Technical Appendix

This appendix consolidates the methodologies and key assumptions underlying the greenhouse gas (GHG) and co-pollutant reductions anticipated from the proposed measures within the application. The aim is to succinctly capture the essence of each measure's impact on emission reductions over a 5-year implementation period. This appendix and the associated calculation spreadsheets show the technical assumptions, models, and methodologies used for estimating GHG reductions to be transparent and alignment with best practices. Where models are proprietary or complex, we have tried to provided summaries.

This appendix includes cumulative greenhouse gas reductions for the periods 2025-2030 and 2025-2050; detailed annual reductions are available in the accompanying spreadsheet workbook.

The electricity intensity values used in all of the measure calculations incorporate Oregon's Clean Energy Targets. The Oregon Clean Energy Targets require Oregon's two largest utilities to reduce GHG emissions from the electricity provided to the state to 80% below baseline emissions levels by 2030, 90% below baseline emissions level by 2035, and 100% below baseline emissions level by 2040. The baseline emissions level is defined as the average emissions for each utility during the 2010, 2011, and 2012 emissions year.

Transportation Models and tools:

- Caret®EV Planner: Utilized for the Oregon Clean Vehicle Rebate Program, this tool forecasts the impact of EV rebates on market share growth and associated GHG emission reductions. Developed by the Center for Sustainable Energy, it incorporates various incentives and current market data to model the light-duty transportation sector's transition to EVs.
- AFLEET Tool: Deployed for estimating the emissions benefits of installing light-duty EV charging infrastructure. It compares the emissions from electric vehicle charging to those from conventional gasoline vehicles.
- Heavy Duty Vehicle Emissions Calculator: Used for assessing the GHG reductions from transitioning medium and heavy-duty vehicles from diesel to electric.

General Assumptions:

- Fuel and Electricity Carbon Intensity: Uses national and state-specific data to calculate emissions from traditional and electric vehicles.
- Vehicle Fleet Dynamics: Includes assumptions about vehicle retirement rates and the adoption of new EVs influenced by available incentives.
- Infrastructure Utilization: Estimates the installation and usage rates of EV charging infrastructure.

Measure 1: Oregon Clean Vehicle Rebate Program
General Description: Aims to increase EV adoption through Standard and Charge Ahead Rebates, with a projection of issuing 4,403 rebates; GHG reductions are modeled based on the substitution of EVs for ICE vehicles, considering the energy mix of Oregon and expected improvements in EV efficiency.
GHG reduction estimate method(s): GHG emissions volumes from the light-duty transportation sector for any given year is calculated by Caret®EV as the sum of emissions derived from the combustion of gasoline by ICEVs and emissions derived from electricity generation to charge EVs, multiplied by the total fuel consumption for each vehicle type in that year. To calibrate this relationship, CSE utilized 2021 data on U.S. light-duty vehicle gasoline consumption and vehicle registration totals to determine state-specific average gasoline consumption per mile driven for light-duty ICEVs and an assumed EV efficiency of 4 miles per kWh of battery charge.

Specific models and tools used: The Caret®-EV modeling software was used to project additional EV rebating and the associated GHG emission reductions. The model is calibrated using data from the U.S. and around the world and is refined over time with the latest data sets as they become available. Caret®-

EV models the total program cost, GHG emissions reduction, EV adoption, and other factors as far as 30 years into the future, based on various incentive types, amounts, and schedules.

Key assumptions about implementation: The measure assumes that 4403 rebates will be issued to low- and moderate-income households during the project period. Caret-EV calculates an annual retirement of vehicles based on the model year distribution of vehicles in the current on-road fleet, based on real world data about the retirement rates of vehicles as a function of their age.

Key details of reference scenario: The CPRG funding scenario represents the baseline scenario with an additional lump sum of $31M of CPRG funding available to OCVRP starting January 2025, all of which is projected to be exhausted by the end of calendar year 2025. CPRG funds are assumed to be used to pay for Charge Ahead used vehicle rebates for ZEVs and both parts of the combined Standard plus Charge Ahead rebates to income-qualified new EV purchasers. The cumulative GHG emissions reductions for the CPRG-funded scenario can be found below under the "Cumulative GHG Emissions Reduction Relative to Baseline (million MT CO2e)" columns on the far right.

*Key assumptions affecting GHG emissions***:** When Caret-EV calculates the GHG emissions from the fleet each year, it takes into account both the current carbon intensity of electricity generation (i.e., the grid decarbonization curve for OR based on the states clean energy targets) and the current distribution of vehicle ages and types, which directly influence total miles driven by the fleet in a year.

The GHG emissions calculated by Caret®-EV only account for vehicle miles driven; they do not include broader "well-to-wheel" considerations related to, for example, electric energy source (with the exception of a region-specific electricity grid carbon intensity value), gasoline refinement and transport, vehicle production, or end-of-life scrapping.

Measure-specific activity data not already listed above: To model the EV market transformation, Caret®-EV implements a logistic growth function of adoption over time, as observed in a variety of other technologies, parameterized by a Bass diffusion model customized to the EV market. At its foundation, the model is calibrated using five years of data from sixteen EV incentive programs in the United States and other countries around the world, relating incentive dollars to the corresponding increase in EV sales. By using EV market data and regression techniques to model sales over time, this approach gives a more complete picture of the relationship between incentive levels, time, and EV adoption than could be provided using price elasticity or choice models over decades-long timeframes. Additionally, Caret®-EV incorporates a learning algorithm, in which model predictions are replaced by data as they become available, which ensures the projections align with reality and tunes the model predictions over time. The Caret®-EV model also considers the history of state rebate uptake, as well as the impacts of the Inflation Reduction Act federal clean vehicle tax credits and the upcoming implementation of Advanced Clean Cars II (ACCII) in Oregon and how it contributes to EV adoption and GHG reduction. The GHG and co-pollutant emissions reduction values (and net co-benefit savings) presented in the tables herein reflect the additional benefits realized through the PCAP funding, beyond the baseline OCVRP model scenario and the baseline contributions for which IRA and ACC II are solely responsible. These emissions reduction and savings values account for the direct impact of the PCAP funding on the efficacy of OCVRP as well as its indirect effect leading to increased participation in IRA and ACC II in subsequent years. These effects are intertwined, highlighting the synergistic nature of integrating additional PCAP funding into the existing and planned EV incentivization programs available to Oregon consumers (OCVRP, IRA, ACC II). CSE used OCVRP rebate data with corresponding S&P Global (formerly known as IHS Markit) vehicle registration data to estimate monthly consumer participation rates in OCVRP for January 2022 – April 2023 (i.e., the percentage of all eligible EV purchases that applied for and received an OCVRP rebate). Averages of these values were used as the starting point for projecting sigmoidal participation rate curves through the end of the Oregon rebate programs in 2035. For the Standard and Charge Ahead (new) rebates, CSE assumed a final participation rate of 80% is reached by 2032 (i.e., the last year of the federal IRA rebates). In the case of the Charge Ahead (used) rebate, CSE assumed a final participation rate of approximately 50%, achieved in 2035. The final participation rate was estimated based on an anticipated lag between the maturation of the new EV market and the used EV market (with the former supplying stock for the latter), as well as personal preferences that might cause purchasers to eschew a rebate in favor of purchasing privately rather than from a dealer.

Caret®-EV uses a census of the current light-duty vehicle fleet in a state, called the initial model year distribution, to understand how the light-duty operational fleet will change over time. For a given starting year of the model projections, the IMYD lists the number of plug-in electric vehiclesand ICEVs in the state for each extant vehicle model year; hence, it describes the distribution of vehicle ages in the fleet. For example, if the starting year of the model projections is 2022, then the inputs to the model for 2022 are based on data collected for that year. Subsequent years starting with 2023 are model projections based on the starting year data. The number of plug-in electric vehicles is equal to the sum of battery electric vehicles (BEVs) and plug-in hybrid electric vehicles. The Caret®-EV model includes a phaseout of PHEV availability corresponding to current state purchasing and national manufacturing trends. For Oregon, this corresponds to PHEVs comprising less than 20% of all new PEVs (BEVs+PHEVs) purchased in 2030, down from more than 25% in 2023.

The IMYD provides a starting point for projections of the operational fleet share of PEVs and ICEVs in future years, as well as contributing to projections of the retirement of vehicles (i.e., removal from the operational fleet) and vehicle miles travelled in each future year (both of which depend on the ages of the vehicles). CSE uses vehicle registration and transaction data sourced from DMV records in the state (supplied by Oregon DEQ) and S&P Global (formerly IHS Markit), respectively, to assemble the IMYD for the state. Caret®-EV then projects the fleet composition forward in time based on the modeled sales for EVs and ICEVs and using proprietary data-backed relationships established by CSE describing vehicle resale and retirement.

GHG emissions reduced: CPRG funds would equal 4463 additional rebated vehicles. This equals 190,000 MTCO2E reduced from 2025-2030 and 1,030,000 MTCO2E reduced from 2025-2050.

Measure 2*:* Community Charging Rebates – Light Duty Charging Infrastructure Rebates

General description: Supports the expansion of EV charging infrastructure, particularly in underserved communities, with plans to install 625 Level 2 and 63 DCFC chargers; emission reductions are estimated by comparing the projected use of this infrastructure to conventional vehicle emissions.

GHG reduction estimate method(s): The methodology assumes that charging infrastructure for light-duty vehicles contributes to emissions reductions by displacing the energy and emissions associated with light-duty gasoline vehicles.

Specific models and tools used: Argonne National Laboratory's AFLEET Charging and Fueling Infrastructure Emissions Tool, AFLEET Tool: Assumptions input into the tool were adjusted over time to reflect the number of chargers funded, estimated charger utilization rates, and expected changes to the carbon intensity of Oregon's electricity because of HB 2021.

Key assumptions about implementation: The methodology assumes that a total of 625 Level 2 and 63 DCFC will be installed over the program period, supported with rebates of $8,000/port and $80,000 per port respectively. The average power level of a Level 2 chargers installed under this program was assumed to be 9.6 kW while the average power level of DCFC installed was assumed to be 125 kW. Emissions do not start to accrue until 1 year after chargers are funded, to account for the time it takes for installation and activation of the chargers. Utilization was assumed to match the "high" scenario outlined in the CFI AFLEET tool through 2030 and then increase to 30% utilization, based on assumptions and findings outlined in ODOT's Transportation Electrification Infrastructure Needs Analysis (TEINA study). Regarding administrative costs, ODOT assumed an additional full time, limited duration employee would be needed for program implementation plus an additional 1% of program funds for other administrative tasks for the first three years when rebates would be processed, and that ODOT could utilize existing staff after that.

*Key details of reference scenario***:** The reference scenario assumes that CCR's one-time funding allocation of $7 million is exhausted prior to 2025 and can no longer fund community charging. As a result, there are fewer chargers installed and fewer EVs displacing the gasoline utilized in internal combustion engine vehicles.

Key assumptions affecting GHG emissions: To account for the increase in emissions associated with electricity use as a result of charging electric vehicles, ODOT utilized DEQ's methodology of calculating emissions from electricity based on annual kilowatt hours dispensed and state specific electricity sector emissions factor reported to Oregon's Greenhouse Gas Reporting program, adjusted overtime to

incorporate the Oregon clean electricity targets. ODOT also assumed that utilization rates would increase to a level of profitability (30%) for private sector Charge Point Operators (CPOs) by 2031.
GHG emissions reduced: A total of 625 Level 2 and 63 DCFC will be installed over the program period, this equals 36,958 MTCO2e reduced from 2025-2030 and 797,977 MTCO2e reduced from 2025-2050.

Measure 3: Medium- Heavy-Duty ZEV Rebate

General description: Provides incentives for the adoption of electric medium and heavy-duty vehicles, with an emphasis on reducing diesel pollution in vulnerable communities; emission reductions are calculated based on the displacement of diesel vehicles and the subsequent reduction in diesel fuel consumption.

GHG reduction estimate method(s): DEQ developed a spreadsheet model to calculate net emissions. Assumptions for vehicle type and fuel volumes are based on existing test projects. GHG emissions were calculated based on an estimate of annual diesel gallons, blended with 5 percent biodiesel, and quantifying emissions using EPA 40 CFR, part 98 Table C-1 and Table C-2 emissions factors. To account for the increase in emissions associated with electricity use DEQ first calculated the kilowatt hours equivalent to the annual volume of fuel consumed. This estimate of power usage was multiplied by a state specific electricity sector emissions factor, reported to Oregon's Greenhouse Gas Reporting program. For projection purposes, the electricity emissions factor was adjusted overtime to incorporate Oregon specific clean electricity targets.

Specific models and tools used: DEQ used Argonne National Laboratory's Heavy Duty Vehicle Emissions Calculator, emissions factors for fuel combustion from 40 CFR part 98 table C-1 and table C-2 and emissions factors for the electricity carbon intensity as reported to Oregon DEQ's greenhouse gas reporting program.

Key assumptions affecting GHG emissions: DEQ assumed vehicles would be purchased over a three-year period, from 2026 through 2028. Initial emissions reductions would occur in calendar year 2026 and that the lifetime of the vehicle is 20 years. The analysis assumes equal adoption of Class 8 and Class 6-7 vehicles.

GHG emissions reduced: Approximately 164 new MHD ZEV in use ($15M @ $85,000). This equals 71,484 MTCO2E reduced from 2025-2030 and 363,828 MTCO2E reduced from 2025-2050.

Measure 4: Medium and Heavy-Duty Diesel Emissions Mitigation Grant Program

General description: Grant program supporting businesses, governments and equipment owners in replacing older and more polluting diesel engines with new electric vehicles.

GHG reduction estimate method(s): DEQ calculated emission reductions attributable to this project by estimating the net emissions associated with the targeted diesel engine being replaced with an equivalent electric vehicle. To calculate the impact DEQ developed a spreadsheet model. Assumptions for vehicle type and fuel volumes are based on existing pilot projects for Class 6-7 and Class 8 trucks. Avoided GHG emissions are calculated based on an estimate of annual diesel gallons consumed by the target vehicle types. Emissions were quantified using the GHG emissions produced from the combustion of the estimated fuel quantity and calculated with EPA 40 CFR, part 98 Table C-1 and Table C-2 emission factors. To calculate net emissions and account for emissions from electricity DEQ used the same methodology for electricity emissions as described in measure 3.

Specific models and tools used: EPA's Diesel Emissions Quantifier tool. Emissions factors from EPA 40 CFR Part 98 Table C-1 and C-2.

Key assumptions about implementation: DEQ assumes the program would result in scrapping old diesel medium- and heavy-duty trucks and replacing them with all electric trucks at 45% reimbursement (based on EPA's DERA program maximum allowed amount).

Key details of reference scenario: Avoided emissions are based on replaced vehicle types and usage from recent pilot program activities and include eCascadia replacing Heavy Duty Class 8 trucks and the eM2s replacing Medium Duty Class 6 trucks.

Key assumptions affecting GHG emissions: Net emissions are based on avoided diesel fuel combustion and the emissions associated with increased electricity consumption.

GHG emissions reduced: Approximately 37new MHD ZEV in use ($6M @ $129,314). This equals 19,106 MTCO2E reduced from 2025-2030 and 81,092 MTCO2E reduced from 2025-2050.

Measure 5: Medium Heavy-Duty Charging Infrastructure Grants

General description: Oregon DEQ's grant program for supporting medium- and heavy-duty zero-emission vehicle charging and fueling infrastructure projects program invests directly in MHD ZEV Charging infrastructure for private fleets, tribes, local government, school districts, and transit providers.
GHG reduction estimate method(s): The methodology assumes that charging infrastructure for the medium and heavy-duty fleets will contribute to emissions reductions by displacing the energy and associated emissions associated with the equivalent heavy-duty vehicle combusting diesel.
Specific models and tools used: DEQ developed a spreadsheet model to calculate avoided emissions over time based on displacement of current diesel vehicles and net emissions taking into account vehicle charger type and the expected usage of the chargers installed under the measure. Initial GHG and co-pollutant emissions are based on emissions outputs from [Argonne National Laboratory's AFLEET Charging and Fueling Infrastructure Emissions tool's Emissions Tool](). These estimates were adjusted over time to reflect usage, the number of chargers installed, and expected changes to the carbon intensity of Oregon's electricity.
Key assumptions about implementation: The measure assumes that DC fast chargers will be installed during the initial years of the funding and operate thorough 2050. The estimates assume a per port usage equivalent to Argonne National Laboratory's AFLEET CFI Emissions tool's high utilization for 2025 through 2030. Starting in 2031, the spreadsheet model assumes a higher utilization rate per charger of 30%. This assumption is based on findings from [Oregon's Transportation Electrification Infrastructure Needs Analysis.]()
Key details of reference scenario: The reference scenario assumes the displacement of the energy equivalent of a heavy-duty vehicle combusting diesel blended with 5 percent biodiesel.
Key assumptions affecting GHG emissions: DEQ first calculated the annual kWh dispensed from each charger type and converted that to the equivalent amount of avoided B5 diesel gallons. Emissions from the combustion of this fuel were calculated using The AFLEET CFI tool. To account for the increase in emissions associated with electricity use DEQ used the same methods as described in measure 3.
Measure-specific activity data not already listed above: The analysis assumes all Level 2 Chargers are 9.6 kW and DC fast chargers are 125 kW.
GHG emissions reduced: Approximately 20 new MHD ZEV Charging Stations equals 3,813 MTCO2E reduced from 2025-2030 and 113,405 MTCO2E reduced from 2025-2050.

Building Measures models and Tools:

- Energy Systems Simulator (ESS) model developed by Sustainability Solutions Group was used for measures 6-9. The document [Data, Methods, and Assumptions Manual for the State of Oregon Resilient Efficient Buildings Taskforce]() describes the modeling approach, data and assumptions, and general methodology used by the ESS.
- SSG used the 2019 Oregon DEQ GHG Inventory to calibrate the model.

Measure 6: Incentives for Building More Energy Efficient Housing

General description: Financial incentives to construct new residential buildings that are at least 10 percent more energy efficient than buildings constructed under Oregon's base building code.
GHG reduction estimate method(s): This measure assumed new housing units receiving incentives would consume 10 percent less energy than units constructed under the base building code. GHG emissions reductions were estimated for the avoided energy use over the lifetime of the housing unit (through 2050 and beyond), measured as a 10 percent reduction in baseline energy use of new residential housing units. Residential building-sector GHG emissions include emissions from the use of lighting, appliances, heating, and cooling. The model estimates emission reductions from fuel combustion and grid-supplied electricity consumed by residential buildings.
Specific models and tools used: Energy Systems Simulator
Key assumptions about implementation: The methodology applied a per-unit (e.g., single-family home, apartment in multifamily building) incentive of $2,000 for new energy efficient housing. The modeling assumed that CPRG-funded incentives could serve 2,355 housing units per year, with a total of 9,420 housing units served by CPRG funds over a four-year period (2025-2028).
Key details of reference scenario: The reference scenario assumed all new housing units are constructed to meet the specifications of Oregon's base building code. The energy use baseline for the reference

scenario reflects the average estimated energy use of a housing unit constructed under the base code over the lifetime of the building, up to 2050. The reference scenario estimates energy use and emissions volumes from the base year (2025) to the target year (2050). It assumes policy measures will not differ substantially from those currently in place, and that retail electricity providers will comply with Oregon's 100 percent clean electricity standard.

*Key assumptions affecting GHG emissions***:** Review ESS documentation

GHG emissions reduced: CPRG funding would support construction of 9,420 housing units, reducing emissions by 116,774 MTCO2E from 2025-2030 and 556,340 MTCO2E from 2025-2050.

Measure 7: Commercial Building Performance Standards Incentives

General description: Financial incentives for commercial building owners that voluntarily comply or achieve early compliance with commercial building performance standards (BPS).

GHG reduction estimate method(s): The methodology assumed that voluntary or early compliance with commercial BPS would reduce annual energy use. The specific building targets are set at the median energy use for various building types and sizes. Those buildings performing below their specific target will be required to install energy efficiency measures, or process improvements, to reach the median energy use target. Greenhouse gas emissions reductions were calculated based on the voluntary avoided energy use for the grant timeframe through 2030, but before subject buildings are required to comply (early adopters). Commercial building-sector GHG emissions are from energy used for lighting, appliances, heating, cooling, and other end-uses. The model estimates emissions reductions from avoided natural gas combustion and grid-supplied electricity used in commercial buildings. Starting values for energy intensities for commercial buildings are taken from the regional Commercial Building Stock Assessment (CBSA) recently completed by the Northwest Energy Efficiency Alliance.

Specific models and tools used: The Oregon Department of Energy reviewed building energy use from the CBSA and compared it to representative BPS targets used in the State of Washington or ASHRAE Standard 100 (Oregon's targets are still in development) to estimate the potential for electricity and GHG emissions reductions for various building types and sizes. This energy reduction was translated to GHG emissions using the EPA natural gas emissions factor and the Oregon statewide average electricity emissions factor normalized to a "per square foot" metric. The number of applicable buildings and their total square footage were estimated using building benchmarking data from the City of Portland, scaled for statewide application.

Key assumptions about implementation: The BPS program establishes two tiers of buildings for reporting and compliance. Tier 1 buildings above 35,000 square feet and Tier 2 buildings 20,000-35,000 square feet. The modeling assumed that CPRG funding would incentivize a total of 321 buildings to voluntarily meet the BPS over a four-year period (2025-2028). Of these 321 commercial buildings the model assumed 8% of the eligible Tier 1 buildings are considered early adopters and are modeled to receive incentives: 25 buildings larger than 200,000 square feet, 32 buildings between 90,000 and 200,000 square feet, 88 buildings between 35,000 and 90,000 square feet. 4% of Tier 2 buildings (176) under 35,000 square feet are modeled to receive incentives. The methodology assumed different incentive levels and GHG emissions reductions depending on the size of the building (larger buildings requiring higher incentive levels but achieve greater reductions), and the overall average incentive per building is calculated at about $37,000 and would provide financial assistance to 81 existing commercial buildings per year.

Key details of reference scenario: The reference scenario estimates energy use and GHG emissions for commercial buildings that are subject to Oregon's BPS but are not yet required to comply with the BPS until a future date. Tier 1 building BPS compliance phases in for buildings 200,000 square feet and up in July 2028, buildings 90,000-199,999 square feet in July 2029, and buildings 35,000-89,999 square feet in July of 2030. The modeling assumes that after Tier 1 compliance is required, no additional "early adopter" energy savings or emission reductions will occur. Energy and GHG emissions reductions are only modeled for Tier 1 early compliance until the compliance deadline. Tier 2 buildings (20,000-35,000 square feet) must report energy usage but are not required to meet BPS targets. Tier 2 buildings are modeled to receive incentives and create GHG emission in all program years.

Key assumptions affecting GHG emissions: DEQ statewide average emissions factors for electricity were used to estimate Scope 2 emissions for buildings and also adjusted for Clean Energy Targets. Oregon

used published EPA natural gas emissions factors to estimate Scope 1 emissions for buildings. Existing building energy performance leveraged the Northwest Energy Efficiency Alliance's "Commercial Building Stock Assessment". Building count and square footage estimates used data from the city of Portland scaled to statewide application.
Measure-specific activity data not already listed above: N/A
GHG emissions reduced: CPRG funding would incentivize early/voluntary adoption of commercial BPS in 321 commercial buildings, reducing emissions by 100,322 MTCO2E from 2025-2030 and 221,126 MTCO2E from 2025-2050.
Measure 8: Heat Pump Incentives
General description: Financial incentives to purchase and install heat pumps in rental housing and award grants to communities to deploy heat pumps in new and existing homes.
GHG reduction estimate method(s): The measure estimated greenhouse gas emissions reductions for the avoided energy use over the lifetime of the heat pump unit, as compared to projected emissions rates for new and existing housing units heated by other sources. For heat pumps installed in existing housing, GHG emissions savings are calculated as the difference between average energy use emissions for housing units with Energy Star heat pumps and the baseline emissions rate for existing housing units with conventional heating systems (electric resistance heat, natural gas, wood, propane, and fuel oil), projected over the lifetime of units installed between 2025 and 2029. The baseline emissions rate reflects current heat source percentages for existing Oregon homes. For heat pumps installed in new residential units, GHG emissions savings are calculated as the difference between estimated emissions associated with electricity consumed by high-efficiency heat pumps over the lifetime of the units and projected emissions associated with other energy sources used to heat newly constructed residential units over the lifetime of the systems.
Specific models and tools used: Energy Systems Simulator
Key assumptions about implementation: The measure assumes that incentives averaging $2,000 will be issued for 3,000 heat pumps per year, with 12,000 total heat pump systems receiving incentives over a five-year period (2025-2029). The measure assumes that two-thirds of heat pump incentives will be issued to existing housing units, and one-third of incentive funds will be issued to install heat pumps in new housing units.
Key details of reference scenario: The reference scenario estimates energy use and emissions volumes from the base year (2025) to the target year (2050). It assumes policy measures will not differ substantially from those currently in place, and that retail electricity providers will comply with Oregon's 100 percent clean electricity standard.
Key assumptions affecting GHG emissions: Review ESS documentation. *Measure-specific activity data not already listed above:* The ESS models and accounts for all energy and emissions in relevant sectors and captures relationships between sectors. In any given year, various factors shape the picture of energy and emissions flows. The model is based on an explicit mathematical relationship between these factors--some contextual and some being part of the energy consuming or producing infrastructure--and the energy flow picture. Residential heating systems are modeled as a stock of heat systems classified by technology, fuel and age, with a similarly classified efficiency.
GHG emissions reduced: CPRG funding would incentivize the installation of 12,000 heat pumps, reducing emissions by 83,225 MTCO2E from 2025-2030 and 368,655 MTCO2E from 2025-2050.
Measure 9: Weatherization Assistance for Existing Houses
General description: This measure would provide financial assistance for weatherization improvements in existing residential buildings, with a priority for residential weatherization investments in low-income and disadvantaged communities.
GHG reduction estimate method(s): Greenhouse gas emissions reductions are estimated for energy savings resulting from weatherization improvements over the remaining lifetime of the house. Using assumptions on thermal envelope performance and heating and cooling degree days, the model calculates space-conditioning energy demand independent of space heating or cooling technologies. The model multiplies the residential building floorspace area by an estimated thermal conductance (heat flow per unit of surface area per degree day) and the number of degree days (heating and cooling) to derive the energy transferred out of the building during winter months and into the building during

summer months. The energy transferred through the building envelope, the solar gain through the building windows, and the heat gains from equipment inside the building is netted from the space-conditioning load required to be provided by the heating and air-conditioning systems.
Specific models and tools used: Energy Systems Simulator.
Key assumptions about implementation: The measure assumes incentives averaging $2,422 will be issued to support the weatherization of 640 existing residential housing units per year, with 2,560 total housing units receiving CPRG-funded weatherization assistance over a four-year period from 2025 to 2028.
Key details of reference scenario: The reference scenario estimates energy use and emissions volumes for existing residential housing units from the base year (2025) to the target year (2050). It assumes policy measures will not differ substantially from those currently in place, and that retail electricity providers will comply with Oregon's 100 percent clean electricity standard.
Key assumptions affecting GHG emissions: Review ESS documentation. *Measure-specific activity data not already listed above*: For each Oregon county, building data (including building type, number of stories, number of units, and year built) was sourced from the 2020 U.S. Census for residential buildings. Total floorspace area for each building type was calculated referencing building archetypes that are typical in Oregon. The initial thermal conductance estimate is a regional average by dwelling type from a North American energy systems simulator, calibrated for the Pacific Northwest. This initial estimate is adjusted through the calibration process until energy use of residential buildings tracks on residential energy use as reported by the State Energy Data System (SEDS). As a reference, we also use values for output energy intensities and equipment efficiencies based on the 2015 Residential Energy Consumption Survey (RECS).
GHG emissions reduced: CPRG funding would incentivize the weatherization of 2,960 existing homes across Oregon, reducing emissions by 32,515 MTCO2E from 2025-2030 and 132,850 MTCO2E from 2025-2050.

Materials and Waste Measures models and Tools:

- Embodied carbon calculator by ARUP for Alameda County, California: Deployed for assessing embodied carbon in buildings and their materials. Inputs customized for Oregon.
- Waste Impact Calculator web app by Oregon DEQ: Utilized for quantifying weight of food waste and yard debris available for anaerobic digestion and composting under new infrastructure.
- Waste Impact Calculator factors, version 1.3, by Oregon DEQ: Utilized for quantifying emissions associated with landfilling, composting, and anaerobic digestion under new infrastructure.
- CoolClimate.org's peer-reviewed regression model (customized for Oregon): utilized to estimate household consumption-based emissions for building reuse and space-efficient housing.
- EPA WARM: used to provide methane potential for landfills, and potential reductions.
- EPA LMOP: used for methane recovery estimates for landfills.
- All GHG emissions are reported in annualized terms.

Measure 10: Building reuse and space-efficient housing
Important note: the following housing-related measure is distinct from the measures listed earlier for "residential and commercial buildings." Those measures reduce emissions associated with operations of buildings, mostly heating and cooling. In contrast, this measure reduces the embodied emissions of construction materials, and the overall consumption-based impacts of households in new dwellings, where utility emissions have been downscaled to correct overlap with other policies. There is no double-counting.
General description: Under the measure scenario, there are two strategies. 1) Vacant and underutilized buildings (such as offices, hotels, and upper stories of downtown retail) will be converted to affordable and workforce housing. Under the reference scenario, an identical number of conventional dwellings will be created with no affordability requirements. 2) Financial incentives will be provided to create smaller forms of housing, such as duplexes, cottage clusters, and ADUs, in areas dense enough to reduce the need for private vehicle use. Under the reference scenario, an equal number of housing units are created in conventional sizes in conventional densities. In this measure, GHG benefits accrue from both

lower embodied impacts (less construction material) and reduced consumption-based impacts of households living in those units – for example, households in denser neighborhoods involve more compact infrastructure and drive fewer miles.
GHG reduction estimate method(s): For embodied characteristics of buildings: an embodied carbon calculator designed for community climate action plans. For the consumption-based impacts of households: an Oregon-specific application of a peer-reviewed consumption-based impact model.
Specific models and tools used: Embodied carbon calculator developed by ARUP; consumption based model based on the "CoolClimate" equations and data of Jones & Kammen (2014, Table 3, model 1).
Key assumptions about implementation: Residential conversions and space-efficient housing focused in areas where reduced vehicle use is feasible; household incomes in affordable units somewhat lower than they would be in conventional; average unit size for converted and space-efficient dwellings is 800 conditioned square feet.
Key details of reference scenario: Conventional development with a 50% mix of dwellings (typically single family detached residences, or SFRs) at 2262 square feet, and 50% smaller units (typically not SFR) averaging 1149 square feet.
Key assumptions affecting GHG emissions: Under both scenarios, household consumption-based impacts (and consequently GHG benefits) are adjusted downward to account for Oregon Clean Energy Targets.
Measure-specific activity data not already listed above: Average household size: 2.57 persons (both scenarios). Average household incomes in 2022 dollars: $142,800 (reference scenario), $86,180 (measure scenario, residential conversion), $114,250 (measure scenario, space-efficient housing). Population densities in persons/sq. mile: 3551 (reference), 4890 (measure). Average vehicles per household: 2.3 (reference), 1.0 (measure). Average rooms per dwelling: 7.4 (reference), 4.2 (measure). For residential conversion, drawn from US Census sources for zip codes 97015 and 97859 (reference) and 97209 and 97801 (measure). For space-efficient housing, drawn from US Census sources for zip codes 97070 and 97006 (reference) and 97214 and 97124 (measure).
GHG emissions reduced: Given 940 housing units created, 70,862 MTCO2E reduced 2025-2030, and 343,847 MTCO2E reduced 2025-2050.

Measure 11: Food waste infrastructure improvements

General description: Under the measure scenario, Oregon will increase its capacity to (aerobically) compost food waste and yard debris and anaerobically digest food waste. Under the reference scenario, Oregon's compost and anaerobic digestion (AD) capacity remain unchanged. The measure scenario reduces GHGs emitted by preventing methane emissions from landfill, and (for AD) reducing emissions associated with electrical generation.
GHG reduction estimate method(s): Emissions associated with end-of-life treatments of yard debris and food waste are drawn from an Oregon-specific, open-source life cycle model of solid waste, with results expressed in annual equivalents. For AD, this model includes displacement of electrical generation.
Specific models and tools used: Waste Impact Calculator by Oregon DEQ (version 1.3).
Key assumptions about implementation: It takes 4 years to build up the complete increased capacity. AD facilities handle food waste only; composting facilities handle a mix of yard debris and food waste. Total transportation burden under increased processing scenario is <= transportation burden under reference case scenario.
Key details of reference scenario: Oregon's existing capacity for composting and AD is maintained but does not increase.
Key assumptions affecting GHG emissions: For both scenarios, it is presumed that food waste composition does not change over time, and that the ratio of food waste to yard debris does not change.
Measure-specific activity data not already listed above: Ratio of food waste to yard debris based on Oregon-specific records in Waste Impact Calculator web app (2021 results). Yearly equivalent processing and transport emissions intensities from Waste Impact Calculator, version 1.3, in kgCO2e/short ton: 79.10 (food waste AD), 95.18 (food waste composting), 399.38 (food waste landfilling), 95.18 (yard debris composting), 232.48 (yard debris composting).
GHG emissions reduced: CPRG funding would support up to 26 projects and 241,500 MTCO2E reduced 2025-2030, and 1,419,561 MTCO2E reduced 2025-2050.

Measure 12: Landfill methane controls

General description: Install enhanced methane controls at municipal solid waste (MSW) and potentially industrial landfills, limited to installations that exceed regulatory requirements.

GHG reduction estimate method(s): Oregon-specific model of landfill methane generation and emissions, with results expressed as yearly emissions. Calculations based on estimated annual methane recovery for sites with horizontal and vertical wells, estimated capture rate efficiency for landfill gas collection systems, as well as estimated ratio for direct to indirect benefits of landfill gas to energy systems from EPA LMOP database.

Specific models and tools used: Estimates of methane generation and emissions from DEQ sector-based GHG inventory and Oregon-specific model of landfill methane generation and emissions, which draws on EPA LandGEM, Mandatory Reporting Rule data, and EPA WARM. Estimates of emissions reduction from private consulting engineers, EPA LMOP, and assumptions drawn from other EPA sources (e.g., oxidation rate of 10%).

Key assumptions about implementation: DEQ will conduct a competitive solicitation that will result in awards for approximately 3-6 projects. Applicants would submit, as part of their application, a detailed engineering evaluation demonstrating costs and estimated emissions reductions. Types of projects might include (but are not limited to) installation of horizontal wells in working areas; installation of vertical wells in closed area; and other practices such as wellfield optimization, biocovers, etc. Grant only funds projects that exceed regulatory requirements.

Key details of reference scenario: Methane emissions from MSW and industrial landfills in three project types; actual results will depend on the competitive solicitation. DEQ evaluated three project types for cost-effectiveness and built an assumed project portfolio as follows: 22% of sub-awarded funds to install landfill gas collection and flaring at landfills which currently have no gas collection; 49% of sub-awarded funds to add horizontal wells for gas collection in active cells at landfills with existing gas collection and energy recovery; 29% of sub-awarded funds to add vertical wells for gas collection in inactive cells at landfills with existing gas collection and energy recovery.

Key assumptions affecting GHG emissions: Methane generation will continue to increase at rates consistent with those modeled 2010-2020; existing regulations and incentives have largely "run their course" such that future emissions will grow in proportion to generation; average oxidation rate at landfill covers is 10%; new landfill collection at facilities without energy recovery will recover gas at 50% efficiency for the first three years, 80% efficiency there-after, and decrease landfill gas generation after year four at a rate consistent with example model estimates; horizontal well installation period of 3.5 years; estimates of methane reduction potential are drawn from EPA literature, and estimates/consultation with landfill gas engineers; added climate benefit of energy recovery is 9.60% of direct benefits, per average for Oregon from LMOP database

Measure-specific activity data not already listed above: Installation of a variety of technologies (e.g., horizontal collectors, vertical collectors, flares) at Oregon landfills. DEQ inventoried Oregon landfills and grouped them into several groups based on existing systems, gas generation, and potential.

GHG emissions reduced: 275,222 MTCO2E reduced from 2025-2030 and 1,110,693 MTCO2E reduced from 2025-2050.