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Technical Memorandum

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SUBJECT: Portland Decarbonization Pathways Visualizer Tool Scenario Analysis and Methods Report

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Introduction

The updated Portland Pathways Analysis Tool allows users to calculate the combined emissions reductions of a wide range of climate actions, supporting the City of Portland's 2030 and 2050 emissions reduction goals (50% reduction of climate warming emissions by 2030, and net-zero by 2050).

This tool uses a wide range of data inputs and calculations to forecast emissions reductions in the major emitting sectors, including buildings, transportation, industry, waste, and refrigerants, as well as estimating the carbon sequestration potential from preserving and expanding forested areas across Multnomah County.

At its core, this tool is built on top of Multnomah County's 2022 greenhouse gas (GHG) emissions inventory, which is developed by the City of Portland on an annual basis to track emissions over time. Other core data inputs include VisionEval transportation impact modeling performed by Metro for the 2023 Regional Transportation Plan, and an updated version of Architecture 2030's Baseline & Projections analysis tool, which forecasts emissions from residential and commercial building energy usage in the City of Portland out to 2050.

Key Takeaways:

The 2030 goal will be largely driven by utility action to decarbonize the grid, but meeting the 2050 target requires an 'All Hands On Deck' approach

If the utilities are successful at hitting their mandated 80% reduction in emissions by 2030, that action alone will enable Portland to achieve its 2030 target, assuming there aren't large increases in emissions from other sectors. However, achieving the 2050 net-zero target requires extensive action across all sectors.

Rapid action starting now is essential to longer-term success and minimizing cumulative emissions

Delaying action now means steeper cuts are required later to achieve Portland's necessary climate goals, which on the one hand will potentially increase the cost and disruptiveness of necessary climate actions, and on the other hand, will lower the chances of meeting the 2050 goal.

Also, the full magnitude heating of climate disruption is driven by our *cumulative* emissions—the total amount of GHGs we release over time above the level our environment can quickly absorb—not by the annual emissions in 2050. Between now and then, the difference in cumulative emissions if the City takes action now vs. waiting until 2030, could result in more than 15 million tons of additional GHG emissions, more than 25% higher than cumulative emissions under the rapid action net zero scenario.

Several actions are indispensable in achieving the 2050 goal

- **Grid decarbonization** – All else being equal, there is no realistic pathway to net-zero that doesn't involve rapid decarbonization of the power grid in alignment with current state policy.
- **Transportation policies and rapid EV adoption** – efforts to reduce emissions in the transportation sector are essential. While in theory, transportation decarbonization can happen via three primary pathways – (1) VMT reduction, i.e., driving less, (2) switching to electric vehicles, and (3) substitution of fossil fuels for renewable fuels – in practice, some combination of all three will be necessary, with an emphasis on 1 and 2. Policies to reduce VMT and increase alternative forms of transportation provide a range of benefits, from GHG reduction to better air quality, to lower fuel and infrastructure costs, but electrifying vehicles is also essential. Renewable fuels, if they are truly zero-carbon across their lifecycle, are well suited to support broader decarbonization efforts, especially where they function as a drop-in replacement for fossil fuels.
- **Refrigerant management** – We may not often think that the appliances keeping our food and drinks cool may be contributing to making our atmosphere hot, but the heat-capturing properties of refrigerants make them exceptionally powerful climate warming gases, hundreds to thousands of times more potent than CO_2. Improving refrigerant recovery and switching to lower-impact refrigerants is an essential move that will have little to no visible impact in most people's daily lives, but failure to effectively manage refrigerants could derail Portland's net-zero goal.
- **Reforestation** – Multnomah County will likely not be able to zero out all emissions by 2050, so some sequestration is necessary to hit net-zero. Forests in the county currently absorb nearly 300,000 tons of CO2 per year. Protecting forests and expanding them through reforestation and urban tree planting could nearly double the annual carbon-sequestration capacity, and without them, net-zero will almost certainly not be possible in 2050.

Net-Zero is Still Possible by 2050

- The change in the baseline trajectory alone since the previous version of this pathways tool shows what can be achieved with focused action; improved building energy codes and state-level grid decarbonization policy have shifted the adopted policy baseline dramatically toward net-zero. It will take continual effort to ensure those goals are met, but the near-term impacts are significant.
- Looking globally, there are numerous examples of communities advancing low-carbon, human-centric urban form and transportation systems, and in a growing list of countries, low-cost renewable energy and electric vehicles are becoming the norm. Adoption of newer, better technologies does not generally advance in a linear fashion, and supportive policies can help drive exponential acceleration of climate action. There is no doubt that transforming Portland to net-zero in 25 years will be a major undertaking, but the long-term environmental, social, and economic benefits are enormous, and there are strong reasons to suspect the goal is still within reach so long as coordinated climate action is sustained.

Analysis of Portland Decarbonization Pathway Scenarios

What is Scenario Analysis?

Scenario analysis is a method for understanding the impact of different choices and under varying uncertain conditions. Scenarios are narrative tools, built upon data and judgment, that allow us to examine the risks and opportunities of possible futures. None of these scenarios will exactly fit reality as it unfolds, and there are complexities and unknown factors that will influence these trajectories in the future. However, these scenarios allow for exploration of possibilities in order to help build a better common understanding around how to most effectively act now to achieve climate goals and support a resilient and thriving community.

Scenarios Developed for This Report

For this report, several scenarios were developed to test the effect of different action trajectories.[1] The time period of the analysis extends from 2022 (the year of the most recent GHG inventory as of the creation of this version of the Pathways tool) out to 2050, the net-zero target year. However, since the current year is 2025, the amount of time remaining until the net-zero target year is approximately 25 years, and each 5-year period from now to 2050 represents about 20% of the time remaining until the target year.

- **Net Zero Path:** This *is the City of Portland's preferred scenario*, and it describes strong action across sectors starting now. Under this scenario, the progress achieved until 2030 in building efficiency and electrification (where existing technologies are proven, effective, and economic), is equal to 20% of the maximum reduction value allowed in the tool. Transition to renewable fuels gets a slightly slower start, with 10% of fuels replaced by 2030, ramping up to 95% replacement of remaining transportation fuels in 2050. The region makes timely progress on the Regional Transportation Plan goals, EV adoption ramps up until 2035, when all new passenger vehicles are electric, and starting in 2027, the region makes incremental progress toward electrifying heavy-duty vehicles, achieving 85% replacement in 2050. Renewable natural gas (RNG) generally replaces fossil gas in industrial facilities, and hits 15% of supply for residential and commercial buildings (reaching approximately 30% of total natural gas supply for the county). The county achieves and maintains compliance with federal AIM act standards, substantially reducing refrigerant leakage in the region. From now to 2030, 15% of land that could potentially be reforested is planted out, and by 2050, 95% of eligible land is reforested.
- **Grid only through 2030:** Under this scenario, local action stalls until 2030, and then the same action as the net-zero pathway is taken from 2030 to 2050. While this scenario achieves the end target, *cumulative emissions*—the total of all emissions from 2025 to 2050—are more than 50% higher, and in reality, waiting to tackle climate goals means the risk of missing the target increases. This scenario was developed primarily to calculate the impact of cumulative emissions when climate action is delayed, and due to the increased risks associated with delay, this scenario is not recommended as the basis for policy action.

[1] Lists of exact scenario input values and results can be found in Appendix I.

- **Missed Targets:** Under this scenario, incremental progress is made but falls short of hitting the targets. Utilities achieve 75% renewable energy in 2030 and 90% in 2040, achieving 100% renewable energy a few years before 2050. Existing building efficiency retrofits make progress but move at roughly half the pace of the Net Zero Path. Electrification occurs in 60% of eligible residential and commercial buildings by 2050, and new natural gas hookups are allowed through the end of period. RNG substitution reaches 10% for residential and commercial buildings, and hits 75% for industry, and other industrial technologies/electrification enables a 50% reduction in other fossil fuel consumption. In the transportation sector, RTP policies and investments are implemented, but new fossil fuel passenger vehicles are allowed until 2040, and ultimately, 50% of the heavy-duty vehicle fleet is electrified. Renewable fuels scale up dramatically, but substitution hits a peak of 75% in 2050. Ultimately, 60% of eligible lands are reforested.

Results & Discussion

Table 1. Scenario Analysis Quantitative Results

Metric	Net-Zero Pathway	Grid Only to 2030	Missed Targets
Emissions % Reduction from 1990 Baseline in 2030	65%	56%	61%
Emissions % Reduction from 1990 Baseline in 2050	100%	97%	91%
Net Remaining Emissions in 2030 (MT CO_2e)	3,707,231	4,612,486	4,133,957
Net Remaining Emissions in 2050 (MT CO_2e)	-119,887*	275,711	924,627
Cumulative Emissions, MT CO_2e, 2025-2050	61,475,247	76,875,305	81,146,671

**Forest carbon sequestration is responsible for the negative emissions in the Net-Zero scenario.*

Of the three scenarios, only the Net-Zero Pathway, with action starting right away, achieves the goal. The Grid Only to 2030 pathway gets close, and it's possible to construct a scenario where action starting in 2030 hits net zero, but that requires maximizing virtually every climate action strategy from 2030 through 2050. The Net-Zero Pathway already requires strong, sustained action through the end of the analysis period, and at this stage, every year counts.

The missed targets strategy represents an approximate modest-ambition pathway in which local and state actions are incremental. Grid decarbonization efforts alone, though delayed in this scenario, provide a substantial emissions reduction in 2030 compared to the 1990 baseline, and still hit zero by 2050, though just barely. EV mandates are delayed 5 years, and renewable fuels are relied on more heavily to make up some of the difference.

Notably, even with 100% renewable energy before 2050 and a significant increase in EVs and renewable fuels, Portland's remaining emissions are close to a million tons per year. While this approach yields a 91% reduction from the 1990 baseline, current science indicates that emissions must hit net-zero by 2050 *and then go below zero for decades* in order to avoid catastrophic consequences. Therefore, leaning on utilities and renewable fuels does not appear to be a viable option to meet scientifically sound targets—broad local and state action across sectors is essential.

It should also be noted that taking emissions below zero requires healthy, growing forests in Multnomah County. Planting trees is important to expand tree coverage and help support healthy forest succession, but any significant loss of existing forest means a reduction in the baseline sequestration assumed in the tool. Therefore, ensuring young trees reach maturity, maintaining healthy forests, reducing wildfire risk, and effectively containing wildfires as they emerge are all essential to ensuring that Multnomah County can reach atmospheric balance.

Methods

Electricity Supply

Electricity, provided by Portland General Electric (PGE) and Pacific Power (PAC), is responsible for a major share of Portland's GHG emissions. Oregon law HB2021 mandates that PGE and PAC reduce emissions by 80% below their 2010-2012 baseline by 2030 and hit zero emissions by 2040. Estimating the carbon intensity of power from the utilities required some assumptions about the rate of change and the overall growth of power demand. For PAC, publicly available documents indicating the expected carbon intensity of power in 2030 were used. For PGE, historical load growth was reviewed over several time periods, with a significant range of future estimates. Given the pace of recent load growth and general expectations for the future, a compound annual growth rate of 2.5% from the most recent DEQ data to 2030 was used to estimate future carbon intensity. For all recent years where data was available from DEQ (through 2023), reported energy consumption and carbon intensity are actual state-reported values. For the period from 2023 to 2030, annual emissions reductions are based on average annual reduction in emissions intensity since 2010. For the period from 2031 to 2040, annual emissions intensity is estimated as a straight-line reduction from the 2030 value to zero. Taken as a whole, this forecast assumes modest incremental emissions reductions until 2030, when compliance requirements kick in and emissions are expected to drop significantly. Then, steady annual emissions intensity reductions take emissions to zero in 2040.

Grid Decarbonization

The pathway described above is the default in the tool, resulting in an 80% reduction in grid emissions in 2030 and 100% reduction (zero emissions) in 2040. Users can adjust the values for 2030 and 2040 to test scenarios in which utilities do not meet the mandated targets. To simplify the interface, the grid decarbonization strategy is located with the 'Buildings' sector strategies.

Buildings

The buildings section of the tool is built on the 2022 inventory values and the outputs of the Architecture 2030 Baseline & Projections Analysis tool (A2030 tool). The inventory provides high-quality data on countywide energy consumption in the buildings sector; the A2030 tool utilizes data from City of Portland, Oregon Department of Energy, Metro RLIS, EPA, and EIA, and models energy usage by building type for all commercial and residential buildings inside Portland city limits out to 2050. The previous 2030 tool was developed using the 2017 buildings list, growth forecast, and grid decarbonization trajectory, all of which have changed substantially in the last 5 years. For this Pathways tool update, the A2030 model was updated to include the latest inventory of buildings, square footage, use type, utility emissions factors, etc., as well as an updated growth forecast and grid decarbonization scenario, in order to reflect these shifts. Outputs from the A2030 model (which cover only the city of Portland), were scaled to the county level using data from the 2022 emissions inventory.

Overview of changes from previous Pathways/A2030 model:

- More complete and accurate buildings data set, updated to reflect significant infill development since 2017.
- Updated baseline residential energy usage reflecting the most recent Residential Energy Consumption Survey (previously used baseline from early 2000s).
- Updated with latest energy split data from EPA.
- Updated commercial energy consumption using energy use intensity values developed by Oregon Department of Energy.
- Updated utility emissions scenario reflecting the grid decarbonization requirements established in HB2021 (80% absolute emissions reduction from the 2010-2012 baseline by 2030, zero emissions by 2040).
- Updated population growth forecast (slower growth from previous scenarios, now aligned with growth assumptions from Metro's modeling for the Regional Transportation Plan)
- Updated new building energy efficiency to reflect recent improvements in building energy codes.

Building Decarbonization Strategies

Grid Decarbonization - Baseline

The % reduction from the grid decarbonization baseline is defined by the user at the top of the buildings section. The tool default is equivalent to on-time achievement of HB2021 targets (see Electricity Supply Above -- default 80% by 2030 and 100% by 2040).

Efficiency (residential and commercial)

Building efficiency improvements incorporate everything from building weatherization to high-efficiency appliances, but this strategy *does not include fuel switching*, e.g., replacing a gas furnace with an electric heat pump. Users can reduce up to 50% of emissions from existing buildings (residential and commercial) using this strategy.

New Construction Energy Codes (residential and commercial)

The tool baseline incorporates recent improvements to building energy codes, but using this strategy, users can select up to 50% additional emissions reductions from new buildings (residential and commercial). Like efficiency, this action does not account for fuel switching. However, the emissions reduction potential from natural gas is linked to the 'Natural Gas in New Construction' action below. For example, if no natural gas is allowed from 2030 to 2050, new construction energy codes will only reduce emissions from electricity.

Renewable Natural Gas (RNG) in Buildings

Renewable natural gas is a hydrocarbon gas from a biogenic source—e.g., captured methane from food waste—that is processed to high purity, making it a drop-in substitution for fossil natural gas in most cases. The State of Oregon's Climate Protection Program (CPP) mandates that emissions from fuels, including natural gas, are reduced over time, achieving a 90% reduction by 2050. A recent ODOE analysis indicates that Oregon's RNG potential could meet approximately 22% of natural gas demand. It is assumed that RNG is more valuable in industrial processes than in residential and commercial buildings, where electric technologies are widely available and competitive with gas alternatives, and the cap for RNG in residential and commercial buildings is set at 15%. Industrial RNG (discussed below) can replace up to 100% of fossil gas in that strategy. Maxing out RNG in buildings and industry in the tool results in RNG supply approximately equivalent to one third of total natural gas demand.

Electrification (residential and commercial)

The electrification strategy describes actions to replace natural gas and other fossil fuels with electricity in existing buildings. For example, replacing a gas furnace with a heat pump and replacing a gas stove with and electric/induction model would fall under this strategy. Technologies are currently available to fully electrify most or all residential and commercial uses, so users can select up to 100% electrification of existing buildings by 2050 in this strategy.

Natural Gas in New Construction

This action describes whether or not new homes will be built with natural gas connections in the periods from 2025-2030 and 2030 to 2050. If users select no, then new homes will be built without natural gas hookups. This choice influences how much natural gas there is to reduce from new construction energy codes, as well as the emissions reductions from RNG substitution.

Non-specific reduction

The non-specific reduction allows users to add their own emissions reductions from actions that are not defined here. In most cases, this value should be left as zero because all emissions reductions must align with values in the inventory and must not be covered by the other existing strategies. However, there may be instances where a specific action is known that will have an additional emissions reduction benefit. This is where that can be entered for buildings. A similar non-specific reduction action is possible in other sectors as well.

Industry

Industrials facilities are a major consumer of electricity, natural gas, and other fuels in Multnomah County. The emissions reduction strategies in this tool are built on data from the 2022 GHG inventory and the grid decarbonization pathways developed for the utilities.

Industrial Decarbonization Strategies

Grid Decarbonization – Baseline

The % reductions for grid decarbonization are defined by the user above in the buildings section (default 80% by 2030 and 100% by 2040). There is no user input for this strategy in the 'Industry' section.

Industrial RNG

Industrial processes, especially processes that require very high sustained temperatures, are generally considered 'hard to abate', meaning technology to decarbonize these emissions sources may not exist, or may not be widely available and cost-effective. For these reasons, RNG is considered to be a good bridge strategy to enable local production and manufacturing to thrive while significantly reducing anthropogenic GHG emissions. For this action, users may select the share of fossil gas replaced by RNG (up to 100%). If 100% RNG substitution is selected here and 15% RNG substitution is selected for buildings, the result is that approximately one in three cubic feet of gas consumed in Portland will be from RNG by 2050, which is the technical limit as indicated above in the building RNG section.

Industrial Innovation

There are many emerging technologies under development that will help to eliminate emissions in the industrial sector, each designed for a unique case. To avoid the complexity and lack of flexibility that would come from picking a list of technologies and scaling them independently, the industrial innovation strategy allows a user to add emissions reductions from new technologies, reducing up to 100% of remaining industrial GHG emissions.

Non-specific reduction

Though the 'Industrial Innovation' action allows for a generalized reduction of emissions, industry also has a non-specific reduction in case there is user benefit in adding an additional as-yet undetermined decarbonization strategy. In most cases, this value should be left as zero because all emissions reductions must align with values in the inventory and must not be covered by the other existing strategies. However, there may be instances where a specific action is known that will have an additional emissions reduction benefit.

Transportation

As a sector, transportation is the largest source of emissions in Multnomah County. Reductions from transportation strategies are built primarily on the 2022 inventory and data from VisionEval modeling performed for Metro's 2023 Regional Transportation Plan Update. VisionEval is a highly detailed model for estimating the impact of a range of planning, land use, and transportation policies on transportation demand and GHG emissions. Because of differences in base year and geographic scope, emissions from the adopted policy baseline and RTP + STS scenario were normalized to the same base year so that emissions reductions from the RTP + STS scenario only includes additional emissions reductions from 2022 onward.

Overview of changes from previous Pathways tool:

Though the previous Pathways tool also utilized data from VisionEval, at that time, the City of Portland had data for a specific set of policy bundles defined using important milestone years and the proper geographic boundary. For this update, only three relevant policy bundles were modeled: (1) RTP plus adopted policy baseline, (2) the RTP plus State Transportation Strategy (STS) scenario representing fulfillment of the RTP policies plus achievement of STS goals, and (3) the RTP + STS + Fleet scenario, which is similar to the RTP + STS scenario except that assumptions for fleet composition and turnover more closely reflect reality. Because of the more valid fleet assumptions, this tool uses the RTP + STS + Fleet scenario as the high action transportation pathway.

To analyze the effect of increased electric vehicle adoption (beyond what was assumed for Vision Eval). We assumed compliance with the state of Oregon's Clean Cars II regulation. This regulation requires that all new cars sold in the state be 100% emissions free by 2035.

Transportation Decarbonization Strategies

Baseline Reductions

No user input is allowed for the baseline reductions. These values represent the base emissions reductions from the RTP + Adopted Policy baseline. According to Metro's documentation, "[t]he RTP23+AP Scenario reflects minimal state-led actions, specifically only that associated with throughway congestion pricing in the Metro region. … This scenario not only has the least VMT per capita reductions, but also the highest GHG of the scenarios because of the current adopted trajectory for the vehicles and fuels in this model (i.e., slower shift to an electrified transportation fleet)."[2]

Policy Scenario

Users may select the 'RTP + Adopted Policy Baseline', the 'RTP + State Transportation Strategy policies' (which is the RTP + STS + Fleet scenario from Metro), or the 'Unchecked Growth' scenario. Unchecked growth assumes current transportation emissions per capita remain unchanged and total transportation emissions grow proportionally as the population in Multnomah County grows. This is not a likely outcome, but it can be selected to demonstrate the emissions reductions expected from the set of existing policies modeled as the baseline by Metro for the Regional Transportation Plan. The RTP + State Transportation Strategy scenario assumes broad state and local action, and provides the most emissions reductions (more details on the policies assumed in this scenario can be found in Metro's documentation linked above). Selecting the adopted policy baseline achieves the emissions reductions indicated in the 'Baseline Reductions' row.

Light-Duty Electric Vehicles

While RTP VisionEval modeling includes EV adoption, the assumed rates of EV transition in RTP scenarios are relatively conservative. The Clean Cars II regulation mandates that all new passenger vehicles are electric in 2035. This scenario estimates the increased emissions reductions beyond those in the policy scenario from more rapid EV adoption. Here, users enter a year on or after 2035 by which all new passenger vehicles must be electric. Vehicle life is estimate to be 15 years, so emissions reductions are based on the difference in emissions between EV operation and the average ICE vehicle operation as EVs increasingly replace ICE vehicles. Delaying the date when all vehicles are electric reduces the overall emissions reduction from vehicle electrification in 2050.

Heavy Duty Electric Vehicles

Heavy duty vehicles are a greater challenge to electrify with current technology, but Oregon's Advanced Clean Trucks Rule incentivizes a shift toward electrification. Users may select the % of heavy trucks that will be electric in 2050, capped at 85%. In accordance with the proposal for the Advanced Clean Trucks rules, electrification is assumed to begin in 2027.

Replace On-Road Diesel with R99 Renewable Diesel

Users may select the % of remaining diesel fuel to be replaced by renewable diesel. This scenario assumes drop-in replacement of fossil diesel. Renewable fuels in this tool are assumed to emit 99% fewer anthropogenic GHG emissions compared to fossil fuels. These fuels still have tailpipe

[2] 2023 Regional Transportation Plan – Appendix J – Climate Smart Strategy implementation and monitoring. *Oregon Metro*, July 10, 2023. *2023 RTP Appendix J*

emissions, some of which can contribute to local air pollution, but to be a truly renewable fuel, the feedstock must be a biological source made from materials that recently captured their carbon from the atmosphere.

Replace Off-Road Fuels with Renewables

Users may select the % of remaining off-road fuels to be replaced by renewables. See the section on renewable diesel above for general comments on renewable fuels.

Replace Remaining Gasoline with Renewables

Users may select the % of remaining on-road gasoline to be replaced by renewables. Renewable gasoline as a drop-in substitution fuel is not widely available at this time, though flex-fuel vehicles using high ethanol blends are commercially available. Users should generally consider electrification as the first option for light-duty vehicles. See the section on renewable diesel above for additional comments on renewable fuels.

Non-specific reduction - manual entry

The non-specific reduction allows users to add their own emissions reductions from actions that are not defined here. In most cases, this value should be left as zero because all emissions reductions must align with values in the inventory and must not be covered by the other existing strategies. However, there may be instances where a specific action is known that will have an additional emissions reduction benefit.

Other Emissions

In addition to the larger building and transportation sectors, smaller sources of emissions such as refrigerants and solid waste also have opportunities for emissions reductions. Unlike building and transportation, these emissions are not from fossil fuel combustion, but from non-energy sources with fugitive gases.

Other Emissions Decarbonization Strategies

Refrigerant Management

The federal government adopted the AIM Act which intends to reduce production and consumption of hydrofluorocarbons (HFCs), which are potent greenhouse gases. HFCs are commonly used as refrigerants and are used in various applications for refrigeration and air conditioning. The Act outlines a phasing down of HFCs with a set schedule, see table to the right. This phasedown aims to reduce their contribution to global warming by transitioning to lower GWP (Global Warming Potential) alternatives. The AIM Act is still in place, but it is unknown if it will continue given changes in the federal government. Per the EPA, the US was below the limits for both production and consumption in 2022 and 2023.[3]

Year	Cap as % of 2015 baseline
2022	90%
2024	60%
2029	30%
2036	15%

[3] https://www.epa.gov/climate-hfcs-reduction/hfc-data-hub-0

Food waste diversion and/or anaerobic digestion instead of landfill

Food waste is a leading source of landfill gas generation, which is predominantly composed of methane. An assumed 58% of GHG emissions are from food waste (based on the national average per the EPA). Diversion of food from the landfill to anaerobic digestion (AD) facilities or compost, or avoiding food waste before disposal, will reduce methane generation in the landfill. The tool assumes anaerobic digestion as the alternative, and models 96.9% methane containment (3.1% fugitive) for a 56% reduction in solid waste emissions (96.9% reduction of 58% from food waste). This is more conservative than assuming food waste avoidance, which would not generate any methane. Additionally, AD-generated methane, sometimes known as biomethane, can be used as a renewable fuel source, and the carbon dioxide emitted during combustion would be biogenic.

If Portland's destination landfill(s) has a higher or lower share of emissions from food waste, the benefit will be higher or lower accordingly. Similarly, if an AD facility is built and has a higher or lower methane containment than modeled, the benefit would change. AD facilities for municipal mixed solid waste are not well studied; the methane containment is based on the average of two studies. One study modeled both wastewater and agricultural AD, while another modeled food waste AD in the United Kingdom. While the food waste study had a lower fugitive rate, an average was created to remain conservative given the variables. Per the UK study, the percentage of losses relative to the calculated production rate ranged from 0.02% to 8.1%[4]. Both the food waste share of methane generation and the fugitive methane rate are adjustable in the tool behind the scenes.

Non-specific reduction

This action allows for a generalized reduction of emissions from non-specific sources in case there is user benefit in adding an additional as-yet undetermined decarbonization strategy.

Carbon Storage

Multnomah County contains a range of forest types. According to the [i-Tree tool](), which is supported by the US Forest Service, SUNY College of Environmental Science and Forestry, the National Association of State Foresters, and others, Multnomah County's trees currently sequester close to 300,000 metric tons of CO_2 per year. This tool uses i-Tree's baseline CO_2 reduction and estimates additional reductions by the maximum plantable area calculated in i-Tree.

Carbon Storage Strategies

Base Forest Carbon Storage

Base storage is determined for Multnomah County by i-Tree landscape, as indicated above.

Additional Forest Carbon Storage

Users may select a % of plantable area (as calculate by i-Tree) to reforest. The pathways tool calculates carbon sequestration as an average per-acre value based on the baseline, so this strategy

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[4] https://americanbiogascouncil.org/wp-content/uploads/2023/07/Sheutz-et-al-Waste-Management-2019-Fugitive-Methane-Emissions-AD-Facilities.pdf

https://www.sciencedirect.com/science/article/pii/S0956053X21000167 implicitly extends beyond simple number of trees planted—rather, this estimates the reduction in emissions when plantable areas are successfully reforested, meaning trees are planted and enough trees survive to maturity in a planted acre to establish new forest.

Limitations of This Tool and Analysis

A city is a complex and multifaceted system; modeling the energy usage of a city over time requires working with a range of data sets and models and deploying many distinct calculations to attempt to piece together a whole picture. In practice, the interactions between these actions are nuanced and often nonlinear, but this tool captures only simple interactions, e.g., if building efficiency reduces natural gas usage by 25%, then there is 25% less remaining gas to be substituted by RNG. The limitations for each action are based on evidence where possible, and where evidence is not conclusive, the limitations are based on judgment. However, it is still possible to create implausible scenarios. For example, a great deal of investment is moving globally into reducing emissions from various industrial products and processes, but to assume industrial innovation will reduce 100% of emissions by 2050 is highly speculative. For another example, renewable fuels in the tool can replace up to 100% of *remaining* fossil fuels in 2050. In a scenario with very little other action on transportation, this result may imply and implausibly high volume of renewable fuels in 2050. Both of these scenarios *may* be possible, but current technology and supply does not support these outcomes, so relying on those pathways is a challenge.

It could be argued that achieving 100% zero-carbon grid energy by 2040 is highly speculative as well, but the *potential supply* of zero-carbon energy far exceeds the threshold to achieve this goal, and the challenges primarily concern transmission capacity and energy storage, where existing technologies could already be deployed to fix bottlenecks if infrastructure can be developed at a sufficient pace.

At the core, this tool is built on the GHG Inventory, which provides the most valid and reliable data on local emissions available, but the primary forecasts from A2030 and VisionEval are models, each built with their own internal logic, input data, geographic boundaries, and sets of core assumptions. This tool transforms these models into outputs that reflect the results of the inventory, and these transformations require certain assumptions. As such, the picture provided by this tool cannot be expected to be perfectly true to life, but to be useful, it must reflect important aspects of reality such that people can explore the data and build a greater understanding. The core assumptions and transformations of the input data are provided below:

VisionEval:

Metro's VisionEval modeling was performed for the 2023 Regional Transportation Plan update. The regional scope of this model run necessitated some calculations to determine emissions specific to Portland. Due to the complexity of VisionEval's model and results, building scenarios on top of the RTP policy scenario required simplifying assumptions with regard to the growth of the EV population. Additionally, the base year of this model is not the same as the base year for the updated pathways tool, so the baseline policy pathway was normalized to the RTP policy at the base year (2022) in order to account only for additional emissions reductions attributable to the RTP policy package.

A2030:

For A2030, the base year and other key variables were updated to improve integration with the Pathways tool, but nonetheless, the tool uses inputs that generalize building characteristics and energy consumption to certain climate regions and then models out energy usage based on these characteristics. Furthermore, the A2030 tool is run explicitly on buildings within Portland city limits, so there is a geographic deviation from the boundary used for the emissions inventory. To correct for geographic differences and any aggregate deviation of the energy consumption patterns in Portland's building stock compared to the broader climate region, the results of the A2030 model were scaled to county level directly using the values from the 2022 inventory.

Of the data sources used in this tool, the VisionEval inputs are the most uncertain, but are likely reasonable with respect to the general direction and magnitude of emissions reductions from RTP policies.

Appendices

Appendix I – Scenario Details

The following tables show the sector results and input values in the updated Pathways tool for each of the three primary scenarios.

1. Net-Zero Pathway

Remaining Emissions by Sector - 2030 and 2050

Sector	Remaining MT CO_2e - 2030	Remaining MT CO_2e - 2050
Electricity Supply	498,963	0
Buildings	1,095,880	14,988
Industry	643,515	95,012
Transportation	1,556,891	48,130
Other	243,424	224,515
Sequestration	-331,442	-502,533
TOTAL	3,707,231	-119,887

	Scenario Action Report - Inputs			Totals
Sector	Action	Scenario input 1	Scenario input 2	2050 Action Total
Buildings	Building Baseline Reductions from Grid Decarbonization - HB2021	80%	100%	100%
Buildings	Residential Energy Efficiency (existing homes)	10%	40%	50%
Buildings	Commercial Energy Efficiency (existing buildings)	10%	40%	50%
Buildings	New Construction Energy Codes (R+C)	10%	40%	50%
Buildings	Renewable Natural Gas	0%	15%	15%
Buildings	Residential Electrification (existing homes)	20%	80%	100%
Buildings	Commercial Electrification (existing buildings)	20%	80%	100%
Buildings	Natural Gas in New Construction	Yes	No	No

Buildings	Non-specific reduction - manual entry	2040	0	
Industry	Industrial Baseline Reductions from Adopted Plans/Policies	80%	100%	100%
Industry	Industrial RNG	2025	100%	100%
Industry	Industrial Innovation	0%	75%	75%
Transportation	Transportation Baseline Reductions from Adopted Plans/Policies	29%	10%	39%
Transportation	Policy Scenario	Regional Transportation Plan Policies		
Transportation	Light-Duty Electric Vehicles	2035		
Transportation	Heavy Duty Electric Vehicles	85%		170%
Transportation	Replace On-Road Diesel with R99 Renewable Fuel	10%	85%	95%
Transportation	Replace Off-Road Fuels with Renewables	10%	85%	95%
Transportation	Replace Remaining Gasoline with Renewables	10%	80%	90%
Other Emissions	Refrigerant Management	Yes	Yes	Yes
Other Emissions	Food waste avoidance and/or anaerobic digestion instead of landfill	2025	80%	80%
Carbon Storage	Base Forest Carbon Storage	299,362		
Carbon Storage	Additional Forest Carbon Storage	15%	80%	95%

2. Grid Only to 2030

Remaining Emissions by Sector - 2030 and 2050

Sector	Remaining MTCO2e - 2030	Remaining MTCO2e - 2050
Electricity Supply	498,963	0
Buildings	1,461,398	283,988
Industry	643,515	95,012
Transportation	1,806,996	142,649
Other	500,976	224,515
Sequestration	-299,362	-470,453
TOTAL	4,612,486	275,711

	Scenario Action Report - Inputs			Totals
Sector	Action	Scenario input 1	Scenario input 2	2050 Action Total
Buildings	Building Baseline Reductions from Grid Decarbonization - HB2021	80%	100%	100%
Buildings	ResidenItial Energy Efficiency (existing homes)	0%	40%	40%
Buildings	Commercial Energy Efficiency (existing buildings)	0%	40%	40%
Buildings	New Construction Energy Codes (R+C)	0%	40%	40%
Buildings	Renewable Natural Gas	0%	15%	15%
Buildings	Residential Electrification (existing homes)	0%	80%	80%
Buildings	Commercial Electrification (existing buildings)	0%	80%	80%
Buildings	Natural Gas in New Construction	Yes	No	No
Buildings	Non-specific reduction - manual entry	2040	0	
Industry	Industrial Baseline Reductions from Adopted Plans/Policies	80%	100%	100%
Industry	Industrial RNG	2030	100%	100%
Industry	Industrial Innovation	0%	75%	75%
Transportation	Transportation Baseline Reductions from Adopted Plans/Policies	29%	10%	39%
Transportation	Policy Scenario	Regional Transportation Plan Policies		
Transportation	Light-Duty Electric Vehicles	2045		
Transportation	Heavy Duty Electric Vehicles	75%		160%
Transportation	Replace On-Road Diesel with R99 Renewable Fuel	0%	85%	85%

Transportation	Replace Off-Road Fuels with Renewables	0%	85%	85%
Transportation	Replace Remaining Gasoline with Renewables	0%	80%	80%
Other Emissions	Refrigerant Management	No	Yes	Yes
Other Emissions	Food waste avoidance and/or anaerobic digestion instead of landfill	2030	80%	80%
Carbon Storage	Base Forest Carbon Storage	299,362		
Carbon Storage	Additional Forest Carbon Storage	0%	80%	80%

3. Missed Targets

Remaining Emissions by Sector - 2030 and 2050

Sector	Remaining MT CO_2e - 2030	Remaining MT CO_2e - 2050
Electricity Supply	624,463	0
Buildings	1,278,639	648,188
Industry	594,255	239,534
Transportation	1,710,900	236,421
Other	246,449	228,164
Sequestration	-320,748	-427,680
TOTAL	4,133,957	924,627

	Scenario Action Report - Inputs			Totals
Sector	**Action**	**Scenario input 1**	**Scenario input 2**	**Action Total**
Buildings	Building Baseline Reductions from Grid Decarbonization - HB2021	75%	90%	90%
Buildings	Residential Energy Efficiency (existing homes)	5%	25%	30%
Buildings	Commercial Energy Efficiency (existing buildings)	5%	25%	30%
Buildings	New Construction Energy Codes (R+C)	5%	25%	30%
Buildings	Renewable Natural Gas	0%	10%	10%
Buildings	Residential Electrification (existing homes)	10%	50%	60%

Buildings	Commercial Electrification (existing buildings)	10%	50%	60%
Buildings	Natural Gas in New Construction	Yes	Yes	Yes
Buildings	Non-specific reduction - manual entry	2040	0	
Industry	Industrial Baseline Reductions from Adopted Plans/Policies	75%	90%	90%
Industry	Industrial RNG	2025	75%	75%
Industry	Industrial Innovation	0%	50%	50%
Transportation	Transportation Baseline Reductions from Adopted Plans/Policies	29%	10%	39%
Transportation	Policy Scenario	Regional Transportation Plan Policies		
Transportation	Light-Duty Electric Vehicles	2040		
Transportation	Heavy Duty Electric Vehicles	50%		135%
Transportation	Replace On-Road Diesel with R99 Renewable Fuel	5%	70%	75%
Transportation	Replace Off-Road Fuels with Renewables	5%	70%	75%
Transportation	Replace Remaining Gasoline with Renewables	5%	70%	75%
Other Emissions	Refrigerant Management	Yes	Yes	Yes
Other Emissions	Food waste avoidance and/or anaerobic digestion instead of landfill	2025	75%	75%
Carbon Storage	Base Forest Carbon Storage	299,362		
Carbon Storage	Additional Forest Carbon Storage	10%	50%	60%