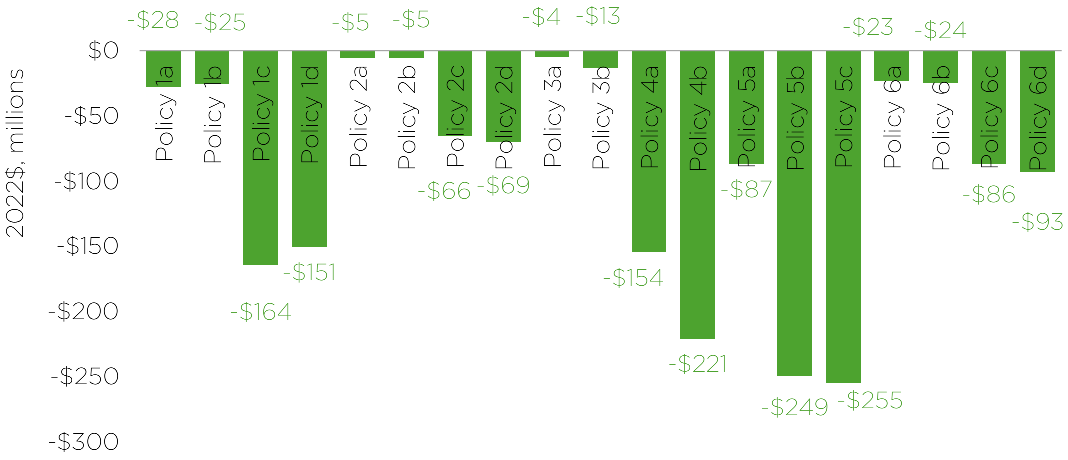

Figure 33. Avoided annual damage as a result of climate change globally (2022-2050)

3.3 Integrated scenarios

The Task Force has multiple policies, and these policies can be integrated into Integrated Scenarios consisting of several of the Policy Concepts (Table 8).

Table 8. Integrated scenario policy summary

SCENARIO	POLICY ELEMENTS
Scenario A	Building envelope retrofits
	New building energy reduction targets
	Space and water heating heat pump adoption
	Solar PV for new public buildings
	Embodied carbon reductions
Scenario B	Building envelope retrofits
	Space and water heating heat pump adoption
	New building energy reduction targets
Scenario C	Space and water heating heat pump adoption
	RNG replacement of NG
	Public building envelope retrofits
	New public building energy reduction targets
	Solar PV for new public buildings
	Embodied carbon reductions

SCENARIO	POLICY ELEMENTS
Scenario D	Building envelope retrofits Space and water heating heat pump adoption New building energy reduction targets
Scenario E	Space and water heating heat pump adoption RNG replacement of NG Public building envelope retrofits New public building energy reduction targets Solar PV for new public buildings Embodied carbon reductions

3.3.1 GHG EMISSIONS

Four of the integrated scenarios (A, B, C, E) resulted in similar average annual reductions in GHG emissions, approximately 2.1 million MtCO2e per year. Scenario D resulted in GHG emission reductions that were 30% greater (3.4 million MtCO2e), by maximizing retrofits and the deployment of heat pumps (Figure 34).

The implication of these results is that various combinations of policies could achieve the same level of GHG emissions reductions. For example, Scenario A consists of policies that change building codes to improve the performance of new and existing buildings (6a), incentivises heat pumps (4a), and decarbonizes public buildings (3a). Scenario B incentivizes building retrofits (2a) and heat pumps (4a,) and improves the performance of new buildings with changes to the building codes (6a). Scenario C consists of a Building Performance Standard (1d), combined with decarbonizing policies targeting public buildings (3b). Scenario D includes an ambitious program of retrofits (2d), combined with a policy for rapid deployment of heat pumps (4b), and policies that change building codes for improving the performance of new buildings (6d). Scenario E includes a high ambition pathway that includes the Building Performance Standard for existing buildings (1c), and decarbonizing policies targeting public buildings (3b).

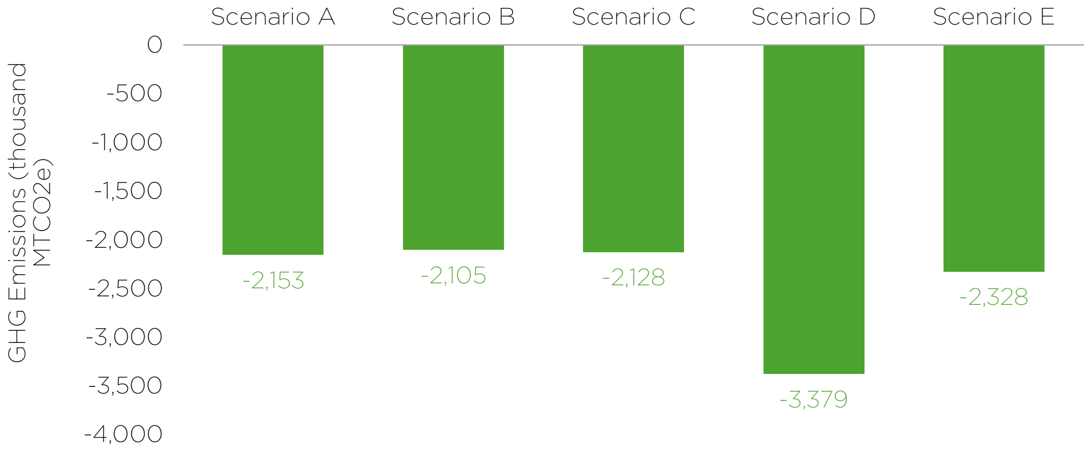

Figure 34. Average annual GHG emissions reductions by Scenario (2022-2050)

Policies 5a, 5b, and 5c, which target reducing material-related or embedded GHG emissions, were also included in Scenario A, Scenario C, and Scenario E, respectively, but the GHG emissions reductions were counted as negative emissions below the x-axis (Figures 35-39).

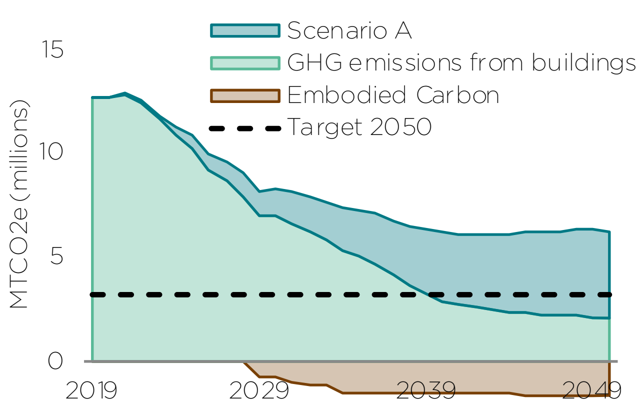

Figure 35. Annual GHG emissions from Scenario A

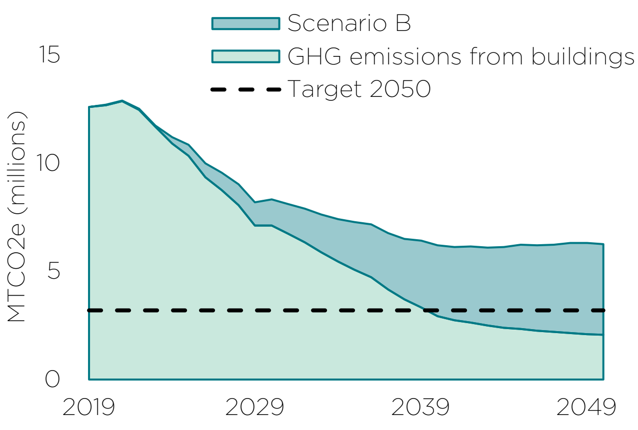

Figure 36. Annual GHG emissions from Scenario B

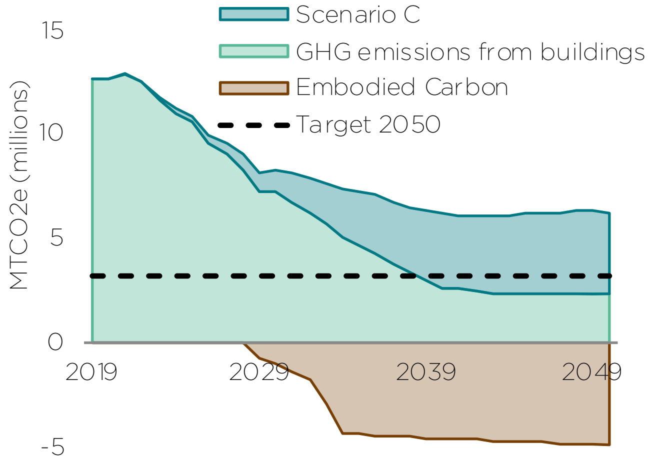

Figure 37. Annual GHG emissions from Scenario C

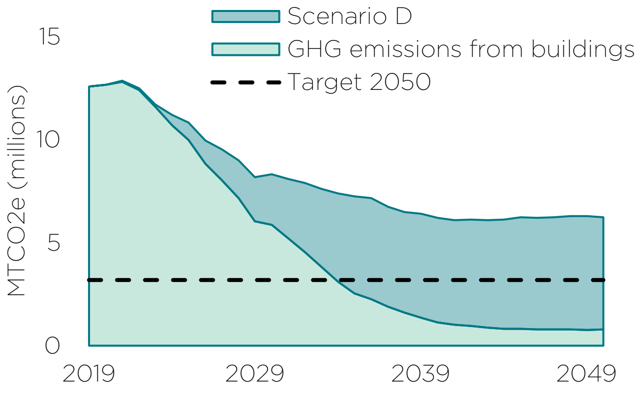

Figure 38. Annual GHG emissions from Scenario D

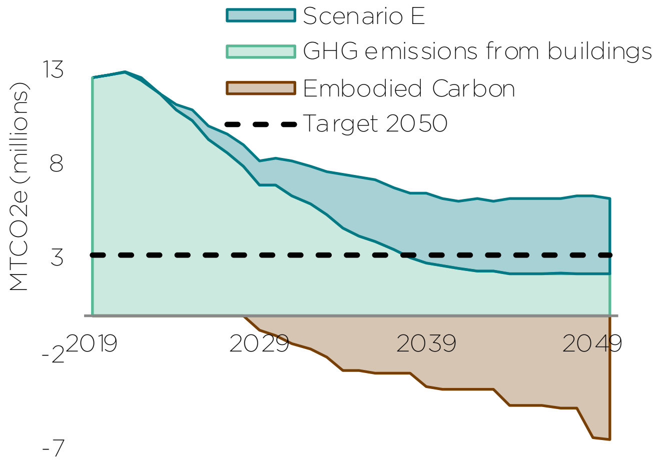

Figure 39. Annual GHG emissions from Scenario E

3.2.2 ADDITIONAL BENEFITS

All of the scenarios reduce annual energy consumption, with Scenarios A, B, C and E reducing approximately 55,000 MMBTU (Figure 40). Scenario D achieves double this reduction through a more rapid and extensive deployment of heat pumps, which displace electric resistance heaters, and deep building retrofits.

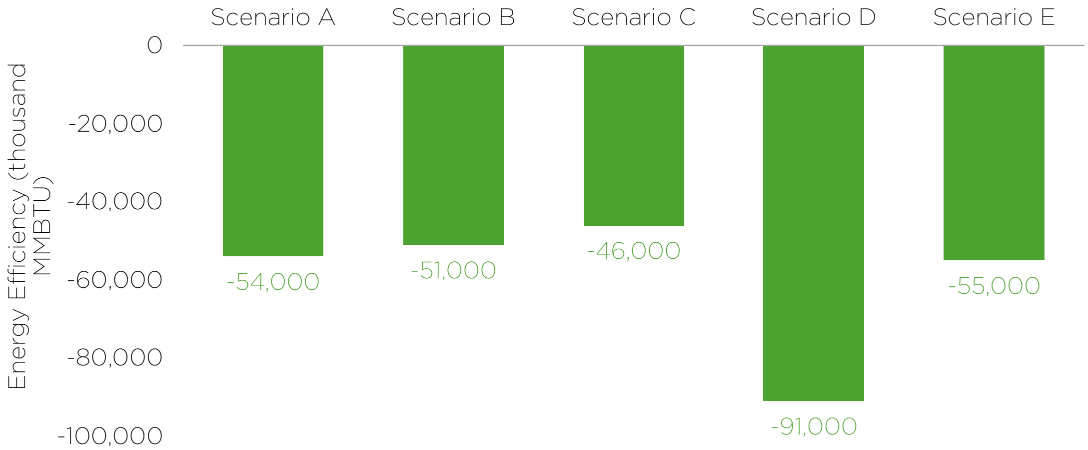

Figure 40. Average annual avoided energy consumption (2022-2050)

Scenario D maximizes the retrofit of homes for energy efficiency and climate resilience, by 2035, increasing the resilience of the state's housing stock. Scenarios C and E implement an improved Building Performance Standard rather than policies for retrofits of homes; Scenario A implements home retrofits using upgraded building code requirements for renovations;and, Scenario B incentivizes home retrofits (Figure 41).

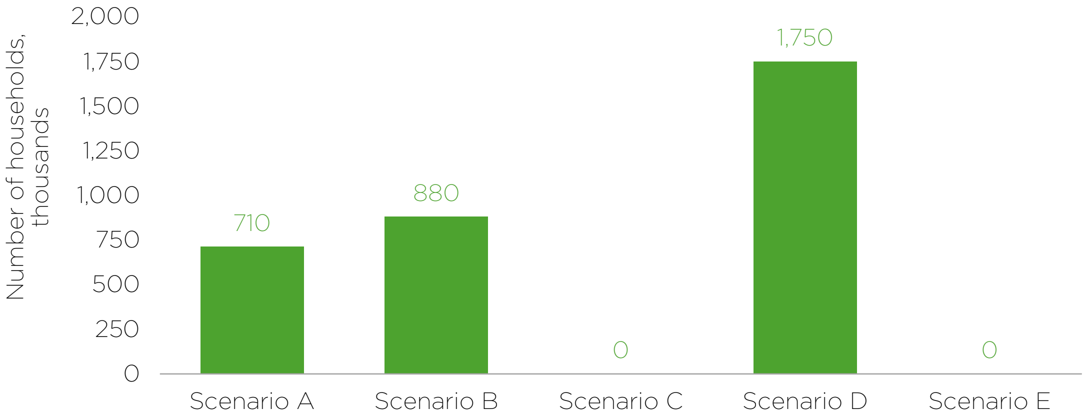

Figure 41. Number of household retrofits that increase resiliency against heat, cold and severe weather events (2022-2050)

All of the scenarios result in reductions in air pollution, and therefore result in decreased health care-related costs (Figure 42).

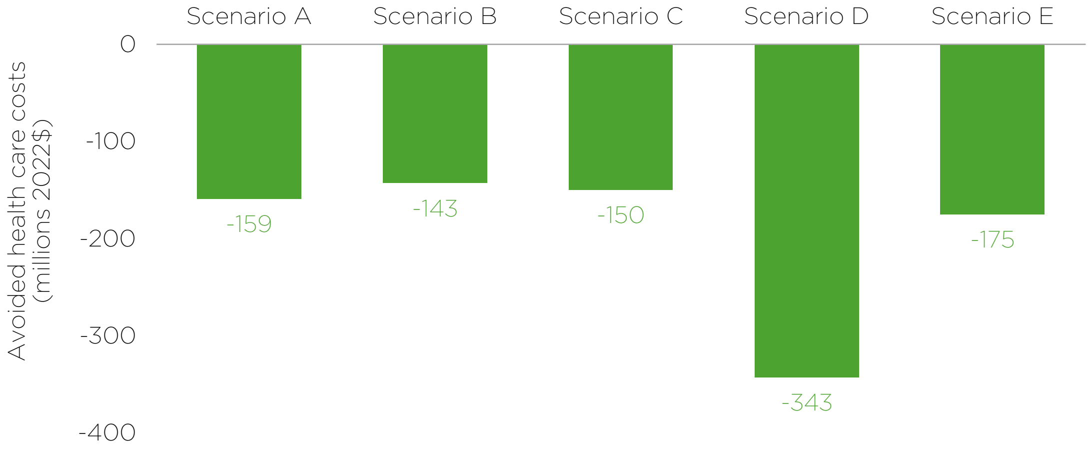

Figure 42. Change in public health costs related to air quality (2022-2050)

All of the scenarios result in reductions in household energy costs between 2022 and 2050. The deep energy reductions in Scenario D see (Figure 40), resulted in drops of almost 60% in household energy costs. However, achieving the cost reductions in Scenario D had a higher capital cost, as illustrated below, in Figure 44.

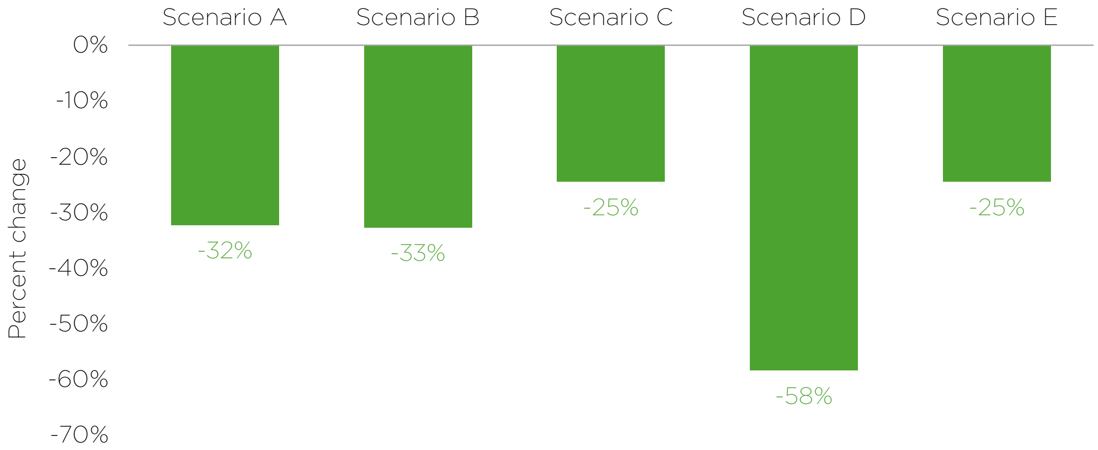

Figure 43. Change in household energy costs, by Scenario (2022-2050)

The average annual capital costs vary from $760 million (Scenario B) to $3.1 billion in Scenario D.[32] The higher capital costs exhibited by Scenario D resulted from the commitment to retrofit 100% of the State's building stock and install heat pumps in 100% of buildings by 2035.

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[32] Bureau of Economic Analysis (2020). Gross Domestic Product by State and Personal Income by State, 2nd Quarter 2022. Retrieved from: https://www.bea.gov/sites/default/files/2022-09/stgdppi2q22-a2021.pdf

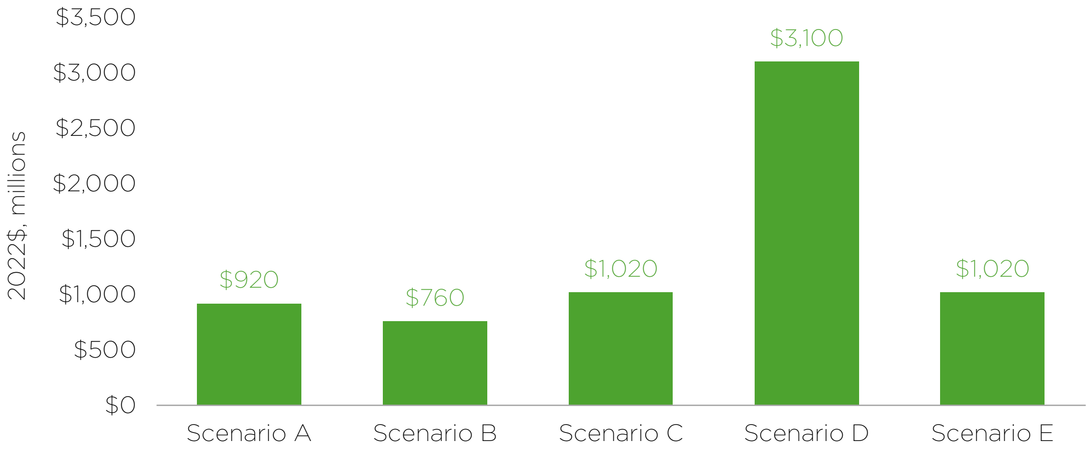


Figure 44. Average annual capital investment, by Scenario (2022-2050)

Four of the scenarios modeled resulted in net financial benefits over the period 2022 to 2050, with savings of $4 billion to $12.4 billion (Figure 45). The scope of Scenario C included a more narrow portion of the State's building stock and, therefore, captured fewer financial saving opportunities. As a result of higher upfront capital costs for home retrofits, compared with the other scenarios, Scenario D resulted in a net cost of $4.5 billion (Figure 45).

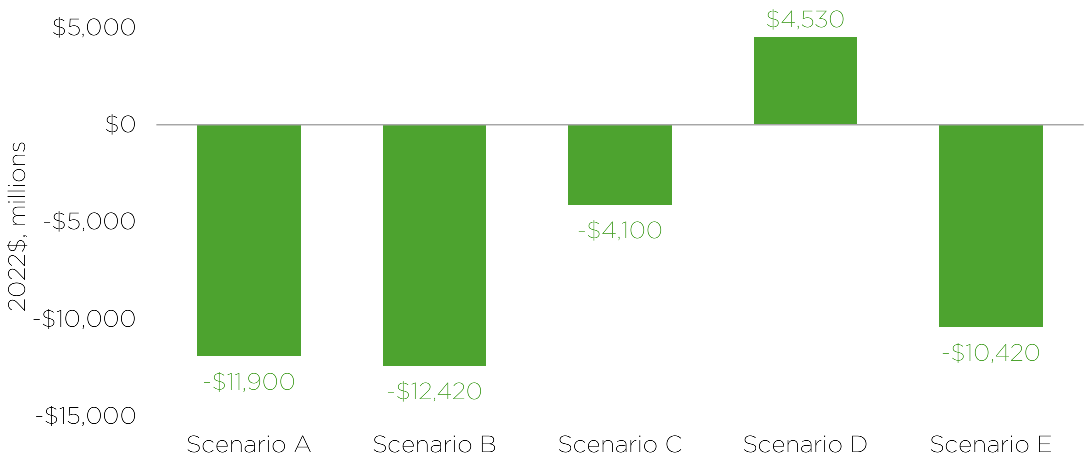


Figure 45. Cumulative net costs by Scenario, discounted at 3% (2022-2050)

Those cost savings shown in Figure 45 for four of the Scenarios were also reflected in the abatement costs. The outcomes for Scenarios A, B, and E demonstrate lifecycle abatement costs that provide savings between $140 and $184/MtCO2e (Figure 46). On the other hand, the outcomes for Scenario D, demonstrate net lifecycle abatement costs of $42/MtCO2e.

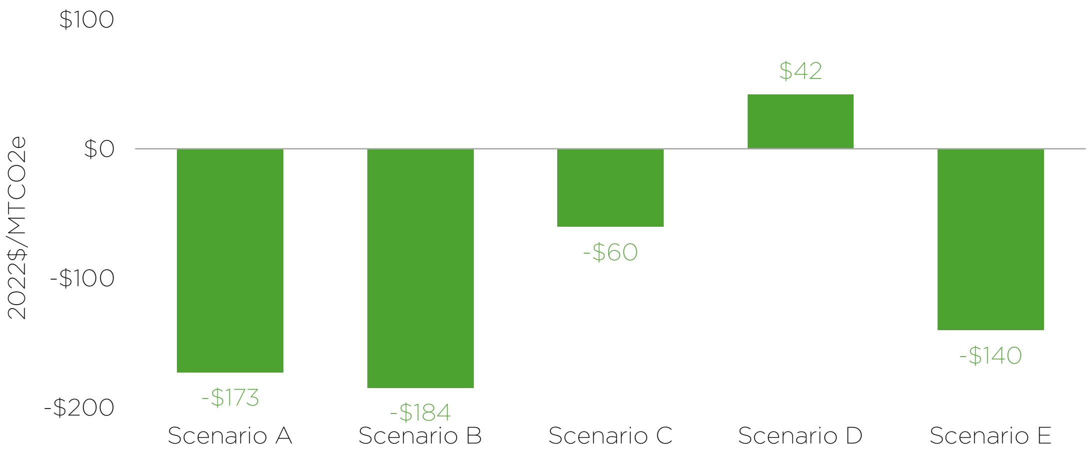


Figure 46. Lifecycle abatement cost (2022-2050)

The average annual person-years of employment aligned with the annual capital investments, shown in Figure 44.. Greater employment numbers were shown as Scenario outcomes with investments in home retrofits.. For example, Scenario D resulted in nearly 15,000 person-years of employment per year, while the other policies ranged from 3,200 (Scenario B) to 6,480 (Scenario E). Furthermore, Scenario A resulted in higher average annual person years of employment because of its inclusion of building retrofits in the public and institutional sectors (Figure 47).

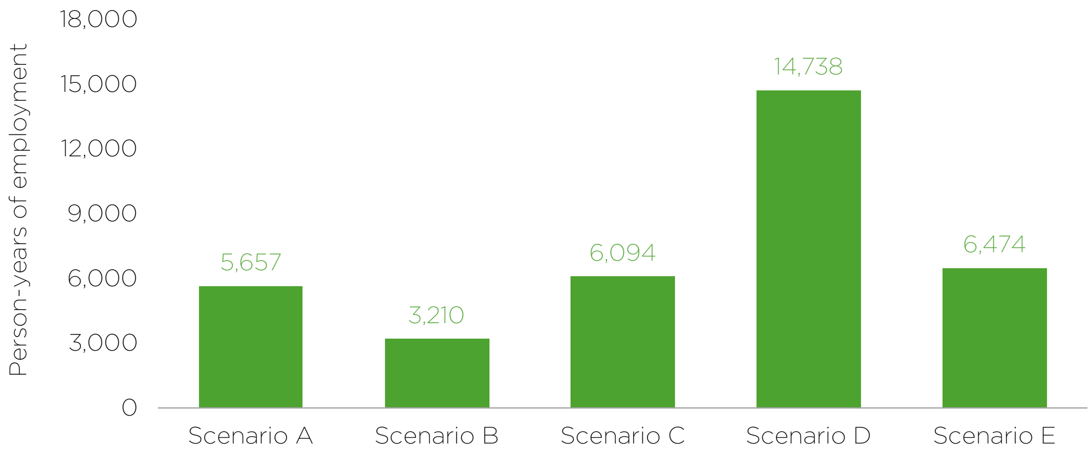


Figure 47. Average annual person years of employment (2022-2050)

The average value of avoided damages due to the changing climate for the Scenarios ranged from $161 million to $255 million per year (Figure 48). On a cumulative basis over the modeled time period of 2022 to 2050, the avoided damages totaled between $4.5 and $9.7 billion.

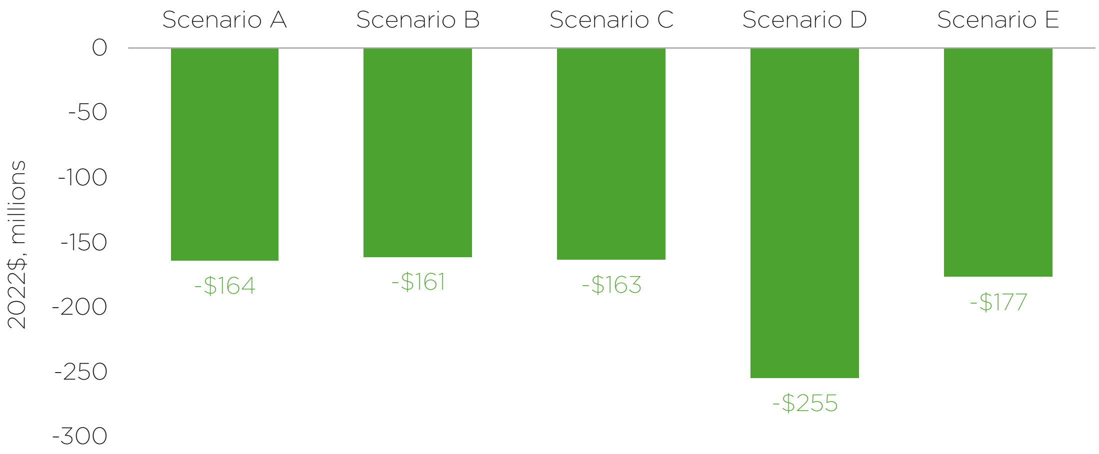


Figure 48. Average annual value of avoided damages from climate change by Scenario (2022-2050)

3.4 Hourly Electricity Demand Analysis

The hourly electricity demand (8,760 hours) for each of the Integrated Scenarios was modeled to assess the impact of the policy concepts on peak electricity demand. An increase in peak demand will require additional renewable electricity generation capacity and increase the costs of electricity. A decrease in peak electricity demand reduces the financial and technical challenge of decarbonising the electricity system, as required by HB 2021.

The projected impact for the Scenarios and the BAP Scenario on the hourly electricity demand in 2050 in comparison to demand in 2019 (purple) is illustrated in Figure 49.

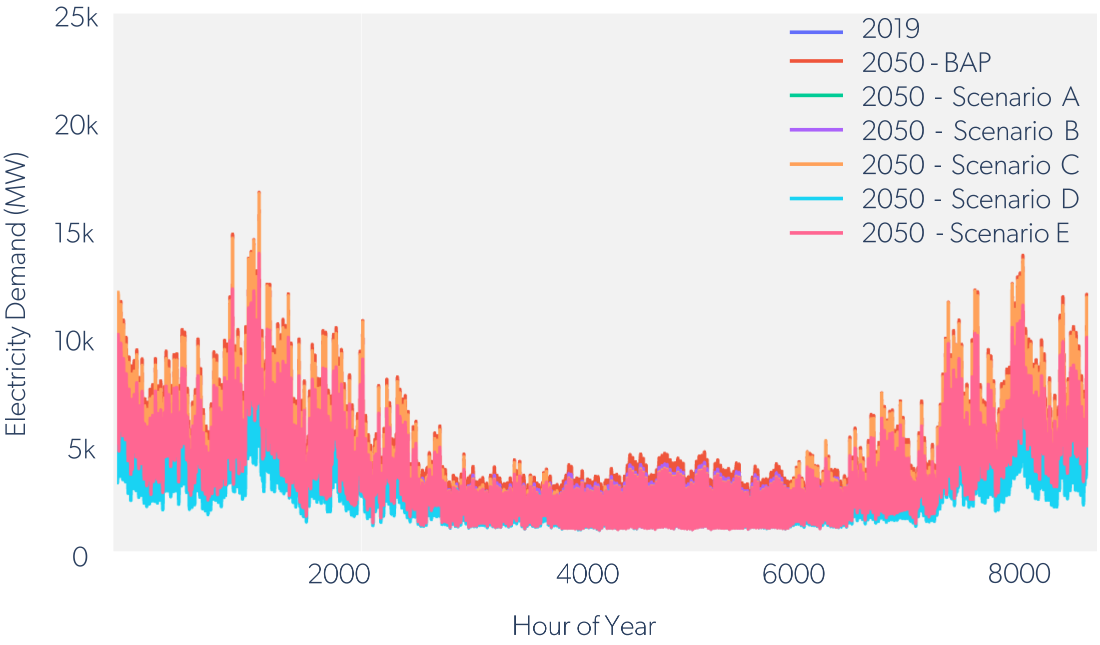


Figure 49. 8760 illustration of peak demand for each of the integrated scenarios in 2050

In general, the Scenarios reduced peak electricity demand at all times of the year relative to both the 2019 scenario and the 2050 BAP scenario. Scenario C increased hourly demand over 2019 levels because it omitted building retrofits, however, demand was still below the 2050 BAP scenario, because it included conversion to heat pumps.

24-hour demand curves are illustrated for summer, fall, spring and winter in Figures 50-54.

Despite population growth, winter peaks do not increase as a result of the combination of improved building efficiency and the replacement of electric baseboard heaters with heat pumps. Additionally, there is back-up natural gas heating in 30% of the households, which reduces increasing demand resulting from decreased efficiency of heat pumps on extremely cold days.

Growth in air conditioning load is also mitigated in most scenarios by the improved efficiency of heat pumps over air conditioners and improved thermal performance of the building stock.

The reductions in demand are most evident in Scenario D (Figure 50), where demand is reduced by more than 50% in the winter and to a much lesser degree in the summer.

Figures 51 and 52 illustrate hourly demand by end-use for a 24-hour period for residential buildings in Scenario A and D. Demand falls against the 2019 scenario and the 2050 BAP scenario in every season. The demand for space heating is apparent in the winter and to a lesser degree in the fall.

Electricity demand in commercial buildings increases in the spring and summer in both Scenario A and Scenario D relative to the 2019 demand curve but in both cases remains below the 2050 BAP demand curve.

The demand curves also highlight opportunities for demand response, notably for domestic hot water heating, and space heating, if storage is installed.

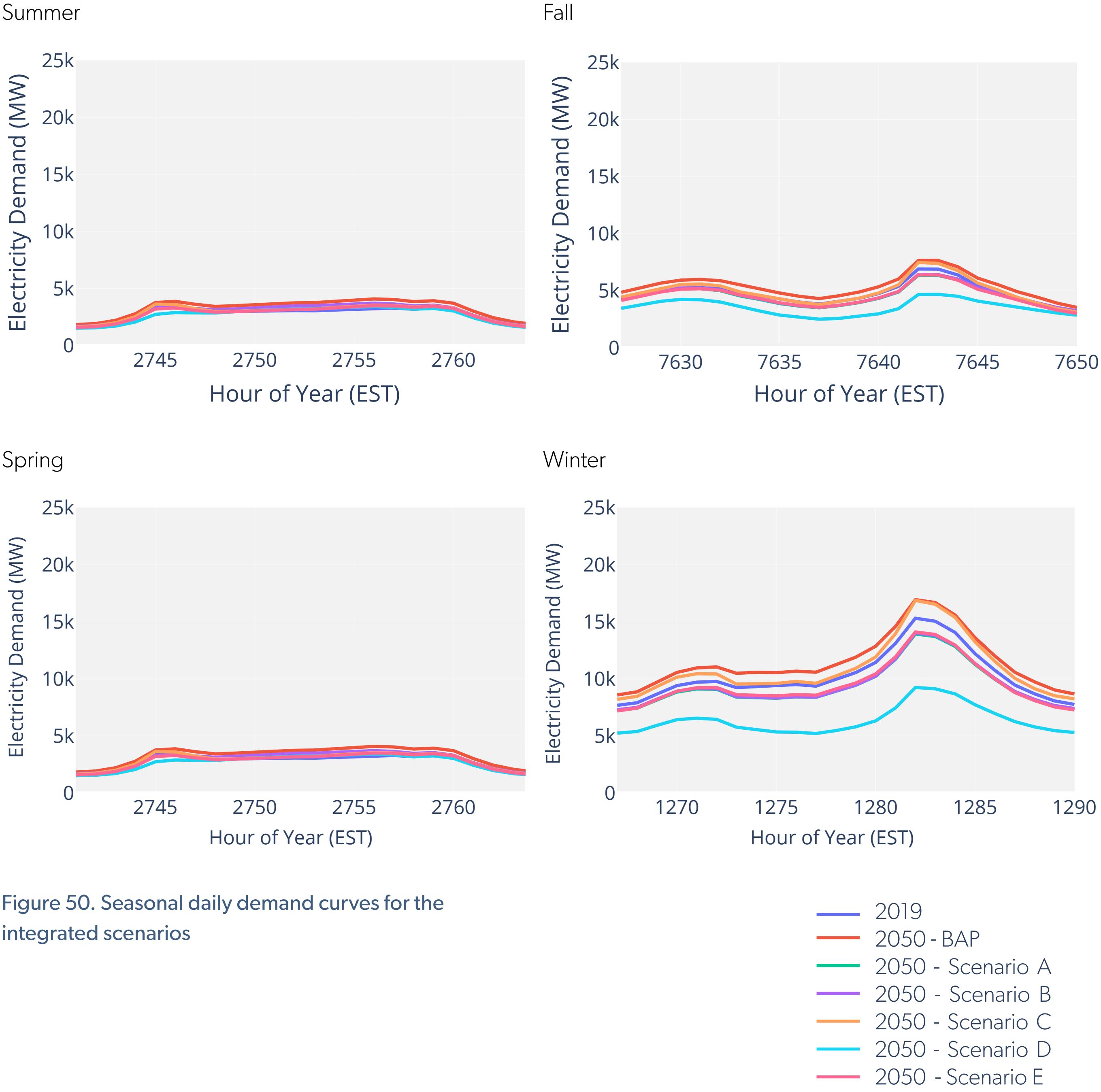


Figure 50. Seasonal daily demand curves for the integrated scenarios

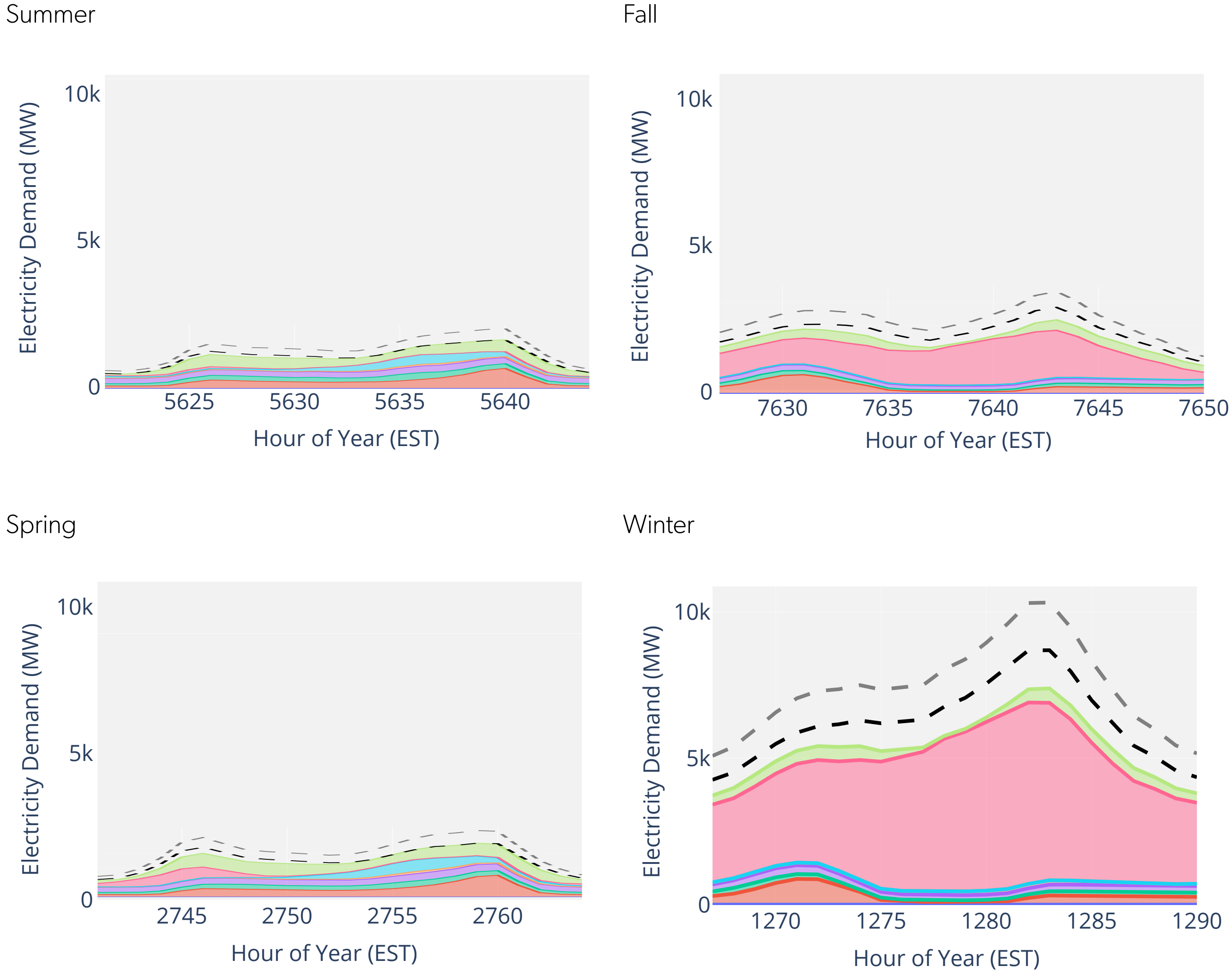


Figure 51. Seasonal daily residential demand curves for scenario A by end use

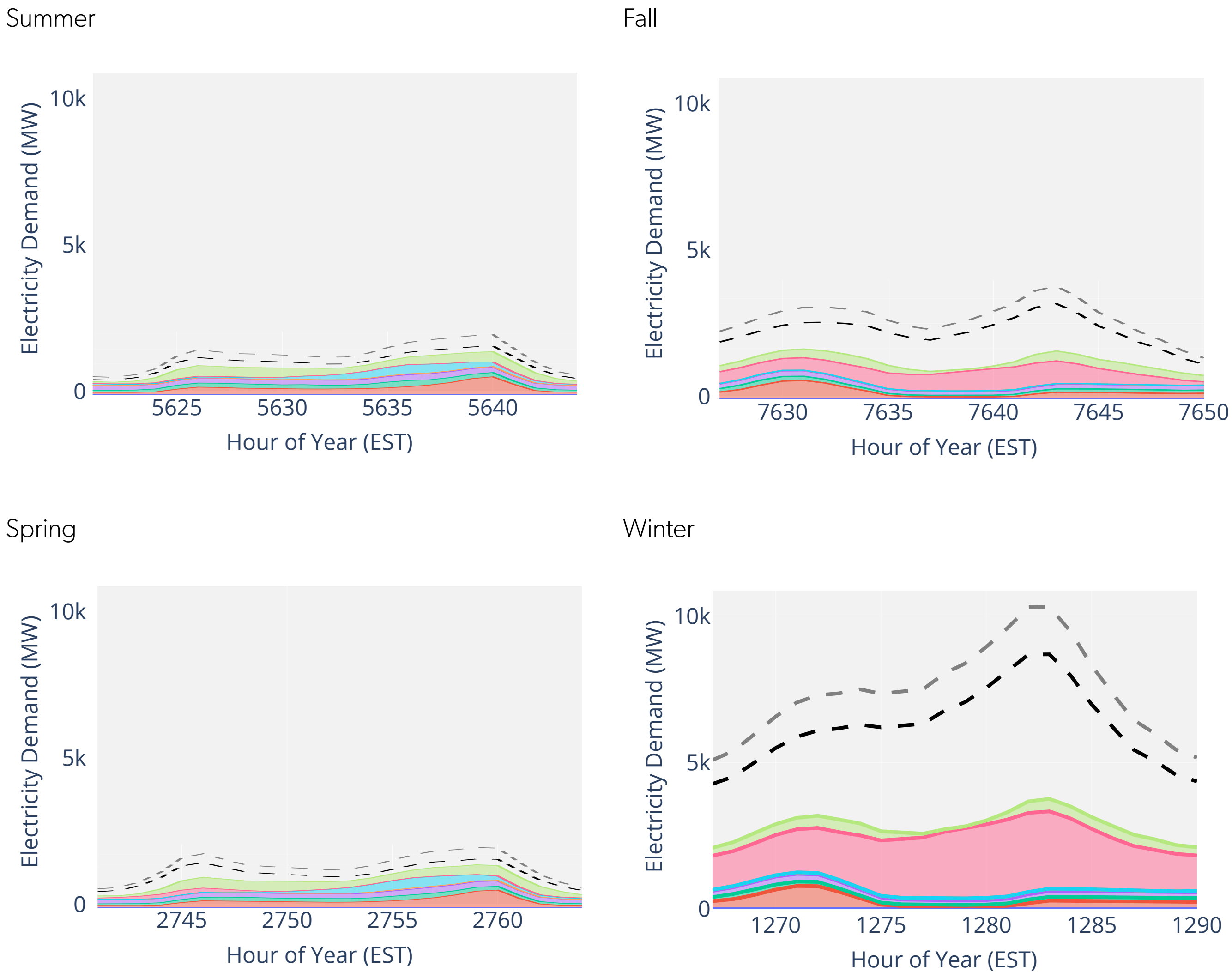


Figure 52. Seasonal daily residential demand curves for scenario D by end use

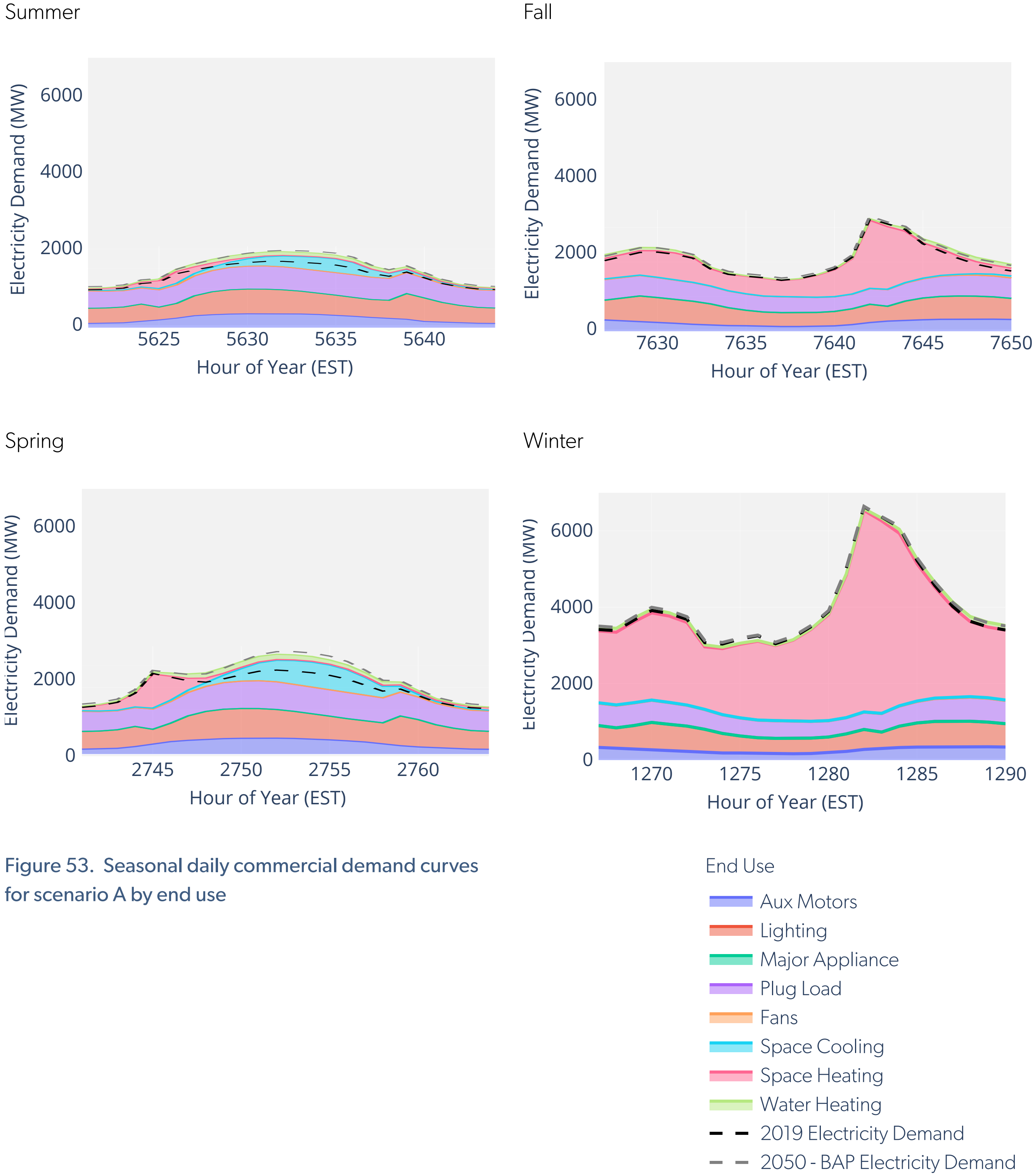
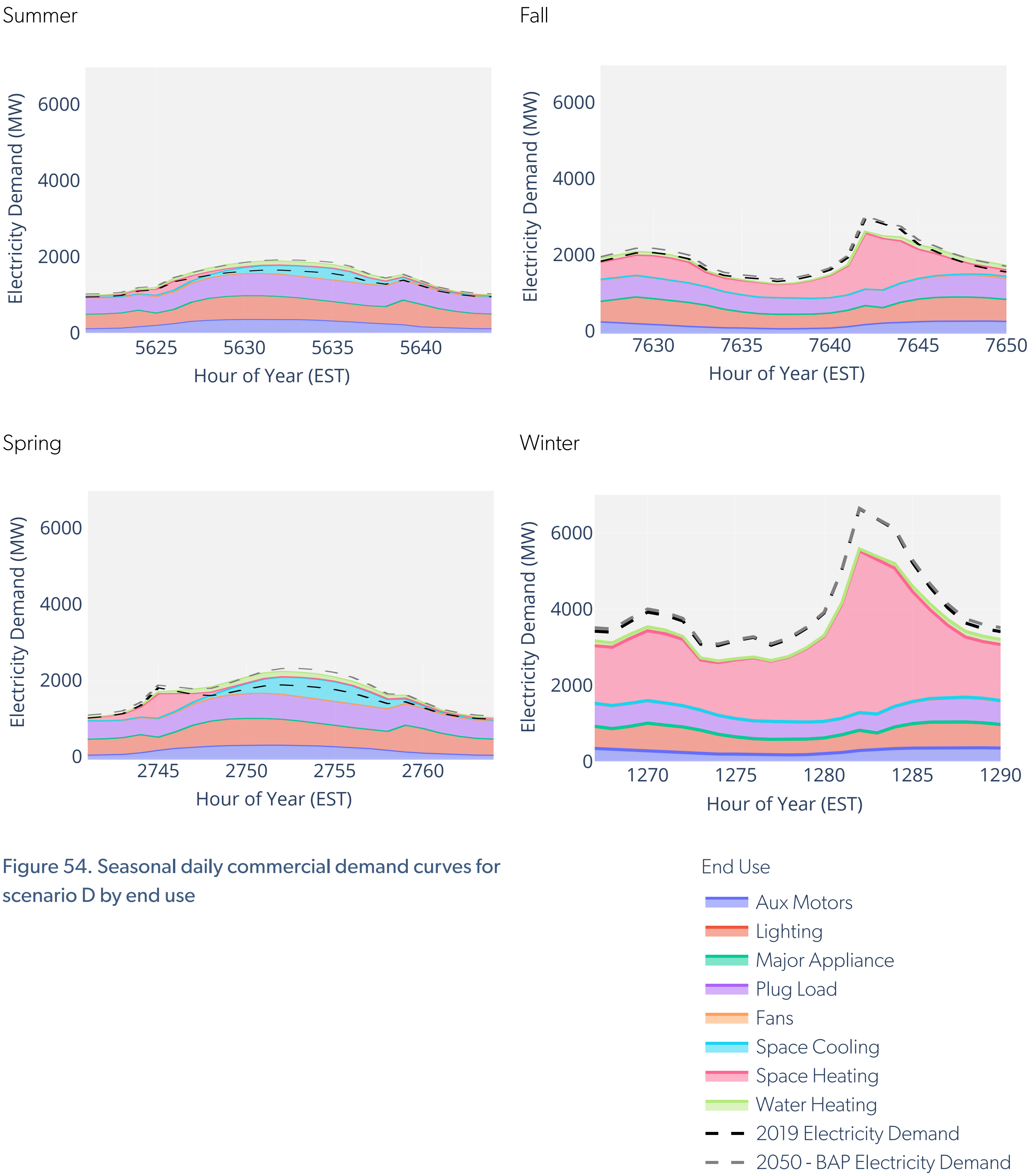


Figure 53. Seasonal daily commercial demand curves for scenario A by end use



Summer

Fall

Spring

Winter

Figure 54. Seasonal daily commercial demand curves for scenario D by end use

4. Discussion

1. **Many of the policies are "no regrets":** Most of the policies generate net financial savings, including:
    a. Policy 1a, 1b, 1c, 1d: Building Performance Standards
    b. Policy 2a, 2b: Promote, incentivize and or subsidize energy efficiency and heating/cooling
    c. Policy 3a: Decarbonize institutional/public buildings
    d. Policy 4a, 4b: Promote, incentivize, and/or subsidize heat pumps
    e. Policy 6a, 6b: Enact energy-efficient building codes
    f. The addition of the financial benefits of the avoided damages of climate change (the social cost of carbon) or avoided health costs further increases this benefit; in this case only policy 2c and 2d have a net cost.
2. **Household energy costs are reduced:** Relative to 2019, policies decrease household costs by between 2.6% and 37% by 2050, using conservative projections on energy costs.
3. **Several policies and all Integrated Scenarios can achieve Oregon's GHG target:** The building performance policies (1c and 1d) and the heat pump policies (4a and 4b) achieve Oregon's GHG target. Policy 4b achieves the deepest GHG emissions reduction. All five Integrated Scenarios achieve Oregon's GHG target.
4. **Capital costs of the more ambitious policies are less than 1% of Oregon's GDP:** Policy 2c and 2d (Promote, incentivize and or subsidize energy efficiency and heating/cooling) require the highest average annual capital investments of approximately $2 billion, 0.74% of Oregon's GDP. Policy 6c and 6d are the second highest at $1.6 billion.
5. **Embodied carbon is the largest opportunity for GHG emissions reductions:** Policy 5b results in average annual reductions of 3.3 million MtCO2e in embodied GHGs. Embodied emissions are accounted for differently than operational emissions, so these reductions don't directly contribute to achieving Oregon's GHG target.
6. **Electricity demand will increase in the BAP scenario:** Population growth increases electricity demand from the residential and commercial sectors in the absence of any policies considered by the Task Force.
7. **The Integrated Scenarios and policies reduce electricity demand from residential and commercial buildings:** Compounding efficiency benefits limit the impact of heat pumps on peak demand in the winter. For example, a poorly insulated house with baseboard heating that gets retrofitted (50% thermal reduction) and that gets a heat pump will need only 1/6 of the electricity from before. Further, Oregon has a reservoir of "free" electricity that is currently consumed by electric baseboard heating. When the electric heating is converted to heat pumps, the efficiency gains

enable the addition of new electricity loads from existing or new buildings without increasing peak demand.

8. **The financial results are sensitive to energy costs:** The financial results are sensitive to energy costs in the modeling. For example, the analysis undertaken assumed a 2022 cost of $13.48/MMBTU for natural gas, however by August 2022, the cost had increased by 41% to $18.98/MMTBU. Increases in the price of natural gas will expand the financial benefits of the Scenarios that include the adoption of heat pumps. Similarly, increases in the cost of electricity would decrease the financial benefit of the Scenarios.
9. **The policies reduce the implementation risks for HB 2021 and CPP:** By reducing electricity demand and GHG emissions from natural gas, the policies reduce the burden for utilities to achieve their respective targets/caps.
10. **Retrofits are more expensive but reduce electricity demand:** Deep energy retrofits are capital intensive but are instrumental in reducing peak demand, and the economic value of the avoided demand, and resulting avoided electricity generation capacity, is not included in this analysis.
11. **Retrofits provide co-benefits:** Building retrofits provide the most jobs (policy 2c and 2d) and increase the resilience of homes. They also result in public health benefits.
12. **Combining policies result in compounding benefits:** The abatement cost of the most ambitious retrofit policy (2c) is $560/MtCO2e. When combined with the most ambitious heat pump policy, which has an abatement cost of -$130/MtCO2e, the combined abatement cost is $42/MtCO2e.
13. **Highest and best use:** RNG is used in policy 1c, alongside heat pumps. Given RNG availability is constrained, it makes sense to preserve this fuel for activities which require combustion, such as industrial applications.
14. **The social cost of carbon:** Avoided damage from climate change as a result of the policies ranges from -$4 million per year to -$255 million per year. New estimates of the Social Cost of Carbon would increase these numbers by a factor of four.
15. **Policies need targets:** Policies can take many flavors, with different outcomes for energy, emissions and additional benefits. Targets, and parameters, such as which component of the building stock is applicable, are necessary in order to achieve those targets.
16. **The scenarios are guideposts, not prescriptions:** None of the scenarios may be the preferred pathway, but they provide directional guidance on what would happen if a policy achieves a particular outcome.

Appendix 1: Policy Details

1	**Building performance standards**	1a	1b	1c	1d
		Direct emissions need to reach 5% below 2035 levels in the BAP by 2035		Direct emissions need to reach 40% below 2035 levels in the BAP by 2035	
		Existing residential, commercial and multi-family buildings			
		All building sizes	Buildings ⇢ 35,000 ft2	All building sizes	Buildings ⇢ 35,000 ft2

2	**Promote, incentivize and or subsidize energy efficiency and heating/ cooling**	2a	2b	2c	2d
		50% of buildings are retrofitted by 2050, thermal energy requirements reduced by 15%		100% of buildings are retrofitted by 2035, thermal energy requirements reduced by 50%	
		All building types			
		Buildings ⇢ 50,000 ft2	Buildings ⇢ 30,000 ft2	Buildings ⇢ 50,000 ft2	Buildings ⇢ 30,000 ft2

3	**Decarbonize institutional/ public buildings**	3a	3b
		New buildings after 2035 are carbon neutral	New buildings after 2023 are carbon neutral
		50% of buildings are retrofitted by 2045; thermal energy requirements reduced by 15%; plug load reduced by 15%	100% of buildings are retrofitted by 2035: thermal energy requirements reduced by 50%; Plug load reduced by 50%

4	**Promote, incentivize, and/ or subsidize heat pumps**	4a	4b
		80% of covered buildings have a heat pump installed by 2040	100% of buildings that are covered have a heat pump installed by 2035
		New and existing residential and commercial buildings	

5	**Assess and disclose material-related emissions**	5a	5b	5c	
		Reduce embodied carbon from construction by 20% by 2030, compared to 2015	Reduce embodied carbon from construction by 60% by 2030, compared to 2015	Reduce embodied carbon from construction by 100% by 2050, compared to 2015	
		Residential and commercial buildings			
6	**Enact energy-efficient building codes- Existing**	6a	6b	6c	6d
		2% of existing buildings are retrofitted each year until 2050, thermal energy requirements reduced by 15%, plug load reduced by 15%		8% of existing buildings are retrofitted each year until 2035, thermal energy requirements reduced by 50%, plug load reduced by 50%	
		Existing residential and commercial buildings			
		Buildings ⇢ 50,000 ft2	Buildings ⇢ 30,000 ft2	Buildings ⇢ 50,000 ft2	Buildings ⇢ 30,000 ft2
	Enact energy-efficient building codes- New	A 40% reduction in new building energy consumption from the 2006 Oregon codes		A 80% reduction in new building energy consumption from the 2006 Oregon codes	
		New residential and commercial buildings			
		Buildings ⇢ 50,000 ft2	All buildings	Buildings ⇢ 50,000 ft2	All buildings

Appendix 2.Comments from the Task Force

COMMENT/ QUESTION FROM THE TASK FORCE	ADJUSTMENT TO THE MODELING APPROACH	DETAILS
What is the definition of "plug load"? **How will the reductions be accomplished?**	No change	Plug loads are energy used by equipment that is usually plugged into an outlet. These sources would include equipment such as appliances, computer equipment and AV equipment. Plug loads are not related to general building lighting, heating, ventilation, cooling, and water heating, and typically do not provide comfort to the occupants. Modern technology usually incorporates a variety of power modes with most electronic devices (computers, stereos, tvs) drawing power even when they are turned off. Some strategies involved in reducing plug load include • Upgrading equipment • Turning equipment off when not in use • Employing plug-load automation and controls • Promoting beneficial occupant behaviour The following source is a good resource for commercial buildings but many of these strategies can be applied to residential buildings as well. Plug Load Frequently Asked Questions (FAQ) | GSA
The use of the AVERT tool	No change	EPA's AVERT tool calculates the change in air pollutants as a result of electricity generation on an hourly basis. The change in outputs is calculated within the model used by the modelling team. While AVERT has a higher temporal resolution, it does not include the full energy system. Additionally, the AVERT tool doesn't project future emissions as the generation mix changes.

COMMENT/ QUESTION FROM THE TASK FORCE	ADJUSTMENT TO THE MODELING APPROACH	DETAILS
The inclusion of Renewable Natural Gas (RNG)	RNG is included in Policy 1	RNG is included in Policy 1. Policy 1 is a Building Performance Standard that applies GHG targets, but does not specify how those GHG targets will be achieved. The amount of RNG available to Oregon is based on the current state of the RNG supply for the US. The total RNG supply in 2040 in the US is assumed to be 3,750 trillion BTUs. Power to gas/Methanation was excluded from this total. This total was shared out to Oregon according to the population of Oregon relative to the total US population, resulting in a total of 47.5 trillion BTUs of RNG available to Oregon by 2040. RNG was distributed to the residential building sector based on the share of natural gas left in this sector after the policy mechanism was implemented. "Best use" scenarios may direct RNG to sectors that are harder to decarbonize and these results may change. Policy 1c and policy 1d consume 7.5 trillion BTUs of RNG by 2040.
The inclusion of CPP	A figure illustrating the impact of CPP has been added to the scorecard (Figure 3)	The impact of CPP is represented in a figure for each policy (Figure 3). Because the analysis applied only to residential and commercial sectors while CPP applies to all natural gas consumption, the assumption was made that CPP GHG reduction requirements apply directly to the residential and commercial sectors to generate the CPP curve in the figure. In this figure, the reductions from the policy are subtracted from CPP, illustrating the additional emissions beyond the impact of the policy that must be reduced in order to achieve the CPP requirements. CPP was not illustrated for policy 5, because policy 5 does not apply to the energy system. The remaining CPP wedge varies in size according to the size of the policy wedge evaluated. No determination was made with respect to how the CPP GHG emissions reductions will be achieved.
The inclusion of hot water heaters	Heat pumps for hot water heaters have been added	Hot water heat pumps were added to policy 1 and policy 4.
GHG targets	A line representing the GHG target has been added to Figure 2	A line has been applied to Figure 2 to illustrate a proportional application of Oregon's GHG target of 80% below 1990 levels by 2050. The target is proportional in that the percent reduction has been applied to the residential and commercial building sectors.
The inclusion of indoor air quality	Not assessed	SSG explored strategies to assess indoor air quality changes as a result of the policies, including meeting with OHA. Given the complexity of factors influencing indoor air quality, such as access to and rate of ventilation, exposure to new materials within the building envelope, combustion within the building envelope and other factors, there was insufficient time to develop a substantive approach.

COMMENT/ QUESTION FROM THE TASK FORCE	ADJUSTMENT TO THE MODELING APPROACH	DETAILS
The inclusion of peak demand	Peak demand will be modeled for the integrated scenarios	Peak demand is generally reduced by policies which increase energy efficiency, and may be increased by fuel switching. Impacts on peak demand will be evaluated in the analysis of the integrated scenarios.
The inclusion of climate resilience	An indicator of resilience is included in the scorecards.	The indicator of climate resilience is the number of homes retrofitted, where a retrofit is assumed to increase the resilience of the building against extreme heat or cold for a longer duration, known as passive survivability. The benefit of access to cooling for dwellings which have heat pumps installed was not assessed.
Method for assessing embodied carbon policy	The modeling approach is aligned with DEQ's approach	SSG worked with data provided by DEQ to model this policy, ensuring alignment with their work.
Inclusion of Inflation Reduction Act Tax Incentives and Rebates	The financial benefits of the IRA have not been quantified. We may include this benefit in the analysis of the integrated scenarios	IRA will reduce the capital cost of applicable actions, increasing the financial benefit.
Inclusion of avoided costs/ stranded investments	Not assessed	Stranded investments are investments in fossil fuel assets that could be lost if climate policies limit emissions in line with climate targets. SSG believes a more detailed representation of gas infrastructure would be required to evaluate this impact.
Inclusion of future price volatility	Not assessed	SSG uses the future price projections from the EIA for the Pacific Region.
Analysis of energy burden	Energy burden will be assessed for the integrated scenarios	If a home's energy costs exceed 6 percent of income it is considered energy burdened. If a household spends more than 10 percent of its income on energy, it is considered extremely energy burdened.
Range of policies	Both a less and more stringent policy implementation has been modeled	
Data from Oregon	Datasets from Oregon are applied.	The model uses data from Oregon wherever possible; in some cases national sources are used which report on data for Oregon (i.e. EIA). A complete set of data sources will be included in the Data, Methods and Assumptions Manual
Full costs to homeowners and businesses	No change	Capital, maintenance and operating costs are evaluated for each policy over the lifetime of the investment.

Appendix 3. Policy Scorecards

Attached

Appendix 4. Integrated Scenario Scorecards

Attached

Appendix 5. Qualitative Policy Scorecards

Attached

Appendix 6. Data, Methods and Assumptions Manual

Attached

Appendix 7. Financial Cost Catalog

Attached