Appendix 10.5.
Scenarios Analysis Report

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Hammerschlag LLC

MEMO

Subject: **Scenario Analysis Tool User's Guide**

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Introduction

The Scenario Analysis Tool permits the Thurston Regional Planning Council (TRPC) and other Thurston Climate Mitigation Plan (TCMP) partners to test impacts of hypothetical climate policies on the future. A user of the Scenario Analysis Tool can posit future reductions in twenty-one strategy metrics related to the Thurston County economy, and receive instant visual feedback regarding the associated greenhouse gas (GHG) reductions. (Figure 1)

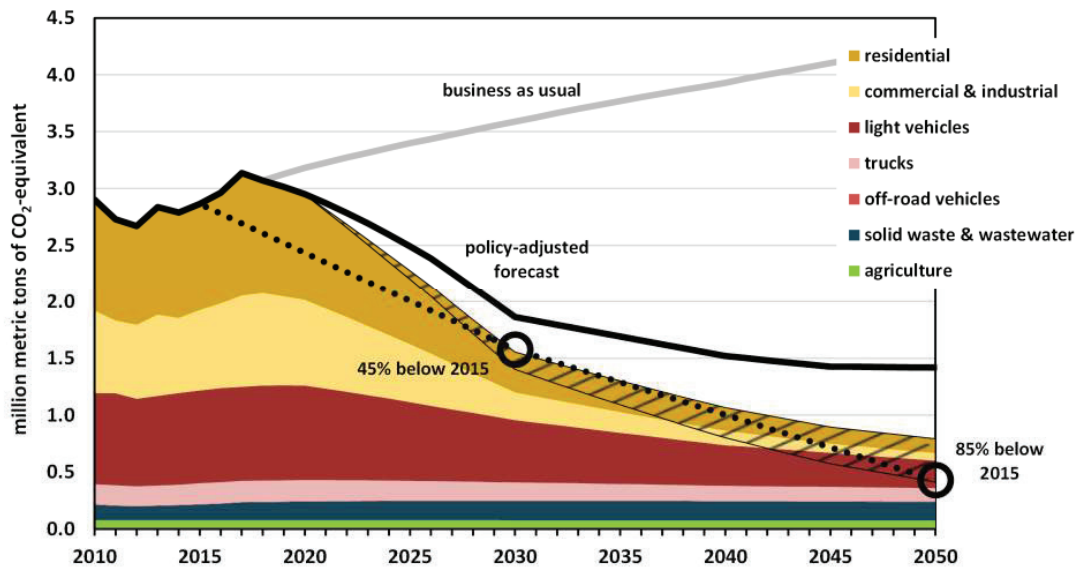

Figure 1 – Sample output of the Scenario Analysis Tool. Data from 2010-2018 are actuals as reported in the Thurston County GHG inventory; data from 2019-2050 are forecast. The crosshatched area indicates potential reductions associated with user input values for carbon sequestration projects or GHG offsets.

This memo is divided into three sections:

The *User Guide* provides “get started” level, practical guidance for appropriate and easy use of the tool. *Methodology* describes in detail how the user’s activity level inputs are translated into GHG emissions outputs. Many readers may want to skip this section, and instead utilize the case study as further guidance toward successful use. *Case Study* applies the tool to proposed TCMP Assessed Actions generated by a collaboration between TRPC, the Climate Advisory Workgroup and the consultant, as of May 15, 2020.

User Guide

Spreadsheet Structure and User Dashboard

The Scenario Analysis Tool is coded in Microsoft Excel 2019, and includes nine tabs ‘cover’, ‘dashboard’, ‘engine’, ‘ref’, ‘preprocessing’, ‘definitions’, ‘units’, ‘change log’ and ‘cites’. All substantive computations occur on the tab ‘engine’, but the user can effectively use the tool working entirely with the user dashboard on tab ‘dashboard’. The dashboard places the primary inputs and outputs in a single visual field. (Figure 2)

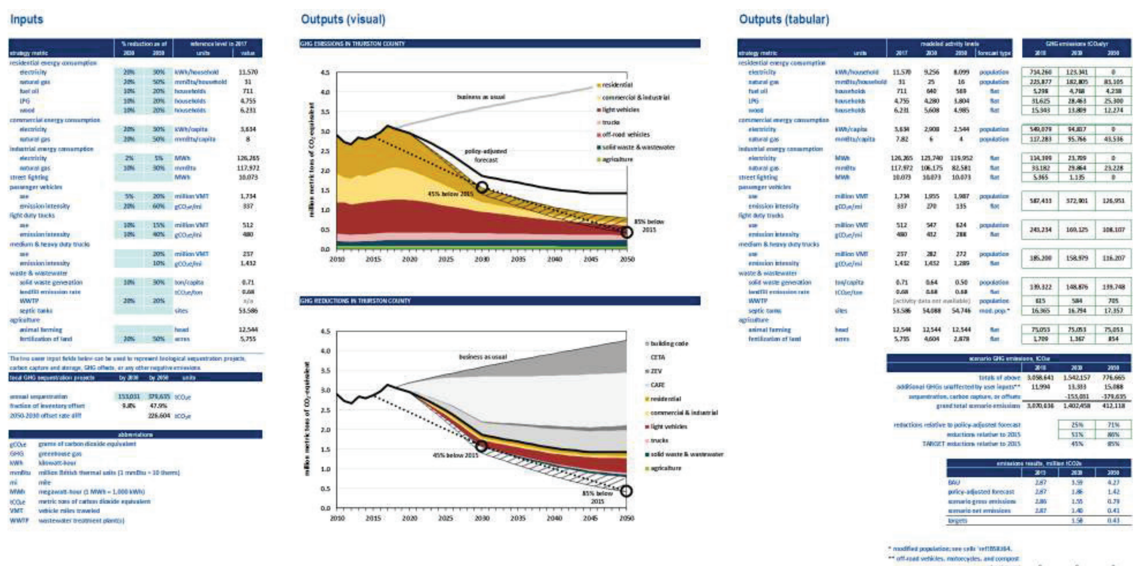

Figure 2 – Major features of the Scenario Analysis Tool’s user dashboard. The tabular area on the left edge provides fields for user input (light blue shaded cells) and a key to abbreviations used in the calculator. The center area includes visual output detailing a forecast of the Thurston County GHG inventory in the upper graphic, and anticipated GHG reductions due to state and federal policies (grey) and TCMP strategies (colors) in the lower graphic. The tabular area on the right forecasts changes to activity metrics and GHG emissions

Graphical Output

The primary feature of the dashboard is the output graphic. The graphic includes the following five components:

- **Business-as-usual (BAU)**: The upward-sloping, grey line; this is the first of two reference scenarios. This represents the emissions we would expect if energy and climate policies remain fixed as they were during the 2010-2018 timeframe, and population grows following current, state forecasts.
- **Policy-adjusted forecast**: The thick, black line; this is the second of two reference scenarios. The policy-adjusted forecast adjusts BAU downward according to the impacts of future energy code components of state building code, the Clean Energy Transition Act (CETA), and anticipated increases to vehicle fuel economies. The vast majority of difference between BAU and the policy-adjusted forecast is due to CETA.
- **Targets pathway**: The downward-sloping, dotted black line. The two open circles represent the two GHG reduction targets: 45% below 2015 by 2030, and 85% below 2015 by 2050, following the interlocal agreement for a regional climate mitigation plan.[1] The dotted black line is a piecewise-linear pathway from actual emissions in 2015 to 2030 target emissions; and to 2050 target emissions. The linear pathway is for visual reference; the interlocal agreement only specifies the two targets, not the pathway.
- **Scenario emissions**: The solid colored areas. Each area represents the emissions from a different sector of the economy. From top to bottom these sectors are: residential buildings (dark yellow), commercial & industrial buildings (light yellow), transportation (red), solid waste & wastewater (blue); agriculture (green); and miscellaneous (grey). The top of the stack of shaded areas represents total emissions. Emissions from 2010 to 2018 are actuals, emissions from 2019 to 2050 are projections.
- **Sequestration**: The crosshatched area along the top of the scenario emissions stack. These represent the user's input of biological sequestration projects, carbon capture and storage, GHG offsets or other negative emissions. If negative emissions are allowed toward target achievement, then the net outcome of the user's inputs should be read as the pathway of the underside of the sequestration wedge.

It can be a point of confusion that the targets pathway references calendar year 2015, but that the transition from actual data to projections is between calendar years 2018 and 2019. The emissions targets were legally specified relative to a baseline emissions year, 2015, to make them definitive. In contrast, the projected emissions are computed by whatever method is most accurate, maximizing the use of historical actuals. Since actuals were available through calendar year 2018, we began the estimates as of 2019 to maximize precision of the tool. This does not affect the computed emission targets in any way.

[1] Thurston County et al., "Interlocal Agreement between Thurston County, The City of Lacey, the City of Olympia, the City of Tumwater, and the Thurston Regional Planning Council for a Regional Climate Mitigation Plan," 2018.

Tabular Output

Tabular outputs are available on the right-hand side of the dashboard, labeled "OUTPUT: GHG emissions by strategy metric" in Figure 2. Each cell in this region of the dashboard reports absolute emissions in the last measured year 2018, as well as in the two target years 2030 and 2050. Even though the user inputs a fractional *reduction*, the tool outputs absolute *emissions*. As the user's input reductions increase, the output emissions decrease.

The emissions reported for each strategy metric are non-overlapping, and add to create the same total as the top of the scenario emissions stack in the graphic. The three such totals for 2018, 2030 and 2050 can be found below the strategy metric-specific outputs in cells 'dashboard'!X42:Z42.

Below the total GHG outputs, the percentage reductions achieved in 2030 and 2050 appear in pink cells 'dashboard'!Y45:Z45, which can be compared to their respective numeric targets in cells 'dashboard'!Y46:Z46.

Input

Reductions to Strategy Metrics

The user can alter scenario emissions by adjusting the twenty-one pairs of 2030 and 2050 strategy metric reductions. In Figure 2, these are the light blue-shaded cells indicated with "INPUT: reductions to strategy metrics". If you leave any of these cells blank, then the tool assumes the emissions are equal to those under the policy-adjusted forecast. In most cases where you input a value for 2030, the policy prescription will imply an equal or more aggressive reduction be input for 2050. The only exception would be for cases where you expect a policy to sunset, followed by a rollback of consumer behavior or infrastructure.

Think of each strategy metric either as an average activity level or as a total activity level. Average activity level if the units listed for the strategy metric are a ratio, total activity level if the units are not a ratio. The first and third strategy metrics offer examples of the two cases.

The first strategy metric is residential electricity consumption, measured in units *kWh/household*. Since these units are a ratio, the metric assesses the degree to which your proposed bundle of policies can reduce the average electricity per household. For example, if your policy bundle reduces electricity consumption by 20% in 10% of all homes, then the average reduction per household is 10% × 20% = 2%.

The third strategy metric, residential fuel oil consumption, is measured in units *households*. Since these units are not a ratio, they assess the degree to which your policy can reduce the total number of households that are using fuel oil.

Other Inputs

Below the graphical output, there are two additional input fields for negative GHG emissions achieved in 2030 and 2050, respectively. For each of the two years, input the negative emissions expected *in that year*, in metric tons of CO_2-equivalent. Unlike the strategy metrics, where the Scenario Analysis Tool automatically computes GHG emissions from your percentage reductions, in the case of the two negative emissions fields you must compute the GHG emissions exogenous to the calculator.

Two 'engine' tab of the tool offers two additional inputs for advanced control of the calculator's behavior. First, at cell 'engine'!G68 you can control the slope of the BAU reference scenario (and hence all the other time series outputs) by choosing an alternate population forecast. This is not recommended, since the central population forecast is TRPC's only formally adopted forecast.

Second, the "exclude heavy-duty trucks" checkbox at cell 'engine'!E83 allows the user to remove heavy-duty truck emissions from the analysis. Most heavy-duty truck emissions in Thurston County are due to Interstate 5 through-traffic, which is out of the partner jurisdictions' control.

Methodology

Step 1: Generate a BAU forecast

For each inventory category, the Scenario Analysis Tool creates a Business As Usual (BAU) forecast of GHG emissions from 2019 through 2050. The BAU forecast represents the anticipated growth of GHG emissions in each inventory category, under the assumption that policies remain identical to those nominally in place during the 2010-2018 period covered by the existing time series of Thurston County GHG inventories.

Each inventory category forecast is based on the calendar year 2018 emissions level. Most inventory categories are assumed to increase proportionally to county population, such that emissions in a future year are equal to the emissions in 2018 multiplied by the ratio of population in the future year and population in 2018. The remaining inventory categories are assumed to remain fixed at the 2018 level. (Table 1)

population-based forecast	flat forecast
residential electricity	industrial electricity
commercial electricity	outdoor lighting
residential fossil gas	industrial fossil gas
commercial fossil gas	off-road vehicles
passenger vehicles	septic systems
light duty trucks	enteric fermentation
medium & heavy duty trucks	manure management
motorcycles	agricultural soil management
solid waste methane	
solid waste process	
solid waste transportation	
composting	
Budd inlet WWTP	
other WWTP	

Table 1 – Thurston County greenhouse gas inventory categories grouped by their forecasting treatment in the Scenario Analysis Tool.

Future populations are drawn from TRPC's adopted forecast,[2] which is computed through forecast year 2040. Population projections from 2041 through 2050 are linear interpolations based on the forecast years 2031 through 2040.

Step 2: Apply future policy impacts

Next, inventory categories affected by anticipated changes to Washington State Building Energy Code,[3] the Clean Energy Transformation Act,[4] or average vehicle fuel economy are adjusted downward according to the corresponding legal requirements. (Table 2)

affected by building code	affected by CETA	affected by vehicle fuel economy
residential electricity	residential electricity	passenger vehicles
commercial electricity	commercial electricity	light duty trucks
residential fossil gas	industrial electricity	medium & heavy duty trucks
commercial fossil gas	outdoor lighting	

Table 2 – Thurston County greenhouse gas inventory categories affected by policy adjustments in the Scenario Analysis Tool.

Impact of Washington State Building Energy Code is described with a linearized policy model. The GHG emission rate from new buildings follow a linear pathway from their rate in 2018, to zero as of 2031 per the prescription in state law. From 2031 through 2050, the GHG emission rate from new buildings remains zero. We assume average building life to be 40 years, so that

[2] https://www.trpc.org/236/Population-Employment-Forecasting

[3] RCW 19.27A.020(2)(a)

[4] 2019 SB 5116

each year 1/40 of the forecast building stock is modeled to be replaced by new stock. The new stock then emits GHGs at whichever rate is ascribed by the linearized policy model at the time of its construction, for the duration of its 40-year life.

The Clean Energy Transformation Act impacts electricity emission factors, which have an instantaneous impact on the emissions forecast, unlike the Building Energy Code. CETA requires elimination of coal-fired electricity before January 1, 2026; limits emitting resources to 20% or less of generation as of January 1, 2030; and requires complete decarbonization as of January 1, 2045. The scenario analysis tool represents these policy requirements with three linear ramps. The first, 2018-2026 ramp begins with Puget Sound Energy's (PSE's) actual mix of coal and gas as of 2018,[5] and ends with the coal fraction entirely replaced with gas as 2026. The second, 2026-2030 ramp ends with gas making up exactly 20% of PSE's mix as of 2030. The third, 2030-2045 ramp ends with zero fossil fuel emissions as of 2045. After 2045, PSE emissions stay fixed at zero. This approach is based on the conservative assumption that the "alternative compliance options" required by CETA during 2030-2044 do not offset the remaining fossil fuel emissions.

The impacts of vehicle fuel economy changes are applied according to forecasts developed by TRPC[6] (Table 3).

	2015	2017	2030	2040	2050
cars (gCO_2e/mi)	443	425	309	246	235
cars (deflator)		1.000	.727	.579	.553
trucks (gCO_2e/mi)	596	570	403	351	339
trucks (deflator)		1.000	.707	.616	.594

Table 3 – Actual (2015) and forecast (2030, 2040 and 2050) vehicle emission intensities provided by TRPC, and emissions deflators computed for the Scenario Analysis Tool. The emission intensities in 2017 were computed by linear interpolation between the TRPC-provided values for 2015 and 2030.

TRPC forecasts of vehicle emission intensity were developed from an amalgam of primary sources. For each vehicle category, the Scenario Analysis Tool computes the emission intensity as of 2017 by linear interpolation between TRPC-provided categories, and assigns an emissions deflator value of 1.0 to this 2018 reference intensity. (2018 is the last year of historical emissions data in the tool.) The calculator then assigns deflator values for each vehicle category proportional to TRPC's projected emissions intensity pathway, from 2019 through 2050.

[5] Department of Commerce, "Washington State Electric Utility Fuel Mix Disclosure Reports for Calendar Year 2018" (Washington State, November 7, 2019), https://www.commerce.wa.gov/growing-the-economy/energy/fuel-mix-disclosure/.

[6] TRPC 2013 Household Travel Survey (miles driven by vehicle model year and fuel type); Puget Sound Regional Planning Council Lifetime mileage-weighted average CO2 equivalent emissions factors for model years 1990-2020, by vehicle type, https://www.trpc.org/317/Household-Travel-Survey.

Expert input from Climate Advisory Workgroup members indicated that Washington's Zero Emissions Vehicle requirement would result in 7% of vehicle sales being EVs by 2025. The model assumes a linear ramp in sales share to 7% by 2025, and then a fixed sales share of 7% thereafter. The statewide, light vehicle fleet gradually accumulates EVs throughout the model timespan. Based on an assumed, average vehicle life of ten years, the light vehicle fleet is approximately 17% EVs by the model horizon of 2050.

Step 3: Compute deflator curves

In the dashboard, the user inputs fractional reductions in each strategy metric anticipated as of 2030 and 2050. For each strategy metric the Scenario Analysis Tool builds a deflator curve consisting of two linear ramps, the first from 2020 to 2030, and the second from 2030 to 2050. The value of each deflator curve begins at 1 in 2020, decreases to 1 minus the user's input 2030 reduction in 2030, and then decreases to 1 minus the user's input 2050 reduction in 2050.

It is in this step that the crosswalk between strategy metrics and inventory categories is executed. (Table 4)

strategy metric	**inventory category(ies)**
residential electricity	residential electricity
residential fossil gas	residential fossil gas
residential fuel oil	residential fuel oil
residential LPG	residential LPG
residential wood	residential wood
commercial electricity	commercial electricity
commercial fossil gas	commercial fossil gas
industrial electricity	industrial electricity
industrial fossil gas	industrial fossil gas
street lighting	outdoor lighting
passenger vehicle use	passenger vehicles
passenger vehicle EF	
light duty truck use	light duty trucks
light duty truck EF	
heavy duty truck use	medium & heavy duty trucks
heavy duty truck EF	
solid waste generation	methane emissions, solid waste process, solid waste transportation
landfill emission rate	methane emissions
wastewater treatment plants	Budd Inlet WWTP, other WWTP
septic tanks	septic systems
animal farming	enteric fermentation, manure management
fertilization of land	agricultural soil management

Table 4 – Inventory categories, by which strategy metrics impact them. The strategy metrics appear in the same order in which they appear on the Scenario Analysis Tool dashboard.

There are three inventory categories that are unaffected by dashboard inputs, and for which no deflator curves are computed. These three inventory categories are: *motorcycles*, *off-road vehicles*, and *composting*.

Step 4: Apply deflator curves to the policy-adjusted forecast

The policy-adjusted forecast for each inventory category created in Step 2, is multiplied by its respective deflator curve computed in Step 3. Inventory categories having no deflator curve are left unchanged.

Step 5: Compute GHG offset forecast

The dashboard inputs for GHG offsets are converted to a 2020-2050 time series, beginning at zero in 2020, with a linear increase to the user's input value for 2030, followed by a linear increase to the user's input value for 2050.

Step 6: Roll up inventory categories into sectors

Finally, the 25 inventory categories are rolled up into five sectors: residential buildings, commercial & industrial buildings, transportation, solid waste & wastewater, and agriculture in preparation for graphing and tabular output on the dashboard. (Table 5)

sector	**contains inventory categories**
residential	residential electricity residential fossil gas residential fuel oil residential LPG residential wood
commercial & industrial	commercial electricity commercial fossil gas industrial electricity industrial fossil gas streetlighting
transportation	passenger vehicles light duty trucks medium & heavy duty trucks motorcycles off-road vehicles
solid waste & wastewater	methane emissions process emissions solid waste transport composting Budd Inlet WWTP other WWTP septic systems
agriculture	enteric fermentation manure management agricultural soil management

Table 5 – Assignment of inventory categories to sectors (for graphical output in the Scenario Analysis Tool dashboard).

Case Study

The delivered version TH-010(s) of the Scenario Analysis Tool contains Cascadia Consulting Group / Hammerschlag LLC estimates for reductions in eighteen of the strategy metrics, in cells 'dashboard'!F7:G34. These are our estimates of strategy metric reductions associated with aggressive deployment of all 71 TCMP Assessed Actions as documented in file <TCMP_draft priority climate actions_20200515.pdf>.[7]

We (Cascadia Consulting Group / Hammerschlag LLC) estimated the strategy metric reductions by collecting, for each strategy metric, the subset of TCMP Assessed Actions that would impact the strategy metric, and estimating based on professional experience the expected reduction under the condition that all actions in the subset are deployed. In each instance we considered the potential assuming full support of relevant municipal, county and state governments. In the case of voluntary measures we assumed widespread consumer or customer interest, but limited by normal economic circumstances. We took into account interactions among each subgroup of actions so that their effect was considered in concert, not simply a sum of the effects if each one were deployed singly.

Residential Sector

strategy metric	contributing actions	reductions 2030	reductions 2050
residential electricity	B1.1 residential energy performance ratings B1.2 residential energy audits B1.4 rental housing EE incentives B1.5 property tax credit B1.6 rental housing EE baseline B3.5 green building tracking B4.5 permitting incentives B4.6 EE tax exemptions B4.7 land use incentives B4.9 permit counter technical assistance B4.11 grid-connected appliances B4.12 multifamily submetering B5.5 solSmart B5.8 solar-ready B5.10 group purchasing G1.7 social research T1.2 middle-density housing T1.3 Eco districts	20%	30%
residential fossil gas	B1.1 residential energy performance ratings B1.2 residential energy audits B1.4 rental housing EE incentives B1.5 property tax credit B1.6 rental housing EE baseline B3.5 green building tracking B4.5 permitting incentives B4.6 EE tax exemptions	20%	50%

[7] Received from Allison Osterberg via email, 2020-05-15.

strategy metric	contributing actions	reductions 2030	2050
	B4.7 land use incentives B4.9 permit counter technical assistance B4.12 multifamily submetering B6.1 natural gas to electric conversions B6.2 electric appliances in new construction B6.4 natural gas transition G1.7 social research T1.2 middle-density housing T1.3 Eco districts		
residential fuel oil	B1.1 residential energy performance ratings B1.2 residential energy audits B1.4 rental housing EE incentives B1.5 property tax credit B1.6 rental housing EE baseline B4.5 permitting incentives G1.7 social research	10%	20%
residential LPG	B1.1 residential energy performance ratings B1.2 residential energy audits B1.4 rental housing EE incentives B1.5 property tax credit B1.6 rental housing EE baseline B4.5 permitting incentives B6.2 electric appliances in new construction G1.7 social research	10%	20%
residential wood	B1.1 residential energy performance ratings B1.2 residential energy audits B1.4 rental housing EE incentives B4.5 permitting incentives G1.7 social research	10%	20%

The *residential electricity* and *residential fossil gas* strategy metrics share the majority of their contributing actions, specifically:

B1.1 residential energy performance ratings
B1.2 residential energy audits
B1.4 rental housing EE incentives
B1.5 property tax credit
B1.6 rental housing EE baseline
B3.5 green building tracking
B4.5 permitting incentives
B4.6 EE tax exemptions
B4.7 land use incentives
B4.9 permit counter technical assistance
B4.12 multifamily submetering
G1.7 social research
T1.2 middle-density housing
T1.3 Eco districts

All of these actions either provide an opportunity to act on both electric and fossil gas energy simultaneously or independently, or they affect the building shell in which case both types of energy consumption are likely to be reduced. Our higher estimate of reduction in 2050 for *residential fossil gas*, reflects the likely substitution of heat pumps for fossil gas furnaces in response to (a) the various efficiency incentives included for both strategy metrics and (b) contributing action B6.1 *fossil gas to electric conversions*.

Residential fuel oil, *residential LPG* and *residential wood* achieve lower reductions, because utilities have far less ability to bring incentive programs for these three fuels to homes.

Comparing Policies for New Buildings vs. Existing Buildings

The Scenario Analysis Tool estimates stock of new buildings vs. existing buildings by assuming a 40-year average building lifetime. So for a policy affecting new buildings, even if it goes into force immediately in 2020, then as of 2030 75% of buildings will be those that existed today, and even by the model horizon of 2050, 25% of buildings will be those that existed today, and therefore unaffected by the new buildings policy. Of course, the longer that implementation of a buildings policy is delayed, the higher these fractions of extant buildings will be in 2050 and especially 2030.

Among the residential buildings actions, those targeted specifically at new buildings are:

B4.5 permitting incentives
B4.6 EE tax exemptions
B4.7 land use incentives
B4.9 permit counter technical assistance
B4.12 multifamily submetering

In our 2030 estimates, these five incentives make no substantive contributions to the 20% reductions estimated for 2030 in residential electricity and residential fossil gas, due to the dominance of existing building stock expected (especially after considering some lag between Thurston Climate Mitigation Plan release and eventual deployment of the policies). By 2050 however, these policies are making substantial contributions to our estimates of the policy bundle impacts to residential electricity (30% reduction total) and residential fossil gas (50% reduction total).

Contribution of Local Renewable Energy Production

Local renewable energy production is supported by the actions:

B5.5 solSmart
B5.8 solar-ready
B5.10 group purchasing

Local renewable energy production is input into the Scenario Analysis Tool as a reduction in demand for grid electricity. Hence these actions are included in the policy bundles that affect strategy metrics *residential electricity* and *commercial electricity* (and, in the case of B5.8 solar-ready, *industrial electricity*).

All three actions provide infrastructure support, but with neither a portfolio standard nor financial incentives. Furthermore, *B5.8 solar-ready* impacts new buildings only (see discussion above). So, the local renewable production actions' contributions to our reduction estimates are small. Strategy metrics *residential electricity* and *commercial electricity* are ratio metrics, so the impact of each action needs to consider penetration into the market as well as the impact at each household. For example, if each household in a *B5.10 group purchasing* collective purchases sufficient panels to displace 30% of its electricity consumption, and as of 2030 5% of all households join collectives, then the reduction to utility electric demand will be
5% × 30% = 1.5%.

Preemption of Electricity Actions by CETA

CETA requires electricity delivered in Washington State to be generated entirely from non-emitting resources as of 2045 (see p. 7). TCMP actions that reduce electric consumption play an important role in meeting the 2030 GHG target, but do not play a role in meeting the 2050 target because at that point all electric consumption will be zero-emissions due to state law.

Commercial and Industrial Sectors

strategy metric	contributing actions	reductions 2030	2050
commercial electricity	B2.1 commercial energy benchmarking & disclosure B2.3 LED lighting B2.6 cool roofs B2.8 performance standard B3.1 energy education B3.4 exemplary buildings B3.5 green building tracking B4.4 green public buildings B4.5 permitting incentives B4.6 EE tax exemptions B4.7 land use incentives B4.9 permit counter technical assistance B5.3 public building solar B5.5 solSmart B5.8 solar-ready B5.10 group purchasing T1.3 Eco districts	20%	30%
commercial fossil gas	B2.1 commercial energy benchmarking & disclosure B2.8 performance standard B3.1 energy education B3.4 exemplary buildings B3.5 green building tracking B4.4 green public buildings B4.5 permitting incentives B4.6 EE tax exemptions B4.7 land use incentives B4.9 permit counter technical assistance B4.11 grid-connected appliances B6.1 natural gas to electric conversions B6.4 natural gas transition T1.3 Eco districts	20%	50%
industrial electricity	B3.1 energy education B4.11 grid-connected appliances B5.8 solar-ready	2%	5%
industrial fossil gas	B3.1 energy education B6.4 natural gas transition	10%	30%

As in the residential sector, electricity and fossil gas are equally susceptible to many of the proposed actions. The commercial sector has historically responded with less elasticity to energy efficiency incentives than the residential sector, which is the primary reason for our somewhat lower estimates here.

Industrial sector emissions are a combination of typical, building HVAC and lighting energy similar to the predominant drivers in commercial sector emissions, but then combined with industrial process loads such as fans, motors, and process heat. In Thurston County industrial sector emissions are relatively small; for example its natural gas combustion emissions, at 33,000 tCO_2e in 2018, are just 1% of the county's 3 million tCO_2e inventory.

Transportation Sector

strategy metric	contributing actions	reductions 2030	reductions 2050
passenger vehicle use	G1.7 social research T1.1 coordinated long term planning- future infill T1.2 middle-density housing T1.3 Eco districts T1.4 20-minute neighborhoods T1.9 ADUs T1.11 land use efficiency T2.2 congestion mitigation T2.17 teleworking/flex work T4.1 increase transit T4.3 rural transit T4.4 fareless system/youth ride free T4.10 rider education/benefits T4.15 promote transit benefits T5.1 walk/bike infrastructure T5.2 barriers to transportation alternatives T5.4 school drop-off alternative modes T5.11 car-free zones T5.13 telecommuting infrastructure	5%	20%
passenger vehicle EF	G1.7 social research T2.4 vehicle efficiency outreach T3.1 EV parking new construction T3.2 free EV parking T3.5 EV ready building code T3.7 EV integration T3.10 convert to EV fleets T3.11 EV education T3.14 EV mass purchase discounts T3.15 EV purchase incentives	20%	60%
light duty truck use	T1.3 Eco districts T1.11 land use efficiency T2.2 congestion mitigation	10%	15%
light duty truck EF	T3.10 convert to EV fleets	10%	40%
medium & heavy truck use	*consultant's reduction target*		20%
medium & heavy truck EF	*consultant's reduction target*		10%

TCMP Assessed Actions approaches to transportation are generally aggressive, and especially take into account the importance of urban form. Vehicle use is famously inelastic, so our 2050 estimate of a 20% reduction in VMT per capita reflects very aggressive policymaking in this arena, matching the contributing actions.

Even though the EV policies proposed to affect the strategy metric *passenger vehicle EF* are perhaps not as comprehensive, they still result in relatively large reduction estimates because they are strongly enabled by the increasing availability and dropping prices of electric vehicles on the national and international market.

In the interests of increasing the potential to meet the particularly challenging 2050 TCMP target, we are also offering two *consultant's reduction targets* for medium and heavy trucks in 2050. Use and emission factor associated with medium and heavy trucks are not targeted by any of the TCMP proposed strategies but, especially in the long term, they can be modestly affected by municipal policy. Use can decrease as a consequence of dense urban design: attention to commercial product delivery within urban planning measures like T1.3 *Eco districts* or T1.11 *land use efficiency* would be effective levers for impacting truck use. Emission factor can also be impacted, by creating regulatory requirements for the types of vehicles permitted to service selected areas or eco districts.

New Emissions from EVs

Adoption of EVs plays substantially into our reduction estimates for strategy metric *passenger vehicle EF*. Though EVs do genuinely displace tailpipe emissions from gasoline and diesel fuel, that displacement is mitigated by new, stack emissions from the power plants that supply the additional electricity demand.

The Scenario Analysis Tool uses simple calculator-style methodologies that do not lend themselves to introduction of a new energy resource (electricity) into a specific sector (transportation) through replacement. This means that scenarios that feature large penetration of EVs into the vehicle market may underestimate the gross emissions inventory. We find this bias to be acceptably limited in scope, because CETA is driving the electric emissions factor to zero on a timeline at least as fast as most imaginable forecasts for substantial displacement of conventional vehicles by EVs. Indeed, new emissions from EVs can only impact 2030 target achievement since the 2050 target comes after CETA's 2045 deadline for complete decarbonization.

Mode Shift vs Urban Planning

"Mode shift" is the professional term of art, for getting people out of their cars. Alternatives to cars include buses, trains, bicycles, walking and telecommuting. Mode shift also includes shifting people from driving alone to carpooling. When viewed in isolation, mode shift as a GHG reduction policy is a method for minimizing the emission factors associated with fixed needs for travel.

Urban planning, on the other hand, can reduce travel needs or travel distances to begin with. Besides simply cutting GHGs due to shorter trip lengths, urban planning induces additional mode shifts by more thoroughly mixing use (placing residences closer to workplaces and shopping districts); increasing density; favoring walking & biking ("complete streets"); clustering development around transit trunk lines such as train tracks; and other methods.

It is our professional experience that isolated mode shift programs often require significant costs or subsidies to encourage participation. Urban planning, on the other hand, seems to induce more significant change with little direct financial cost to the responsible government (though there may be indirect costs). Hence, we weight the reductions achievable with the TCMP Assessed Actions package strongly toward 2050 versus 2030, to reflect the slower penetration but higher effectiveness of the urban planning policies included.

Solid Waste & Wastewater Sector

strategy metric	contributing actions	reductions 2030	 2050
solid waste generation	G1.7 social research W4.4 waste audits W4.10 waste less food program	10%	30%
wastewater treatment plants	W1.1 municipal energy efficiency W3.1 nitrous oxide capture	20%	20%

Solid waste (landfilled waste) generation has been strongly targeted by municipal policy for decades. The TCMP Assessed Actions in this sector are relatively indirect and do not have a lot of power to reach beyond the substantial voluntary participation in recycling and composting already occurring. This limits our estimates for impacts in this strategy metric. That said, the bulk of methane generation from typical, municipal solid waste arises from food waste, which is already a primary target of municipal waste diversion programs. We estimate that roughly one-third of the methane commitment associated with Thurston County solid waste still comes from food. Successful, complete diversion of this stream to composting could reduce solid waste emissions at least 30%.

Wastewater treatment plants are receiving substantial design & improvements attention in Thurston County, so we model ambitious reductions in their associated emissions deployed in the near future, but no additional plant improvements after 2030.

Agriculture Sector

strategy metric	contributing actions	reductions 2030	 2050
fertilization of land	A1.2 nutrient management A2.1 regenerative agriculture	20%	50%

Thurston County includes both successful examples of and strong advocacy for progressive farming techniques that can reduce GHG emissions associated with chemical fertilizers. The two proposed actions relating to fertilization of land are likely to be embraced strongly, and will have a receptive audience. Hence we assigned relatively ambitious reductions to this strategy metric.

Land Use and Sequestration

strategy metric	contributing actions	reductions or tCO_2e seq. 2030	2050
sequestration	A5.1 reforestation & afforestation program A6.5 municipally-controlled canopy A6.9 tree canopy preservation G4.3 other emission sources and sinks	153,000 tCO_2e	380,000 tCO_2e

Sequestration is not technically a strategy metric in the Scenario Analysis Tool, but the user dashboard allows input of net sequestration estimates for 2030 and 2050, respectively. We are offering values of 153,000 tCO_2e and 380,000 tCO_2e for the two years, based on afforestation of 8% of Thurston County's land area (about 37,000 acres) and conversion of about 30% of Thurston County's agricultural land from conventional to regenerative agriculture.

Carbon Sequestration in Forests

The sequestration rates for new forest are based on stakeholder committee input, in particular from Dylan Fischer, professor in Forest Ecology at TESC. Prof. Fischer reported the following sequestration rates based on experience with reforestation projects in the Olympia region:

- 4.05 tCO_2/acre-yr averaged over the first ten years of growth;
- 8.65 tCO_2/acre-yr averaged over the first twenty years of growth; and
- 10.18 tCO_2/acre-yr averaged over the first thirty years of growth.

With these values we calculated for 2030: 37,000 acre x 4.05 tCO_2/acre yr = 150,000 tCO_2/yr, and for 2050: 37,000 acre x 10.18 tCO_2/acre yr = 376,000 tCO_2/yr. These are probably slight underestimates since Prof. Fischer provided 10- and 30-year averages of forest growth rates, while forest growth typically only accelerates over that length of time in the maritime Pacific Northwest. The likely underestimate of growth rate provides a margin of comfort around the goal of afforesting 8% of Thurston County's land area, which stretches the limit of what is available.

Carbon Sequestration in Agriculture

Regenerative agriculture enhances soil health by increasing soil organic carbon levels while ensuring appropriate carbon to nitrogen ratios, and increases carbon sequestration by maximizing plant productivity. The sequestration impact of regenerative agriculture is computed against 30% of cropland. The gross quantity of cropland 22,109 acres was based on the USDA 2017 Agricultural Census and verified by stakeholders Pat Rasmussen, Lynn Fitz-Hugh, and Thurston Conservation District staff. 30% of this value is about 6,600 acres.

The rate of soil carbon sequestration through regenerative agriculture is much lower than the rate of aboveground carbon sequestration through forest growth - we used a value of 0.5 tCO_2/acre-yr derived from published literature.[8] 6,600 acre x 0.5 tCO_2/acre yr = 3,300 tCO_2/yr. Published literature does not offer estimates of the duration over which soil carbon sequestration can continue -- eventually, the accumulation will be asymptotic because topsoil cannot simply gain carbon forever. Anecdotes seem to point to a nominal assumption of about twenty years. So, we can expect the 3,300 tCO_2/yr rate to be in decline by the time we get to 2050, but because no quantitative algorithm is available we just assumed it would remain a constant throughout the forecast period. So, the estimate for 2030 can be considered nominal and for 2050 somewhat liberal.

Management of the Urban Tree Canopy

The urban tree canopy was a subject of significant discussion during meetings of the Climate Advisory Workgroup, and the target subject of two of the Assessed Actions. However, the urban tree canopy is not included in Thurston County's GHG inventory, so the Scenario Analysis Tool is unable to quantify the GHG reductions or sequestration achievable by preserving or expanding the urban tree canopy.

Incorporating urban tree canopy management in the Thurston Climate Mitigation Plan would be most successful if including all of the following steps:

- Add urban trees inventoried by municipal governments to the GHG inventory;
- Add all land to the GHG inventory, to prevent biomass inventory leakage;[9]
- Design and implement a mechanism for tracking tree loss associated with new developments on forested land;
- Design strong policies achieving Assessed Actions A5.1 *reforestation & afforestation program*, A6.5 *municipally-controlled canopy*, and A6.9 *tree canopy preservation*.

[8] Tristram O West and Gregg Marland, "A Synthesis of Carbon Sequestration, Carbon Emissions, and Net Carbon Flux in Agriculture: Comparing Tillage Practices in the United States," *Agriculture, Ecosystems & Environment* 91, no. 1–3 (September 2002): 217–32, https://doi.org/10.1016/S0167-8809(01)00233-X.

[9] Biomass inventory leakage results when, for example, the GHG inventory includes only trees counted in incorporated municipalities. If a municipality inside the inventory boundary tightens restrictions on land clearing, then developers will target less regulated land in unincorporated Thurston county, and the more rural land clearing will escape detection by the inventory. Of course, leakage can occur outside the county boundaries as well, a phenomenon largely outside of the TCMP's control.

Because the urban tree canopy hast not been inventoried, we do not know if it is currently an emissions sink or source. If it is a sink or near-zero source, then ambitious implementation of these steps could contribute additional sequestration beyond that computed for afforestation above.

Other Venues for Sequestration

Though not included among the 71 Assessed Actions, there are at least two other potential venues for carbon sequestration in natural systems: prairies, and the Puget Sound. Well-managed prairie ecosystems can sequester carbon in grass rootstock, and eventually in soil carbon. Prairie management for carbon could go hand-in-hand with existing programs for habitat conservation. In the Puget Sound, kelp or other aquatic, herbaceous species show potential for contributing meaningful carbon sequestration. These and other natural resources can contribute additional sequestration if it is needed to meet the GHG targets.

Action Performance Risk

The 71 Assessed Actions vary greatly in their ability to induce GHG reductions. Many are indirect actions, performing the function of enabling other, direct GHG reductions. A few examples of enabling actions are:

> **B5.8 Solar-Ready** - Amend local development code to require solar-ready construction for all building types.
>
> **G1.7 Social Research** - Work with higher education institutions to research effective behavior change through marketing and educate. Use this information in developing campaigns to reduce high emissions GHGs.
>
> **T3.1 EV Parking New Construction** - Require large commercial and residential buildings to dedicate a percentage of parking spots for electric vehicle charging.
>
> **T5.13 Telecommuting Infrastructure** - Develop grants and provide financial resources for installation of infrastructure necessary to support telecommuting.

Enabling actions are an important part of a healthy, integrated climate action plan that lays a comprehensive groundwork for change. In fact, this is a core reason for the assessment of policy bundles when assigning strategy metrics in the Scenario Analysis Tool, rather than individual policies.

Four of the 71 Assessed Actions offer social benefits, but run some risk of returning minor emissions benefits if not interpreted or managed properly::

> **G4.4 vulnerable populations** - Develop a data and monitoring mechanism that is specific to marginalized groups and their needs related to climate change and climate reality (e.g., access to transportation, access to A/C, proximity to cooling centers) and develop a plan to address these vulnerabilities with solutions that help reduce GHG emissions.
>
> Planning around vulnerable populations does not *per se* reduce GHG emissions. Rather than casting this intention as an action, it might be more effective to elevate it to a core or underlying principle of the TCMP.

T4.3 rural transit - Identify and implement first/last mile solutions for rural ridership (engage rural home owners associations for representation and feedback). Present this plan to TRPC with direction to explore pilot programs and secure funding sources.

Large mass transit vehicles operating with only a few riders can emit more GHGs per passenger-mile than single-occupancy passenger vehicles.[10] Rural transit can be an enabling action underlying transit expansion generally, but air emissions modeling should first ensure that GHG reductions in the denser parts of the transit network counterbalance potential increases in rural areas.

W2.2 water audits - Conduct water audits of city and county facilities to determine prioritization of capital improvements.

GHG emissions of water use are negligible.

W6.6 supply chain - Provide free technical assistance to local businesses in reducing the carbon intensity of their supply chains.

Upstream GHG emissions due to product manufacture and transport are substantial, but occur outside Thurston County, and outside the Thurston County GHG inventory. Folding the supply chain into the TCMP would be an appropriate way to expand climate stewardship, but requires an expansion of project scope considerably beyond what was undertaken in the current process.

Finally, there are four Assessed Actions that are proper enabling actions, but that are not treated in the above analysis because they apply equally, or nearly equally, to all sectors and actions:

G4.1 emissions inventory - Prepare and publish an annual emissions inventory that tracks greenhouse gas emissions by jurisdiction and source category. Review and update emissions inventory methodology as necessary to address improvements to data or methodologies, improve consistency, incorporate changes to state or federal policies, or report on issues of local interest.

G4.2 performance measures - Develop community GHG reduction goals and performance measures. Regularly update and publicize for community to track their progress.

G4.6 social cost of carbon - Develop and adopt policies that require the use of a "social cost of carbon measure" in zoning, development, construction, and transportation decisions.

G5.5 legislative agenda - Prioritize combating climate change in the municipality's legislative agenda each year. Instruct municipal lobbyist to track and report on climate bills, and to advocate for those bills that will help reduce local emissions. Work with other cities to add this to the AWC priorities.

Result

Implementing all estimated strategy metric reductions described in the previous sections produces final Scenario Analysis Tool output as shown in Figure 3.

[10] This problem is compounded by "dead-heading," driving an empty transit vehicle to or from a rural route's endpoint.

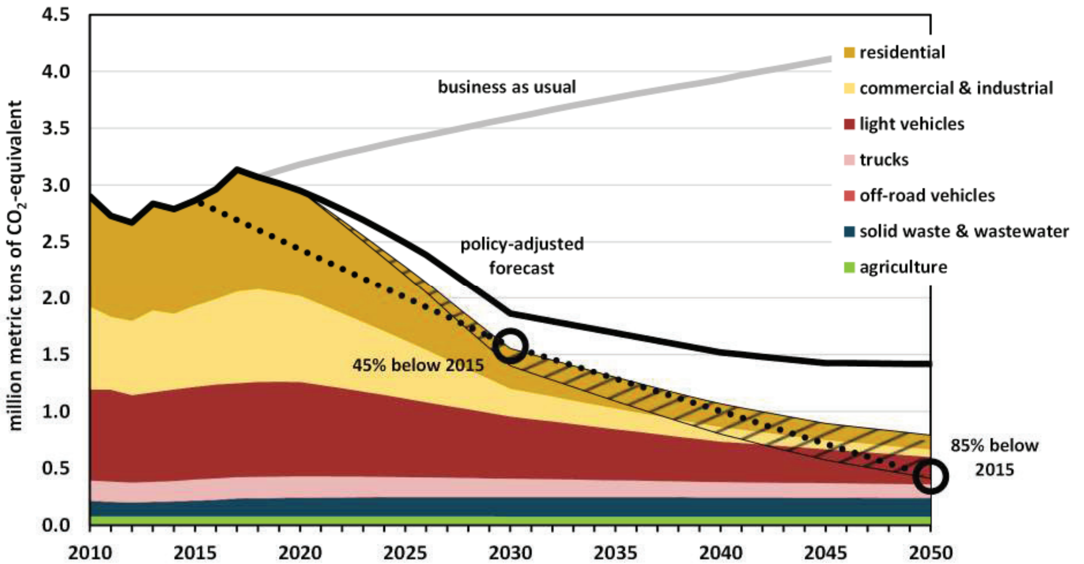

Figure 3 – Scenario Analysis Tool output under the Case Study assumptions and reduction estimates.

The impacts of state, federal and TCMP policies can also be visualized as reductions (rather than the resulting, absolute emissions), per Figure 4.

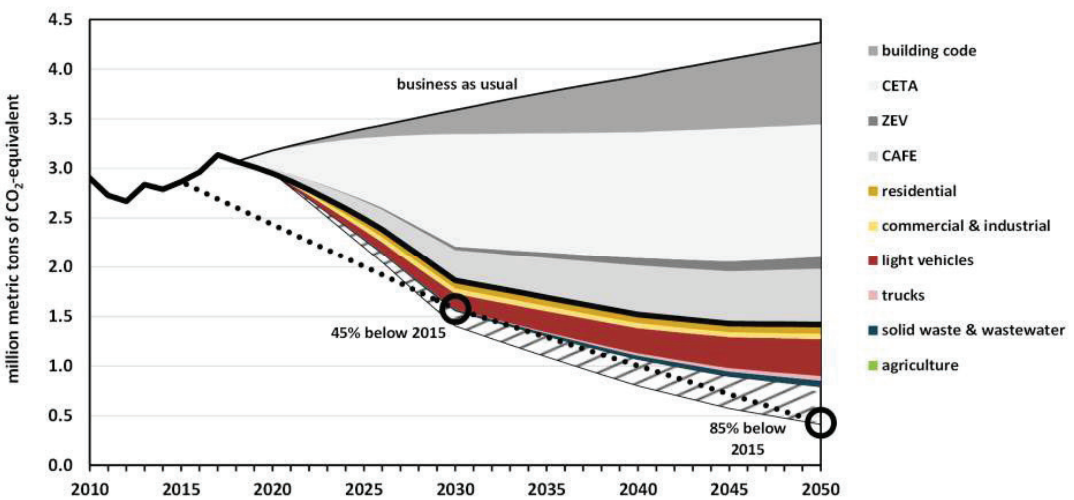

Figure 4 – GHG reductions caused by federal and state (grey-shaded) and TCMP (colors) policies. The cross-hatched area is additional reduction associated with sequestration in forest and soils.

It is clear from Figure 4 that that CETA plays a critical role in achieving the 2030 target, by bringing the policy-adjusted forecast strongly downward. For both target years, state (building code, CETA and ZEV) and federal (CAFE) policies play a significant role in suppressing emissions far enough that the TCMP strategies can bridge the difference to the TCMP targets.

Target achievement requires not just aggressive GHG reduction, but also aggressive sequestration. The gross emissions (the top of the stack of solid-colored areas) exceeds the 2050 target; sequestration is represented by the cross-hatched overlay, and the net emissions appear as the lower edge of the cross-hatched overlay. This lower edge passes through or below the centers of both target circles, as desired. The results are presented numerically in Figure 5.

emissions results, million tCO_2e			
	2015	2030	2050
BAU	2.87	3.59	4.27
policy-adjusted forecast	2.87	1.86	1.42
scenario gross emissions	2.87	1.56	0.79
scenario net emissions	2.87	1.40	0.41
targets		1.58	0.43

Figure 5 – Scenario Analysis Tool output under the Case Study assumptions and reduction estimates.

These results represent only one scenario for achieving the targets. The Scenario Analysis Tool is designed to be transparent and accessible, so that TCMP partners can model alternative scenarios that may be more achievable in the political, economic and physical contexts of Thurston County and its communities. We encourage the project partners to experiment with the tool and find the best path forward to achieving their GHG reduction goals.

Respectfully submitted,

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