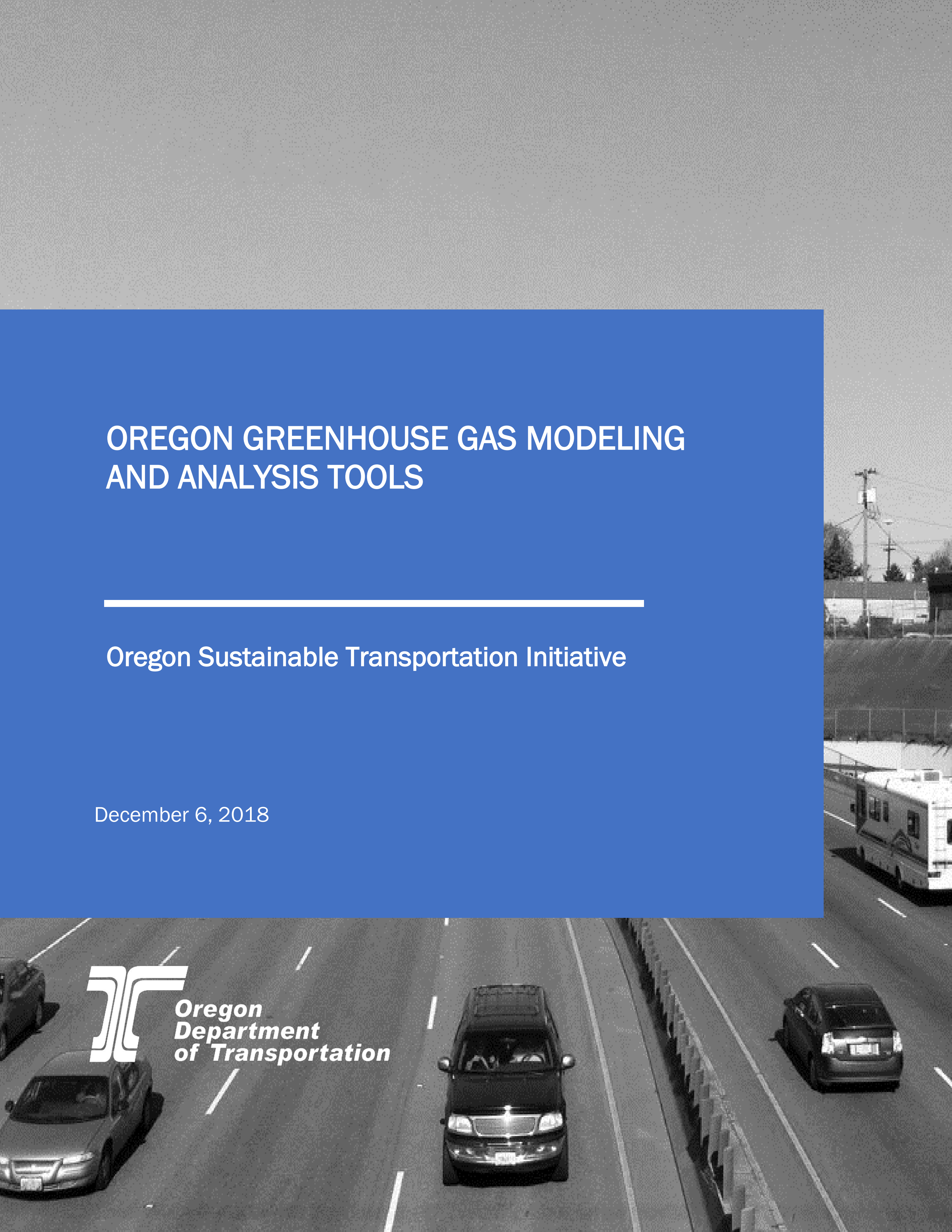

OREGON GREENHOUSE GAS MODELING AND ANALYSIS TOOLS

Oregon Sustainable Transportation Initiative

December 6, 2018

Oregon
Department
of Transportation

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AAMPO	Albany Area Metropolitan Planning Organization
ABM	Activity-Based Travel Demand Model
ADOPT	Automotive Deployment Options Projection Tool
AFLEET	Alternative Fuel Life-Cycle Environmental and Economic Transportation
AGSE	Airport Ground Support Equipment
APM	ODOT's Analysis Procedures Manual
AV	Autonomous Vehicle
CAA	Clean Air Act
CalEEMod	California Emissions Estimator Model
CAMPO	Corvallis Area Metropolitan Planning Organization
CAPCOA	California Air Pollution Control Officers Association
CARB	California Air Resource Board
CEQ	Council on Environmental Quality
CLMPO	Central Lane Metropolitan Planning Organization
CLSP	Central lane Scenario Planning
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CUTR	Center for Urban Transportation Research, University of South Florida
CWCOG	Cascades West Council of Governments (Staff for AAMPO and CAMPO)
DASH	Dynamic Activity Simulator for Households
DLCD	Department of Land Conservation & Development
DMV	Department of Motor Vehicles
DRAM	Disaggregate Residential Allocation Model
DTA	Dynamic Traffic Assignment
EERPAT	Energy and Emissions Reduction Policy Analysis Tool
EMPAL	Employment Allocation Model
EPA	U.S. Environmental Protection Agency
EV	Electric Vehicle
FASTSim	Future Automotive Systems Technology Simulator
FAZ	Forecast Analysis Zone
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
GHG	Greenhouse Gas

GIS	Geographic Information System
GreenSTEP	Greenhouse Gas Statewide Transportation Emissions Planning Mode l (VisionEval family)
GREET	GHG, Regulated Emissions, and Energy Use in Transportation Model
HB	House Bill
HCM	Highway Capacity Manual
HCS	Highway Capacity Software
HPMS	Highway Performance Monitoring System
ICE	Infrastructure Carbon Estimator
ICLEI	International Council for Local Environmental Initiatives
IDAS	ITS Deployment Analysis System Tool
IPCC	Intergovernmental Panel on Climate Change
ITS	Intelligent Transportation System
JEMnR	Jointly Estimated Model in R Code
LA	Los Angeles, CA
LCDC	Land Conservation & Development Commission
LCOG	Lane Council of Governments
LUSDR	Land Use Scenario DevelopeR model
MA^3T	Market Acceptance of Advanced Automotive Technologies
MOVES	Motor Vehicle Emissions Simulator Model
MPG	Miles per Gallon
MPO	Metropolitan Planning Organization
MRMPO	Middle Rogue Metropolitan Planning Organization
MWVCOG	Mid-Willamette Valley Council of Governments
NHTS	National Household Travel Survey
NO_x	Nitrogen Oxide
N_2O	Nitrous Oxide
NREL	National Renewable Energy Laboratory
ODEQ	Oregon Department of Environmental Quality
ODOE	Oregon Department of Energy
ODOT	Oregon Department of Transportation
OMIP	Oregon Modeling Improvement Program
OMSC	Oregon Modeling Steering Committee
OR-GREET	Oregon Version, Greenhous Gasses, Regulated Emissions, and Energy Use in Transportation Model
OSTI	Oregon Sustainable Transportation Initiative
OSUM	Oregon Small Urban Model
PECAS	Production, Exchange and Consumption Allocation System
PM_{10}, $PM_{2.5}$	Particulate Matter Concentrations
ROI	Return on Investment
RSPM	Regional Strategic Planning Model (VisionEval family)
RTP	Regional Transportation Plan
RVCOG	Rogue Valley Council of Governments (Staff for RVMPO and MRMPO)
RVMPO	Rogue Valley Metropolitan Planning Organization
SB	Senate Bill
SIP	State Implementation Plan for Air Quality Conformity

SO_x	Sulfur Oxide
SWIM1	ODOT Statewide Integrated Model (1st generation)
SWIM2	Oregon's Statewide Integrated Model (2nd generation)
STS	Oregon Statewide Transportation Strategy
TDM	Transportation Demand Management
TEAM	Travel Efficiency Assessment Method
TEEMP	Transport Emissions Evaluation Models for Projects
TLUMIP	Transportation and Land Use Model Integration Project
TOPS-BC	Tool for Operations Benefit Cost Analysis
TPAU	ODOT Transportation Planning and Analysis Unit
TRIMMS™	Trip Reduction Impacts of Mobility Management Strategies
TSM	Traffic Simulation Models
TSP	Transportation System Plan
UGB	Urban Growth Boundary
USDOT	United States Department of Transportation
VisionEval	Family of national strategic planning models built from GreenSTEP
VOC	Volatile Organic Compound
VMT	Vehicle Miles Traveled

EXECUTIVE SUMMARY

Reducing the production and impacts of greenhouse gas (GHG) has been a priority in Oregon for many years. In 2010, the legislature called upon the Oregon Department of Transportation (ODOT), in collaboration with the Oregon Department of Land Conservation and Development (DLCD), to help identify ways to reduce GHG emissions from transportation sources. The Oregon Sustainable Transportation Initiative (OSTI) was created in response to this legislation, bringing in additional agency partners such as the Oregon Department of Environmental Quality (ODEQ) and the Oregon Department of Energy (ODOE).

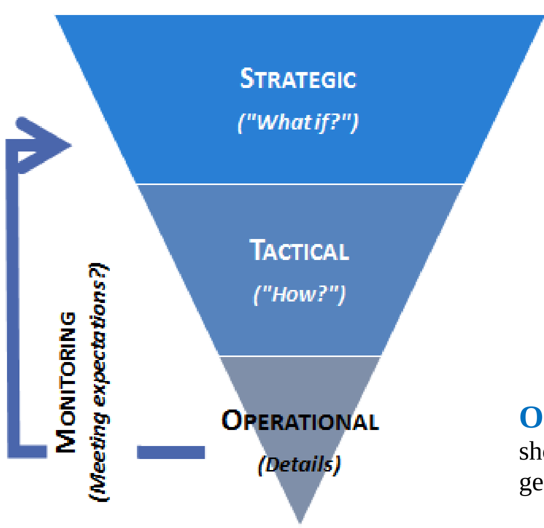
ODOT's leadership in the ability to forecast and analyze the effects of governmental policies and actions on GHG has been foundational to this work. Analyzing the potential effects of broad transportation policy changes on future GHG, including resilience to changing transportation options and pricing, is very different from examining the GHG effects of physical changes to transportation system. This document describes the spectrum of GHG analysis areas that may be of interest to state and local policymakers and explains ODOT's current analysis capabilities across that spectrum.

Current analysis tools are best suited for high-level policy analysis, rather than assessing the impact of a single transportation improvement project on GHG. Also, while tools and methods exist to forecast future GHG production, it is currently difficult to precisely measure it after the fact.

Spectrum of Analysis Needs

ODOT and its regional and local partners have GHG analysis needs that may range from very broad to very focused, covering both long- and short-term horizons. The figure below provides suggested terminology to describe these different analysis needs.

MONITORING involves measuring the actual impact of strategic, tactical or operational decisions. Work in this category includes collecting, managing and reporting measured data.



STRATEGIC LEVEL ANALYSIS explores the potential effects of major paradigm shifts and broad policy changes by evaluating many futures.

ANALYSIS AT THE TACTICAL LEVEL helps to assess the impact of potential investment programs at the statewide or regional level.

OPERATIONAL ANALYSIS helps with short-term decisions in more narrowly-focused geographic areas.

At the **strategic** level, decisionmakers may be interested in exploring "what if" scenarios to help with long-term visioning, policy making, or resilience planning related to GHG. Using strategic-level analysis, decisionmakers can examine many different scenarios (combinations of governmental policies and external factors) to determine the GHG levels that could be expected under each scenario. Policies and other broad agency actions can then be aligned to help achieve a desired future scenario.

Analysis at the **tactical** level helps decisionmakers work out how best to implement funding under a single future scenario. For tactical analysis, a specific land use pattern, a single set of economic assumptions, assumed fuel prices, and other assumptions are fixed rather than variable. Analysis at the tactical level may flow from previous work at the strategic level, and the goal of tactical analysis is often to optimize transportation system performance and GHG benefits under a single strategic scenario.

For projects related to traffic control systems or conditions of chronic congestion, understanding the full GHG impact may require a more focused and detailed analysis. Work to respond to inquiries at this level would be considered **operational** analyses.

Reporting and monitoring work may also be needed to help gauge the effectiveness of decisions made and actions taken at the strategic, tactical or operational level. Rather than predictive analysis, monitoring work involves analyzing and drawing conclusions based on actual observed data and information. Monitoring provides a feedback loop that can be used to alter long term plans (strategic) as well as specific projects (tactical and operational), scenarios and analysis assumptions.

Current GHG Analysis Tools: Capabilities and Limitations

Oregon has multiple transportation modeling and analysis tools available to assist with statewide, regional and local transportation system analysis. Many of these tools are used for multi-faceted analysis, including but not limited to GHG estimation and forecasting. These tools do not provide direct solutions, but they can provide essential information for sound decision-making.

While Oregon has some of the best transportation analysis tools available nationwide, there is no single tool capable of providing GHG assessment at every analysis level. Selection of the correct tool or tools depends on the types of policies, actions and trends that need to be evaluated, and the level of detail desired. Analysis tools and processes are often combined for GHG analysis.

Strategic Planning Tools

ODOT participates in a national partnership known as VisionEval[1], for the development of strategic planning models. The VisionEval suite of analysis tools includes ODOT's

[1] VisionEval is a national initiative to develop an open source programming framework for disaggregate strategic planning models. This work is supported by a multi-agency partnership that includes ODOT. For more information, see https://gregorbj.github.io/VisionEval/.

model for GHG forecasting at the statewide level, as well as a regional version of VisionEval that can be applied at the MPO level.

VisionEval tools were originally developed in response to an Oregon legislative requirement for GHG analysis; however, VisionEval tools are also sensitive to and can evaluate many other community livability indicators and risk of factors, many of which may be beyond the control of state and local transportation agencies. For example, population and employment growth, housing costs, income growth, fuel price, vehicle ownership and insurance costs. VisionEval allows analysis of broad policy actions in traditional planning areas such as land use density, public transportation, parking costs, and non-motorized travel, as well as analysis of emerging paradigms such as eco-driving, car-sharing, and travel demand management programs.

VisionEval simulates travel activity at the household level, so that decisionmakers can understand the effects of specific household travel behavior and vehicle choice on GHG. The relationship between cost and pricing factors and household travel choices can also be examined, and commercial fleet emissions can also be evaluated.

While VisionEval tools have significant capabilities, they emphasize breadth and rapid computation over detail. Instead of a highly accurate single future, hundreds of scenarios can be analyzed quickly, to explore tradeoffs and risks to help set policy direction.

In addition to VisionEval, land use sketch planning tools have also been used in Oregon to support the GHG scenario planning process. These are excellent tools for outreach and educational activities, such as public workshops. Land use sketch planning tools focus on how different land use patterns compare to one another on a variety of measures and can often include rough GHG estimates. The resulting land use patterns can provide land use scenarios for use in strategic or tactical models.

GHG production can be significantly influenced by factors that are beyond the control of state and local governments. For example, population growth, which is a major driver of increasing GHG, cannot always be predicted with precise accuracy over long timeframes. And, strategies that may offer significant potential for reducing future GHG, such as advances in new vehicle and fuel technologies, can be more directly tied to federal regulation and market forces than actions at the state and local government level. Although state and local governments may have limited influence over these factors, the ability to understand and the risks of alternative futures is nonetheless valuable and is a beneficial aspect of strategic planning models.

VisionEval and land use sketch planning tools are designed to test numerous policy scenarios quickly, making them useful tools for assisting with visioning and goal setting exercises. However, these high-level tools do not model travel conditions on the actual transportation network. Where an estimation or forecast of actual trips on the transportation network is desired, the use of tactical analysis tools, such as travel demand models, is required.

Tactical Analysis Tools

Oregon's flagship **Statewide Integrated Model (SWIM)** is a powerful analysis tool that can evaluate the effects of statewide policy actions related to GHG. SWIM simulates regional and statewide activities for land use, transportation and economic interactions. The model forecasts travel characteristics, including intercity and rural travel, which are needed for comprehensive GHG analysis. Travel information from SWIM must be combined with vehicle and fuel data to estimate GHG production.

MPO Travel demand models are used to forecast travel patterns (auto, walk, bike and transit) on the transportation system. In Oregon, ODOT provides travel demand models for the metropolitan areas of Corvallis, Albany, Grants Pass, Rogue Valley, and Bend. Larger metropolitan areas, including Portland Metro, Lane Council of Governments in Eugene, and the Mid-Willamette Valley Council of Governments in Salem, each manage their own travel demand models.

Supplemented by other tools, travel demand models can help to evaluate a range of potential policies and actions related to GHG. Travel demand models (including SWIM) do not directly estimate or analyze GHG. However, by predicting how and where multi-modal trips will occur on the transportation network, travel demand models can predict travel times, speeds, vehicle miles traveled and other information that can be used with other analysis tools to estimate GHG.

The EPA's **Motor Vehicle Emissions Simulator (MOVES)** is designed to work in concert with travel demand models, to help estimate air quality effects of planned transportation investments. MOVES is not a stand-alone GHG analysis tool. It receives speed and volume of travel data from other tools to estimate GHG production.

Land use forecasting models are used with other strategic or tactical tools to provide insight on how land use patterns and the transportation network affect each other, thereby helping to improve GHG estimates prepared by other tools.

Each of these tactical-level analysis tools has various capabilities for estimating how travel and transportation systems are likely to respond to changes in land use, population, employment, new transportation facilities and transit service. Oregon's tactical tools were not originally developed for GHG estimation or prediction, but nonetheless provide useful outputs and insights for GHG analysis. A limitation with GHG analysis at the tactical level, however, is that many because of the long run times, future assumptions are typically fixed so the ability to factor in future uncertainties is limited. Also, most tactical tools require significant staff time and resources to set up and run an individual scenario, making them less practical than strategic-level tools for evaluating multiple future scenarios or policy combinations.

Operational Analysis Tools

Tools for operational analysis primarily include traffic simulation software for analyzing signal timing, roadway design features, travel times, vehicle throughput, chronic congestion impacts and other localized effects. These tools capture emissions due to crashes and other non-reoccurring congestion, which are not typically covered in travel demand models. While GHG production may be output directly from operational tools, these outputs have not been validated to Oregon vehicle and fuel policies. Additionally, due to their significant detail, operational tools are typically configured to have a narrow geographic focus, so any offsetting GHG benefits or impacts that might occur elsewhere on the transportation system are not considered. At the operational level, therefore, it is not currently possible to forecast the true effects of a single project on GHG. Adding GHG estimation capabilities to operational analysis tools would require a significant investment of resources.

Monitoring Capabilities

Measuring GHG directly is not currently possible and there are few accepted proxy measures. So, monitoring the effectiveness of governmental policies and actions often requires an indirect approach.

Consistently formatted local, regional and statewide data that may be helpful for gauging GHG levels is exceedingly limited. Fuel sales information is often suggested as a ready data set for GHG monitoring; however, currently fuel sales data are only available at the statewide level and for select cities that have local fuel taxes. Also, traits such as average per-person miles, vehicle mix, and fuel mix can vary significantly from region to region. Sub-state apportioning of fuel sales data, or even odometer readings for accurate use of sub-state DMV data, is therefore not a simple matter, since localized differences in volume of travel and fleet conditions would need to be factored in.

Ability of Tools to Address Actions and Programs

While the national VisionEval partnership has helped frame and guide GHG analysis at the strategic level, currently there are no accepted standard analytical guidance for GHG estimation at tactical and operational analysis levels[2]. It may be possible to add GHG estimation capabilities at all levels of analysis; however, a large investment of public resources would be required to refine existing tools for this purpose.

Some third-party tools are under development by private industry that have the potential to help monitor travel time, speeds, bicycling and transit use data. These emerging tools may someday help to improve GHG monitoring as well as improve analysis capabilities at all levels.

In the meantime, ODOT leverages the capabilities of existing tools to evaluate the potential effects of GHG policies and programs by combining tools that may individually provide a partial picture. At the strategic level, many policy-level questions about GHG can be fully addressed by existing tools. For more detailed analyses, however, only a

[2] Current air quality conformity models are designed with a different purpose and focus.

partial answer may be feasible at this time and achieving even a partial picture may require assembling pieces from multiple tools.

The table below lists sample topics and potential activities related to GHG that may be relevant to Oregon policymakers. For each, an indication of whether the topic can be addressed, or only partially addressed at this time is provided.

Table 1. GHG Analysis Capabilities in Oregon

Key to GHG Analysis Levels

STRATEGIC: Long-term visioning, high-level policy and planning analysis. (Less detail, many scenarios.) *Example: MPO GHG Strategies.*

TACTICAL: Assessing the impacts of potential investment programs at the statewide or regional level. (More detail, fewer scenarios) *Example: MPO Regional Transportation Plans.*

OPERATIONAL: Decision-making in more narrowly focused areas especially with chronic congestion. (Greatest detail, fewest scenarios.) *Example: Project-Level Traffic Analysis.*

MONITORING[3]: Collecting, managing and reporting measured data to assess the actual impact of decisions.

Topic Can be:
● Addressed[4]
◐ Partially Addressed

Level of Effort Required for Analysis[5]
$ Low
$$ Med
$$$ High

Notes

There are many complexities associated with tool capabilities. Ratings indicated in this table are a general assessment only.

National tools with potential applicability are noted with bold italics. Refer to Appendix B.

GHG Topic, Strategy or Question↓	Strategic Level	Tactical Level	Operational Level	Strategic Analysis	Tactical Analysis	Operational Analysis	Notes
VEHICLE AND ENGINE TECHNOLOGY ADVANCEMENTS							
Vehicle Age Programs (Programs that accelerate vehicle turnover)	●	◐		***$***	***$***		
Vehicle Type Programs	●	◐		***$***	***$***		
Fleet Eco-Driving Programs	●			***$***			
Vehicle Stop-Start Technology (limit idling)	◐		◐	***$***			Could estimate using factors while awaiting tool development
Automated/Connected Light Duty Vehicles	◐	◐	◐	***$$***	***$$$***	***$$$***	Significant model development is needed

[3] ***No specific tools have yet been designed for GHG monitoring, although models at the strategic and tactical level may be helpful in the monitoring process.***
[4] ***A green dot indicates the topic may be addressed with level-appropriate accuracy using best available tools. For example, a green dot in the Strategic Level column represents less detail and accuracy than a green dot in the Tactical Level column.***
[5] ***Level of effort indicated is for analysis effort only and does not include the initial model development and implementation effort.***

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GHG Topic, Strategy or Question↓	Topic Can be: Strategic Level	Topic Can be: Tactical Level	Topic Can be: Operational Level	Level of Effort: Strategic Analysis	Level of Effort: Tactical Analysis	Level of Effort: Operational Analysis	Notes ***There are many complexities associated with tool capabilities. Ratings indicated in this table are a general assessment only.*** ***National tools with potential applicability are noted with bold italics. Refer to Appendix B.***
Automated/Connected/Platooned Trucks	◖	◖	◖	$$$	$$$	$$$	Significant model development would be needed or ***ERRPAT*** (a national VisionEval tool) could be applied
FUEL TECHNOLOGY ADVANCEMENTS							
Vehicle Fuel Efficiency Options (Hypermiling, Low Roll Tires)	◖			$			Could estimate using factors while awaiting tool development
Fuel Mix (by fuel type) /Clean Fuels Program	●	◖		$	$$$		Tactical tools would require significant development. ***OR-GREET*** 2.0 is available to analyze this topic at a statewide level.
Change in Transit Fuel Types (CNG versus Diesel versus Electric)	●	●		$	$$		
ENHANCED SYSTEM AND OPERATIONS PERFORMANCE							
Ramp Metering	●	●	◖	$	$$	$$$	
Variable Message Signs, Variable Speed Limits	◖	◖	◖	$$$	$$$	$$$	
Transport Management Center				$$	$$$	$$$	High-level assessment only - ***TOPS-BC***
Traffic Signal Coordination	●	◖	◖	$	$$	$$$	
Incident Response Management	●	◖	◖	$	$$	$$$	
Road Weather Management				$$$	$$$	$$$	***TOPS-BC/IDAS*** could provide some info

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GHG Topic, Strategy or Question↓	Strategic Level	Tactical Level	Operational Level	Strategic Analysis	Tactical Analysis	Operational Analysis	Notes
Traveler Information/511 Systems		◐	◐		*$$*	*$$$*	
Reduce Speed Limit		●	◐		*$*	*$$$*	
Yield signs / Roundabouts		◐	◐		*$$$*	*$$$*	
Pavement Roughness					*$*		Analysis at the tactical level could be a simple factoring method.
High Occupancy Vehicle Lanes		●	◐		*$$*	*$$*	
Latent Demand	◐	●		*$*	*$*		
TRANSPORTATION OPTIONS							
Bus Only/Preference Vehicle Lanes		●	◐		*$$$*	*$$$*	
Decrease Transit Fares / Fare subsidies		●			*$*		
Changes to Transit Service	◐	●	◐	*$*	*$$*	*$$$*	Microsimulation would be detailed and costly
Change in Transit Vehicle Types (Rail versus Bus)	●	●		*$*	*$$*		
Discount Transit Passes		◐			*$$*		ABMs would have more functionality than traditional trip-based travel demand models
Intercity Transit Service		●			*$$$*		Capability for statewide analysis only at this time.

<u>**Key to GHG Analysis Levels**</u> **STRATEGIC:** Long-term visioning, high-level policy and planning analysis. (Less detail, many scenarios.) *Example: MPO GHG Strategies.* **TACTICAL:** Assessing the impacts of potential investment programs at the statewide or regional level. (More detail, fewer scenarios) *Example: MPO Regional Transportation Plans.* **OPERATIONAL:** Decision-making in more narrowly focused areas especially with chronic congestion. (Greatest detail, fewest scenarios.) *Example: Project-Level Traffic Analysis.* **MONITORING[3]:** Collecting, managing and reporting measured data to assess the actual impact of decisions.	**Topic Can be:** ● Addressed[4] ◖ Partially Addressed			**Level of Effort Required for Analysis[5]** ***$*** Low ***$$*** Med ***$$$*** High			**Notes** ***There are many complexities associated with tool capabilities. Ratings indicated in this table are a general assessment only.*** ***National tools with potential applicability are noted with bold italics. Refer to Appendix B.***
GHG Topic, Strategy or Question↓	**Strategic Level**	**Tactical Level**	**Operational Level**	**Strategic Analysis**	**Tactical Analysis**	**Operational Analysis**	
Increase Park-and-Ride		●			***$$***		
Transit Priority		◖	◖		***$$$***	***$$$***	
Qualitative Upgrades to Transit Service		◖			***$$$***		Need transit survey data
Pedestrian Improvements	◖	◖			***$***		ABM or pedestrian-specific model required
Bicycle Improvements	◖	●		***$***	***$***		ABM or bike-specific model required
Bike Share	◖			***$***			VisionEval offers a high-level mode shift assessment
Personal Light Vehicles (e.g. e-bikes, e-scooters)	◖	◖		***$***	***$$***		
Traffic Management Agencies				***$***			High-level assessment only, possibly using ***IDAS***
Last Mile/Mobility Hubs		◖			***$$$***		Further ABM development is needed
Vanpools / Shuttles	◖			***$$$***			***RPAT*** functionality could be used
Car-Sharing (Station or 1-Way)	◖	◖		***$$$***	***$$$***		
Car Service (Driver or Driverless)	●	◖		***$***	***$$$***		Further ABM development required
Personal Vehicle Eco-Driving Programs	●			***$***			
Telecommuting		●			***$$***		ABM allows for testing
Home, Work-Based Demand Management Programs	●	◖		***$***	***$$$***		Further ABM development required

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EFFICIENT LAND USE							
Density / UGB Management	●	●		*$*	*$$*		
Infill Development	●	●		*$*	*$$*		
Mixed Use/Transit-Oriented-Development	●	●		*$*	*$$*		
Access Management	◖	●	◖	*$*	*$*	*$$*	
PRICING AND FUNDING MECHANISMS							
Traditional Toll Roads		●			*$$*		
Managed/High Occupancy Lanes		◖	◖		*$$$*	*$$$*	
Parking Pricing Policies	●	●		*$*	*$$*		
Employer Cash-Out Programs	●	◖		*$*	*$$*		Only ABM travel demand models have some analysis capability at the tactical level.
Parking Management (example – 2-hour limit)		◖			*$$*		
Cordon/Area Pricing		●			*$$*		
Congestion Pricing	●	●		*$*	*$$*		
Carbon Pricing / Fuel Tax	●	●		*$*	*$$*		

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							There are many complexities associated with tool capabilities. Ratings indicated in this table are a general assessment only. ***National tools with potential applicability are noted with bold italics. Refer to Appendix B.***
Emissions-Based Fees	●	●		*$*	*$$*		
Vehicle Miles Travelled Fee	●	●		*$*	*$$*		
Pay-As-You-Drive Insurance	●	◖		*$*	*$$*		Only ABM travel demand models have some analysis capability at the tactical level.
Household Travel Costs Feedback on Travel	●	◖		*$*	*$$*		Only strategic tools take vehicle types into account to evaluate household travel costs.
MULTI-MODAL FREIGHT							
Light and Heavy-Duty Truck GHG	●	◖		*$*	*$$*		Metro's freight model may have applicability
Commodity Flow (import/exports)		◖			*$$$*		***EERPAT*** or Metro's freight model may be applicable
Rail/Freight Improvements		◖			*$$$*		***EERPAT*** or Metro's freight model may be applicable
Marine Improvements		◖			*$$$*		***EERPAT*** or Metro's freight model may be applicable
Overweight Load Permits		◖			*$$$*		Metro's freight model may be applicable
Weigh-in-Motion Screening		◖			*$$$*		***IDAS*** may be applicable

Key to GHG Analysis Levels

STRATEGIC: Long-term visioning, high-level policy and planning analysis. (Less detail, many scenarios.) *Example: MPO GHG Strategies.*

TACTICAL: Assessing the impacts of potential investment programs at the statewide or regional level. (More detail, fewer scenarios) *Example: MPO Regional Transportation Plans.*

OPERATIONAL: Decision-making in more narrowly focused areas especially with chronic congestion. (Greatest detail, fewest scenarios.) *Example: Project-Level Traffic Analysis.*

MONITORING[3]: Collecting, managing and reporting measured data to assess the actual impact of decisions.

Topic Can be: ● Addressed[4] ◖ Partially Addressed

Level of Effort Required for Analysis[5]: *$* Low, *$$* Med, *$$$* High

GHG Topic, Strategy or Question↓	Topic Can be: Strategic Level	Topic Can be: Tactical Level	Topic Can be: Operational Level	Level of Effort: Strategic Analysis	Level of Effort: Tactical Analysis	Level of Effort: Operational Analysis	Notes
							There are many complexities associated with tool capabilities. Ratings indicated in this table are a general assessment only. ***National tools with potential applicability are noted with bold italics. Refer to Appendix B.***
Truck Stop Electrification				***$$$***	***$$$***	***$$$***	MOVES has some capabilities to model crankcase extended idle exhaust (hydrocarbons) and auxiliary power exhaust for long haul combo trucks. This may be helpful for analyzing truck stop electrification.
Truck Only Toll Lanes		●	◖		***$$***	***$$***	

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INTRODUCTION

The State of Oregon has been working to reduce the production and impacts of GHG for most of the 21st century. In 2010, the Oregon Legislature enacted Senate Bill 1059, which called upon the Oregon Department of Transportation (ODOT) to use its modeling and analysis capabilities and to work together with the Department of Land Conservation and Development (DLCD) to reduce GHG emissions from transportation sources. The legislation established the Oregon Sustainability Transportation Initiative (OSTI), which provides a collaborative framework for ODOT and DLCD to accomplish these legislative objectives. Other state agency partners such as the Oregon Department of Environmental Quality (ODEQ) and Oregon Department of Energy (ODOE) have also been participating in OSTI.

Among other things, the 2010 legislation required OSTI to develop a "Modeling and Analysis Toolkit" designed to assist local governments with developing and executing actions and programs to reduce GHG emissions from motor vehicles with a gross vehicle weight rating of 10,000 pounds or less. The first edition of this document was produced in response to the 2010 legislation[6], to outline the capabilities of Oregon's current analysis tools with respect to GHG.

Since 2010, Oregon has continued to move forward on many fronts regarding GHG:

- In 2011, ODOT provided GHG analysis tool support for DLCD's mandated rulemaking process to set GHG reduction targets for the metropolitan areas in Oregon. These targets were reviewed and extended in 2017. OSTI supported target evaluations and scenario planning[7] in four metropolitan regions: Portland, Eugene-Springfield, Corvallis, and Rogue Valley, and several city GHG inventories.

- In 2013, ODOT accepted the Oregon Statewide Transportation Strategy (STS), which "is a state-level scenario planning effort that examines all the aspects of the transportation system, including the movement of people and goods, and identifies a combination of strategies to reduce greenhouse gas, or GHG, emissions. The STS identifies a variety of effective GHG emissions reduction strategies in transportation systems, vehicle and fuel technologies, and urban land use patterns."[8] This effort used a mix of analysis tools.

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[6]Bettinardi, A., GHG Modeling and Analysis Tools Overview. Oregon Department of Transportation, Salem, Oregon:2012.
[7] Oregon Scenario Planning Guidelines, *Resources for Development and Evaluating Alternative Land Use and Transportation Scenarios*, Volume 1.1, August 2017. Oregon Department of Transportation. Retrieved from https://www.oregon.gov/ODOT/Planning/Documents/Oregon-Scenario-Planning-Guidelines.pdf
[8] Statewide Transportation Strategy. *Planning and Technical Guidance*, Oregon Department of Transportation, accessed 8 October 2018, https://www.oregon.gov/ODOT/Planning/Pages/STS.aspx.

- In 2018, ODOT published the STS 2018 Monitoring Report[9]. This report addressed ODOT-led actions within the STS, described additional emissions reduction efforts by the agency, and provided a summary of progress towards achieving the overall STS vision. GHG assessments have also been reported in various ODOT mode and topic plans and supported legislative and state plans.

- In 2018, ODOT also updated its Air Quality Manual to include considerations for greenhouse gas emissions and climate change during the environmental review process for transportation projects.[10]

- To complete this work and to answer anticipated future questions, Oregon has developed a world-class toolset that provides a wealth of information about GHG policies and potential impacts. However, even though Oregon has sophisticated tools that can be used to address transportation-related GHG emissions questions, further advances in the development of the practice are required to fully respond to the State's questions around current and future GHG reduction plans. This includes modifying existing tools and providing adequate resources to deploy and apply them.

This document focuses on Oregon's existing tools and how they can be used to assist in the evaluation of policies, plans, programs and actions relative to GHG emissions reduction. The document also addresses tools currently under development and includes a discussion on next steps to address pending and anticipated modeling and analysis needs. Further, it attempts to provide a simple overview of where the State currently stands in its ability to answer different types of questions around GHG.

It is important to understand that no tool provides "the answer" to the complex issue of GHG emissions reduction, nor can a given tool dictate state or local actions that should be taken. Rather, this document describes a variety of tools that can be used to inform and guide the user as options and scenarios are developed and compared. Different tools will be more appropriate than others depending on level of detail and what policies and trends need to be considered.

Development of Oregon's modeling and analysis tools and data is ongoing. Since expertise to develop and use the tools is limited, significant collaboration and cooperation among local governments and agencies is necessary to use these tools effectively. This is therefore a living document that may be updated as tools and processes evolve.

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[9] Oregon Statewide Transportation Strategy, *A 2050 Vision for Greenhouse Gas Emission Reduction, 2018 Monitoring Report*, April 2018. Oregon Department of Transportation. Retrieved from http://www.oregon.gov/ODOT/Planning/Documents/STS-2018-Monitoring-Report.pdf

[10] Air Quality Manual, Project Level, Version 1.0, October 1, 2018. Oregon Department of Transportation. Retrieved from https://www.oregon.gov/ODOT/GeoEnvironmental/Pages/Air.aspx

This report includes:

- A background on Oregon's collaborative modeling environment;
- A framework for understanding how tools support a lifecycle of planning decisions;
- Various approaches for estimating GHG emissions, and a brief assessment of how well each captures the key drivers of emissions;
- A tool-by-tool overview of individual modeling and analysis tools currently used in Oregon and how they can be used to support GHG decisions;
- A summary of which tool(s) can be used to estimate GHG impacts for different types of analyses; and
- An overview of continued development of tools to address Oregon issues.

Additional information on contributors and reviewers for this report, a discussion of other selected modeling and analysis tools available nationally, and information on GHG target setting and scenario planning activities in Oregon may be found in the Appendix.

Background: Oregon's Transportation Modeling Environment

Since GHG strategies encompass areas of authority across multiple state and local agencies, collaboration between partners is an essential aspect of GHG planning and analysis. Multi-agency vetting of tools, methods, assumptions, and data, with associated guidance for consistency is an important part of this work.

For many years, Oregon has been at the national forefront of transportation modeling and analysis, through a productive collaboration between state and local agencies. In 1994, ODOT embarked upon a comprehensive Oregon Modeling Improvement Program (OMIP) to consider how to meet the many state and federal rules and regulations for transportation planning and analysis. OMIP brings together stakeholders and provides forums for information exchange and development of new ideas. It also identifies new and expanded modeling tools to provide information for efficient and effective decision-making. These tools address many types of interactions that allow analysis of complex relationships of land use, transportation, the environment and the economy.

Modeling tools require staff expertise to develop, use and maintain them. As a result, ODOT and the larger MPOs have become the primary developers and users of these tools. Many modeling tools require data specific to the local area, and collecting, maintaining and entering data can be expensive and time-consuming. There is uneven capability and depth of knowledge across MPO staff and local city staff and many rely on ODOT and the larger MPOs for assistance in defining opportunities and applying the tools. Therefore, using the modeling tools described in this document requires expanded collaboration, cooperation and staff resources from all involved, including ODOT, MPOs and local governments.

Collaboration and cooperation among those involved in model development and application have been key to the success of Oregon's program. The Oregon Modeling Steering Committee (OMSC) was formed in 1996 to provide a forum for interagency input as tools are developed to forecast future transportation conditions. The OMSC's mission is to ensure Oregon continues to have the right tools, skills and expertise needed to answer important questions about Oregon's transportation systems; and the group coordinates the land use-transportation modeling efforts of federal and state agencies and MPOs. OMSC membership includes Oregon and southwestern Washington MPOs, and state and federal agencies involved in land use and transportation modeling. OMSC participants who provided peer review for the development of this document are listed in Appendix A.

Oregon's modeling tools can evaluate many potential GHG reduction scenarios. Further improvements and efficiencies can be realized in the short-term by adjusting and linking existing modeling tools, and this work is currently underway. However, continued investment will be required for a complete evaluation of GHG reduction scenarios. The OMSC provides a forum for assessment, collaboration, development and application of expanded and new tools; it is providing direction for short-term improvements, to identify gaps in GHG evaluation that need to be addressed, and to review the potential for national tools that can be adapted to Oregon.

OREGON'S MODELING & ANALYSIS TOOLS

General Tools Framework

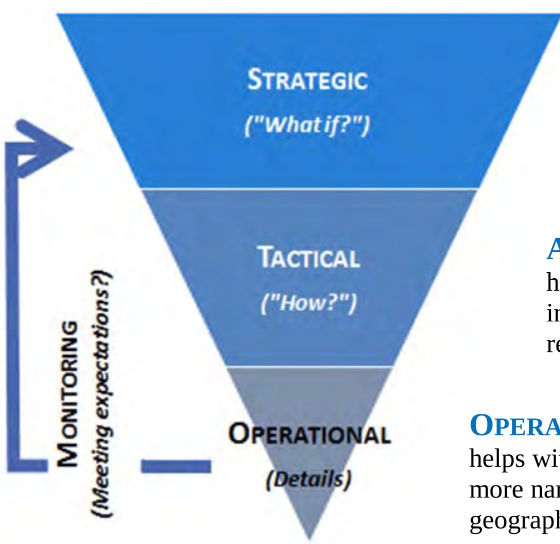
ODOT, MPOs, and local agencies have a suite of transportation and land use modeling and analysis tools available to them. These tools are used when an agency or a community wants to evaluate potential ramifications of policy actions, and to evaluate how a combined set of plans, programs and actions work together to produce a specific result. These tools do not provide direct answers, but rather they inform the decision-making process by testing scenarios to see whether stated policy goals and the desired vision can be achieved.

ODOT's various analysis tools are applicable at different spatial and temporal scales. Policy and program changes must be matched with the appropriate tool, and outcomes must be considered in the context within which they were modeled. For example, a model designed for use at a regional level may not be useful at a neighborhood level, if the mechanisms and relationships embodied within the software are not sufficiently explicit to deal with local variations in the built environment or were designed to represent "average" behavior of large classes of people.

Each level of tool in Oregon's toolkit has different GHG analysis capabilities. While Oregon has some of the best transportation analysis tools available nationwide, there is no single tool capable of providing a GHG assessment at every analysis level. Different tools will be more appropriate than others depending on level of detail desired and policies and trends that need to be considered. Figure 1 provides suggested terminology to describe the different tool purposes and analysis needs.

Figure 1. GHG Analysis Levels

MONITORING involves measuring the actual impact of strategic, tactical or operational decisions. Work in this category includes collecting, managing and reporting measured data.



STRATEGIC LEVEL ANALYSIS explores the potential effects of major paradigm shifts, program level investment, and broad policy changes on alternative futures.

ANALYSIS AT THE TACTICAL LEVEL helps to assess the impact of potential investment programs at the statewide or regional level.

OPERATIONAL ANALYSIS helps with short-term decisions in more narrowly-focused geographic areas.

At the **strategic** level, decision makers may be interested in exploring "what if" scenarios to help with long-term visioning, policy making, or resilience planning related to GHG.

Outside forces can be significant and thus important to include in some stages of analysis to understanding the uncertainty in the effectiveness of GHG reduction actions. For example, fuel price, which is a major driver of increasing GHG, cannot always be predicted with precise accuracy over long timeframes. And, strategies that may offer significant potential for reducing future GHG, such as advances in new vehicle and fuel technologies, are often more directly tied to federal regulation and market forces than actions at the state and local government level. Although state and local governments may have limited influence over these factors, the ability to understand and quantify their effects at a strategic level is valuable.

Using strategic-level analysis, decision makers can examine many different scenarios (combinations of governmental policies and external factors) to determine the GHG levels that could be expected under each scenario. Policies and other broad agency actions can then be aligned to help achieve a desired future scenario; to perform risk and uncertainty analysis as a high-level screening tool which can then better inform "tactical" level analyses.

Analysis at the **tactical** level helps decision makers work out how best to implement actions under a single future scenario. These tools can help refine the thoughts and decisions that were reached during strategic-level analysis. For tactical analysis, a specific land use pattern, a single set of economic assumptions, assumed fuel prices, and other assumptions are typically fixed rather than variable.

For projects related to traffic control systems or conditions of chronic congestion, the full GHG impact may require a more focused and detailed analysis. Work to respond to inquiries at this level would be considered **operational** analyses.

Operational tools provide the ability to evaluate both reoccurring and non-reoccurring congestion; a significant component of GHG production. Non-reoccurring congestion is an aspect of travel that is not currently well represented in transportation models and tools, however operational level analysis is beginning to provide some methodologies for analyzing all the aspects of day-to-day transportation operation, including non-reoccurring congestion, such as weather events, crashes, holiday travel, sporting event congestion, etc.

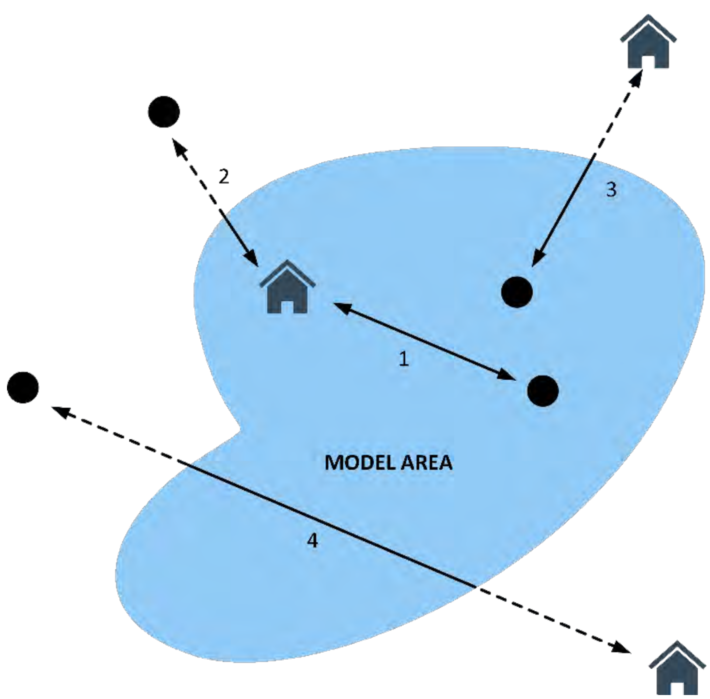
Another type of analysis work that is increasingly requested is **monitoring**, to help gauge the effectiveness of decisions made and actions taken at the strategic, tactical or operational level. Rather than predictive analysis, monitoring work involves analyzing and drawing conclusions based on actual observed data and information over time. Monitoring provides a feedback loop that can help decisionmakers determine whether to alter long term plans (strategic) or specific projects (tactical and operational). Feedback from the monitoring process can also lead to evaluation of new scenarios and reconsideration of analysis assumptions.

Practical Considerations

Oregon legislation and other GHG inventories require calculating GHG as a *household* measure. VisionEval tools allow household GHG estimation at the strategic level; however, GHG accounting at tactical and operational analysis levels is less straightforward.

For example, for MPO planning, Oregon's most powerful tactical analysis tools are MPO travel demand models. These models are designed to analyze the effects of land use and transportation investment decisions on the transportation network inside an MPO planning area. However, many people living outside metropolitan areas travel to destinations inside the MPO boundary, for work, school, recreation, access to services and other reasons. GHG is produced from those external household travel activities that cannot be attributed to households within the MPO area. Similarly, long distance trips made by people traveling through a metropolitan area also contribute to GHG production that cannot be assigned to households within the MPO area. Figure 2 illustrates this issue. Note that there may be multiple jurisdictions included in the model area, that would further complicate the reporting options.

Figure 2. Ability of Travel Demand Models to Estimate Household GHG



1. ***Household travel activities that occur entirely within a model area:*** *GHG from these trips can be estimated.*
2. ***Households inside the model area with travel activities outside the model area:*** *Only the GHG produced from the portion of the trip within the model area can typically be estimated.*
3. ***Households outside the model area with travel activities inside the area:*** *GHG from the portion of the trip inside the model area could be estimated although this GHG is not contributed by households located inside the model area.*
4. ***Households with long-distance travel, or trips with both origins and destinations outside the model area****: GHG from the portion of a through trip that occurs inside the model area could be included in GHG estimates, although this GHG is not contributed by households inside the model area.*

GHG analysis performed beyond a "strategic" level of detail needs to be done with caution and understanding of these limitations. While it may be possible to add GHG estimation capabilities at greater levels of detail, a large investment of public resources would be required to refine existing tools for this purpose.

When monitoring GHG is considered, some third-party tools are under development by private industry that have the potential to efficiently provide observed travel time, speeds, bicycling, and transit use data, and overall a much more detailed and frequent assessment of current day travel behavior. These emerging tools may someday help to improve GHG monitoring, as well as analysis capabilities at all levels. Third-party data may also be useful in developing new proxy measures that can be used to evaluate progress toward GHG goals.

When considering and comparing GHG tools and methodologies, it is also important to keep in mind that there are key differences, both in analytical approach and in how calculations are defined. Some key assumption and definitional differences that occur between tools include:

- The level of detail considered for multiple assumptions and factors that have a significant impact on GHG emissions, such as population shifts, income levels, changes in vehicle operating costs, future fleet technology, land development patterns, and transportation system projects.

- The level of detail considered for modeling travel activity, such as interactions between mode choice, and how travel behaviors changes in response to congestion, travel time, and transit service options.

- The level of system operations detail considered, such as whether models can account for things like ITS deployment, and vehicle powertrain curves.

- The analysis time period considered; peak period, average weekday, annual average day, etc.

- Energy sources considered; carbon fuels only or electricity generation as well.

- How GHG production is defined; just at the tailpipe or the full lifecycle production of GHG to create the energy necessary for transportation.

- Types of vehicles considered; personal, commercial, heavy truck, transit, and/or air.

- How VMT is defined; just commute trips, only trips with both ends in the analysis area, VMT for all trips made by the households in a region on all roads, or the VMT that is estimated on all roads within a given area. Some models may estimate VMT within a discrete model area, but may not adequately capture external trips that begin, end or travel through the model area.

While there can be many definitional differences between tools and methodologies, they are not necessarily difficult to overcome. It is critical, however, that analysts are aware of the differences, so that they can properly compare information produced by different tools operating at different analysis levels.

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INDIVIDUAL TOOLS

Although no single tool by itself provides full evaluation of GHG emissions, Oregon's "core" analysis toolkit addresses the majority of Oregon's current GHG analysis needs. This section describes existing modeling and analysis tools and the types of GHG actions and programs they are designed to address. A focused list of national tools that may be adapted to answer additional questions is available in Appendix B.

For this summary, individual tools have been categorized according to the analysis level (strategic, tactical, operational or monitoring) where they are most often used. Note, however, that the capabilities of some tools can span more than one analysis level.

STRATEGIC TOOLS "*What would it take*"

Strategic models can help with long-term visioning, policymaking, funding, and resilience analysis but sacrifice detail so that many possible future scenarios can be evaluated quickly. Strategic-level tools used in Oregon include the *VisionEval*[11] suite of statewide and regional analysis tools, as well as land use sketch planning software offered by a variety of vendors.

VisionEval

What it does: VisionEval allows for GHG visioning and testing of policy scenarios. It measures a high number of policy interactions by micro-simulating reactions of individual households, primarily using relationships found in the National Household Transportation Survey (NHTS). VisionEval uses simplified relationships to facilitate quick run times to support the needs of policy-level decisions.

Why it is important: VisionEval can comprehensively evaluate sets of GHG strategies, providing measures to help planners and decision-makers assemble programs to achieve the greatest GHG reductions acceptable to policy-makers.

How VisionEval Addresses GHG:

Comprehensively and quickly evaluates sets of GHG strategies and policies, including detailed vehicle, fuel forecasts and operation cost changes relative to household budgets.

Works as a high-level strategic tool, and therefore does not address specific projects.

Background: The VisionEval model was developed by ODOT at the request of Oregon's Global Warming Commission to help analyze programs and policies to reduce transportation sector GHG emissions. A metropolitan version of the VisionEval Tool,

[11] VisionEval is a family of statewide and metropolitan strategic planning tools based on the GreenSTEP model developed by ODOT in 2009 to address scenario planning related to GHG legislative requirements. The family which also includes ODOT's RSPM and federal EERPAT and RPAT tools, is moving to a common software framework (VisionEval), supported by an FHWA-hosted pooled fund partnership.

previously referred to as the Regional Strategic Planning Model (RSPM), has supported scenario planning for several Oregon MPOs.

How it works: VisionEval simulates how the following characteristics could impact GHG emissions from household travel:

- Urban characteristics, such as density, mixed use, public transportation, non-motorized transportation, car sharing, parking management.

- Road characteristics, such as the supply of freeways and other arterials and the management of incident delay and more advanced operations programs deployed on freeways and arterials. An aggregated congestion approach is used which captures reasonable congestion effects and thus models capacity limitations and ITS policies without a network. As the ratio of a metropolitan region's overall VMT demand as compared to lane mile capacity grows, speeds decline and travel is iteratively shifted to balance freeway and arterial speeds.

- Marketing characteristics, such as the deployment of work and home-based travel demand management programs, eco-driving, low-rolling resistance tires, and pay-as-you-drive insurance.

- Vehicle and fuel characteristics, such as fuel economy (including impacts from congestion and eco-driving practices), proportions of plug-in hybrids and electric vehicles, and fuel carbon intensity.

- Vehicle fleet characteristics, such as the proportions of autos and light trucks and the age distribution of vehicles. Also included are the fuel characteristics of commercial vehicles, heavy trucks, and buses. Current assumptions are reviewed by Oregon Departments of Energy and Environmental Quality.

- Prices relative to household budgets, including fuel price, reduced operating costs of high MPG vehicles, fuel taxes, mileage taxes, carbon taxes, and parking fees.

- Factors outside ODOT's control, such as economic health (incomes), population growth, fuel price forecasts.

VisionEval

Advantages:
- Quick results.
- Broad transportation and GHG policy-level analysis.
- Tool consistent with MPO GHG target rule.
- Able to assess many scenarios to identify risk and uncertainty.

Limitations:
- Requires training to run and analyze results.
- Operates at a high level.
- Built from national, not local, data
- Must be linked to other models to evaluate specific roadway or transit projects.

VisionEval links a series of sub-models that forecast outputs, such as vehicle ownership and household daily VMT. The demand side of the model is disaggregated; it includes a synthetic population generator and an auto ownership model. The supply side is handled in an aggregate way: it does not include a detailed transportation infrastructure network, but instead approximates regional congestion effects.

VisionEval addresses the entire state or metropolitan region and is responsive to regional differences. The model distinguishes between households living in various metropolitan place types, as well as other urban and rural areas to reflect their different characteristics in terms of density, urban form, transportation system characteristics, and deployment of household-level programs.

The outputs of the model include fuel consumption by fuel type, electric power consumption by electric vehicles, and CO_2 equivalents for fuel and electric power consumed. Other measures of mobility, household cost, and the environment are also available. VisionEval operates at the individual household level. The treatment of assumptions that determine travel characteristics is simplified, enabling the model to have a high degree of policy sensitivity and interactivity and yet be easy to set up and run quickly.

Works best for: Quick analysis of sets of GHG strategies and policies at a regional or statewide level. This tool was used to develop GHG reduction targets for metropolitan areas in Oregon and is therefore best equipped to calculate GHG outputs comparable to these targets.[12]

Considerations:

- Because VisionEval was developed to analyze statewide transportation planning policy, it estimates detailed location characteristics based on larger area-wide averages. Metropolitan VisionEval applications allow more detailed analysis for several policies at a census-tract level.
- VisionEval does not represent a transportation network and the interactions that occur between land use types. Performing a GHG analysis that is suitable for an MPO Regional Transportation Plan (RTP) or a local agency Transportation System Plan (TSP) requires using a travel demand model in addition to VisionEval.
- VisionEval tools focus primarily on light duty vehicles, both household and commercial vehicles, with simplified accounting of heavy-duty vehicles (trucks and buses) emissions. Heavy freight vehicles are handled more comprehensively

[12] Example calculations for estimating GHG using VisionEval tools can be found in the OSTI Scenario Planning Guidelines Technical Appendices, starting on p.110. https://www.oregon.gov/ODOT/Planning/Documents/Oregon-Scenario-Planning-Guidelines-Tech-Appendix.pdf

in the FHWA’s Energy and Emissions Reduction Policy Analysis Tool (EERPAT) model. Since EERPAT is based on the same modeling approach used in VisionEval, this functionality may be available in future VisionEval upgrades.

- VisionEval is a relatively new model and staff training is required to operate the tool and to conduct output analysis.

- VisionEval is an aspirational tool, meaning that the user can develop a future scenario that may not be practically feasible. An example of this is that a user could run a scenario where Oregon’s vehicle fleet is 100% electric. This scenario may or may not be practical depending on the timeline assumed in that scenario. It’s up to the operator of the tool to ensure that the scenarios developed are helpful to the questions being asked.

Works well with: VisionEval can be used as a stand-alone tool or can be configured to work with travel demand and land use models/tools. Many VisionEval inputs are drawn from more detailed travel demand models and Oregon land use Place Types.[13]

Who runs the tool: ODOT develops, maintains and applies VisionEval at a statewide level. For metropolitan areas, ODOT staff can run a customized regional version of VisionEval to support scenario planning efforts led by MPOs.

For more information:

OSTI Scenario Planning Users Guide:
https://www.oregon.gov/ODOT/Planning/Pages/Strategic-Assessment.aspx

More about VisonEval tools: http://visioneval.org/

Land Use Sketch Planning Tools

What it does: Land use sketch planning software enables stakeholders to test a large range of possible land use scenarios quickly. Sketch planning tools are used to produce general order-of-magnitude estimates of transportation and land use demand and impacts, and to quickly assess and screen land use and transportation scenarios, which can then be fed into travel demand and GHG models.

Why it is important: Land use sketch planning tools facilitate identification and evaluation of a wide variety of options or alternatives, helping planners and policymakers to find alternatives which best meet the purpose and goals of the

How Land Use Sketch Planning Tools Address GHG:

Land Use sketch planning tools focus on how different land use patterns compare to one another on a variety of measures, often including rough GHG estimates; they enable evaluation of many scenarios quickly.

[13] ODOT and DLCD developed Oregon land use Place Types to assist communication of land use plans. For more information see: https://www.oregon.gov/LCD/CLIMATECHANGE/Pages/Place_Types.aspx

project or plan. Further in-depth studies can then be conducted for those alternatives which are most viable.

These tools have been shown to be especially useful for public meetings or workshops, where it is desirable to rapidly evaluate a wide variety of alternatives and receive quick feedback on potential outcomes of the alternatives.

Background: Land use sketch planning tools are used to produce general order-of-magnitude estimates of transportation and land use demand and impacts. These tools are generally less costly and easier to implement than sophisticated engineering analysis software. In Oregon, land use sketch planning software has been used to test and refine transportation plans, produce small-area concept plans and build scenarios. They can provide baseline carbon emissions analysis of different land use patterns and can work in conjunction with the VisionEval suite to evaluate the GHG implications of different land use patterns, or with a travel demand model to estimate traffic on local roadways and forecast traffic patterns.

How it works: Land use sketch planning tools typically employ a design metaphor. An analyst uses a sketch planning tool to "paint" land use types or "draw" multi-modal transportation improvements over the area of interest. The tool then reports various land use and environmental measures, including GHG emissions, based on the designated land use types and infrastructure changes. This process allows stakeholders to quickly compare land use and transportation effects, such as increased walkability.

Often, land use sketch planning tools are spreadsheet-based or geographic information system (GIS)-based techniques that apply similar concepts to aggregated or generalized data. The measures produced by these tools are estimated based on average values and relationships typically obtained from peer-reviewed research.

Land use sketch planning tools are not intended to provide a comprehensive analysis, but rather to give a quick indication of the relative magnitude of effects that might be expected from different land development scenarios and options. Three land use sketch planning tools that Oregon jurisdictions have used in the past recently or that are currently being used in use Oregon are Envision Tomorrow (Fregonese Associates), CommunityViz (City Explained, Inc.), and SPARC with INDEX (Criterion).

Land Use Sketch Planning Tools

Advantages:

- Quick comparison of many scenarios.
- Immediate feedback.
- A standalone tool for GHG assessment.

Limitations:

- Set up requires significant time, resources and data.
- No demographic constraints.
- Building-based factors are applied; these models do not capture transportation and land use interactions.
- Peer review of methods unclear

Works best for: Order-of-magnitude evaluation of many scenarios quickly. Good visualization tools to facilitate public discussions.

Considerations:

- While commercial land use sketch planning software packages are available “off-the-shelf”, significant time and resources are required to create the current conditions case (existing conditions) and the reference case (base scenario) as the starting point. Creating a current conditions and reference case requires accumulating and setting up local data upon which the future land use changes are “sketched”. This includes compiling parcel and land use data, zoning information, future projections, and other potential data sources.
- After a reference case is created, land use sketch planning tools can allow stakeholders to evaluate land use patterns relatively quickly. This immediate feedback allows for informed discussions to take place between planners, decision-makers, and community stakeholders.
- The evaluation measures produced by land use sketch planning tools are not complete GHG estimates and are simply used to compare one land use scenario against another. Since they are derived from a building-based framework, without a transport network, Oregon-specific vehicle and fuel attributes, and associated interactions, transportation metrics are less sophisticated than land use outputs. More nuanced transportation GHG estimates can subsequently be produced by models that better account for complex interactions.
- Since land use sketch planning tools are often used to focus on a subarea of a region, it is the responsibility of the user to ensure that household, population, demographic, and employment totals remain constant across all the scenarios. This is a critical step for scenario comparison that must not be overlooked. Land use models can help put demographic constraints on land use sketch planning tools. For example, sketch tools, such as INDEX, can be used in an aspirational or visioning mode where “the sky is the limit” and ignoring forecasts, or they can be used in forecast-compliant mode where land use designs are evaluated against the expected forecasts for the study area. Totals or controls should be held constant across all scenarios being evaluated, except in the case of sensitivity analysis. This could include testing the resiliency of a given scenario or plan against an unforeseen event, like higher population, loss of a bridge, or higher gas prices. Land use models are held to regional controls, so the sub-area patterns that they produce are an integral part of the demographic estimates of the entire region. At the outset, all scenarios should be compared with the same set of inputs.
- Not all land use sketch planning tools have a built-in way to ensure that demographic controls are maintained, so an auditing process needs to be run to verify that each scenario is within bounds. Following outreach and refinement of a small set of land use patterns, the refined set of scenarios can be fed into VisionEval and/or the local travel demand model to further assess GHG reductions.

- Land use sketch planning tools focus on how different land use patterns compare to one another on a variety of measures, including GHG. However, sketch tools do not take into account larger policy decisions, such as pricing.
- Land use sketch planning tools have been used in Oregon for special long-range visioning studies, including screening scenarios later run in VisionEval and travel demand models, but are not currently in day-to-day or routine use.

Works well with: VisionEval, travel demand models.

Who runs the tool: An important note for land use sketch planning tools, is that they are not currently common-use tools in Oregon. The uses provided below are cases where an agency or jurisdiction utilized a land use sketch planning tool for a specific project and when that project was complete the use of the tool also ended. This differs from most of the other tools discussed in this document, which are, for the most part, continuously used. Many of the examples provided below of use cases are several years old at this point.

- **Envision Tomorrow**: Portland Metro and City of Bend with vendor support.
- **CommunityViz:** Corvallis Area Metropolitan Planning Organization (CAMPO) with vendor support.
- **INDEX:** Lane Council of Governments (LCOG)with vendor support. Metro has also used INDEX as a public involvement tool for transportation and land use projects.

For more information:

- Metro Climate Smart: https://www.oregonmetro.gov/climate-smart-strategy
- Envision Tomorrow: http://envisiontomorrow.org/
- CommunityViz: http://communityviz.city-explained.com/communityviz/index.html
- LCOG: http://www.lcog.org/367/Sustainable-Transportation-Initiative/
- SPARC with INDEX: http://crit.com/our-portfolio/planning-support-software/

TACTICAL TOOLS *"How"*

Tactical Models use fixed assumptions (e.g. economic forecast, fixed fuel prices) to work out how to best implement allotted funding. For Oregon, these tools vary in geographic coverage, ranging from statewide level to regional (MPO) levels. MOVES, a national air quality model developed by the U.S. Environmental Protection Agency (EPA), is a detailed supplemental tool that can estimate GHG emissions from the vehicle miles and speeds of statewide and regional travel demand models.

Oregon Statewide Integrated Model (SWIM)

What it does: Oregon's SWIM model allows regional and statewide policies to be tested to inform decision-makers on the complex interactions between land use, the transportation network, and the economy.

Why it is important: SWIM has been used to examine a variety of transportation and land use policy actions within the context of economic growth, investments, and their interactions through time.

The more extensive second-generation SWIM includes statewide trends and can inform and represent external trends that impact local areas, such as commuting patterns between urban centers from smaller cities and other travel shed issues; freight movement by truck, commodity flows, and through traffic.

How SWIM Addresses GHG:

SWIM simulates regional and statewide activity for land use, transportation and economic interactions. The model forecasts travel characteristics, including intercity and rural travel, which are needed for comprehensive GHG analysis.

Travel information from SWIM must be combined with vehicle and fuel data to estimate GHG production.

While SWIM is designed to answer questions at a larger regional scale than a typical local agency's jurisdiction, SWIM can be used to provide local models with information on travel characteristics that occur outside their model boundaries; for example, whether densification in an MPO would shift more commuters into surrounding rural areas, potentially increasing VMT and GHG emissions.

SWIM is used to test "what if" scenarios related to public policy options, scenarios related to economic uncertainty such as population growth, energy prices, and economic growth. This unique tool assists in evaluating potential impacts associated with future uncertainty.

Background: In 1996, ODOT embarked upon the Transportation and Land Use Model Integration Project (TLUMIP) to develop a set of integrated economic-land-use-transportation models to meet evolving analytical needs at the regional and statewide levels. The intent of this effort was to help implement policies that addressed the needs of the state while avoiding unintended consequences arising from the complex relationships between transportation, land use and the economy. This program resulted in the SWIM model, which included extensive model design,

Statewide Integrated Model (SWIM)

Advantages:

- Consistent evaluation of economic activity, regional land use, transportation and freight.
- Provides information on intercity and rural travel.

Limitations:

- Model run times are 4 days for a 20-year forecast.
- Substantial expert staff resources needed.
- Data intensive.
- Must combine with other data to estimate GHGs.

data development, peer review, and sensitivity testing. This tool has been used for analytical studies for over 15 years.

How it works: SWIM is a set of integrated sub-models representing the economy, population demographics, businesses and industry, commodity flows, land use patterns, commercial and person travel, and the traffic resulting from this activity. The structure is modular, which allows for updates and improvements to be made with minimal disruption to the full model. SWIM also represents Oregon's trade interactions with neighboring states and other external trade partners. The economic forecast in SWIM is based on the state and national forecasts used for the official state revenue forecast. SWIM includes a large number of inputs and parameters estimated for each module. It is used to produce 20-year forecasts to evaluate policy impacts to location of households and businesses, gross state product, freight movement and traffic flows.

Works best for: Testing the impact of regional and statewide policies on land use, transportation and the economy. SWIM can be used to compare alternative policies or investment programs side-by-side to understand the potential magnitude and direction of impacts on future activity in Oregon. It can also be used to explore future uncertainty with respect to areas beyond agency control, such as population growth, employment growth and other aspects of the Oregon and national economy.

Considerations:

- Because of its complexity and statewide application, only ODOT staff and resources use SWIM to develop scenarios, it's not transferable to other users.
- Although it is useful for developing and analyzing a wide range of policy alternatives and options, it can require several weeks or more to set up and run the model over several scenarios.
- SWIM is designed to respond to large (regional or statewide) projects and policy questions, and is not suitable for fine-grained questions, such as specific land use changes (i.e., a new shopping center) or small network projects (i.e., widening of a 1-mile section of urban road).

Works well with: ODOT is currently developing connections with local and MPO travel demand models.

Who runs the tool: ODOT modeling staff develop, maintain and apply the SWIM model, with support from technical consultants when needed.

For more information:

https://www.oregon.gov/ODOT/Planning/Pages/Technical-Tools.aspx#SWIM

Travel Demand Models (MPO Models)

What it does: Travel demand models are designed to make travel "choices" that are consistent with real world travel behaviors. The choices are influenced by the available transportation infrastructure, the allocation of people and jobs, travel costs and choices, as well as other details about the region. Known travel behavior and relationships are used to replicate the "real world" transportation system around us.

How Travel Demand Models Address GHG:

Supplemented by other tools, travel demand models can be used to evaluate a range of potential policies and actions related to GHG.

Output travel must be combined with vehicle and fuel data to estimate GHG production.

Travel demand models can be used to predict future travel patterns and demands based on changes in the transportation system (i.e., wider roads with more capacity, new transit service, closed roads, etc.); changes in the land use (i.e., more residential development, a new industrial site, etc.); and changing demographics (i.e., more or less people in a specific area, access to a vehicle, aging population, etc.).

Why it is important: Travel demand forecasting can test the impacts of critical "what if" questions about proposed plans and policies. By simulating the travel demand on a computerized representation of a road network, deficiencies in the system can be identified.

Model results can provide users with a variety of information on travel behavior and travel demand for a specified future time frame, such as forecasted highway volumes for roadways, transit forecasts, the effects of a proposed development or zoning change on the system. They allow planners to analyze the effects of latent demand and other unanticipated impacts to the system.

Travel demand models are important tools in planning future network enhancements and analyzing proposed projects and policies. Information from travel demand models is used by decision-makers to identify and evaluate different approaches to addressing transportation issues and to select policies and programs that most closely achieve a desired future vision.

Background: Starting in the mid-1990s, ODOT and the MPOs coordinated their efforts to conduct household travel surveys and to use those surveys to develop a common structure for metropolitan area travel demand models. As a result, most metropolitan area travel demand models in Oregon have similar capabilities and functionality.

While model structure is similar for metropolitan areas, each model is developed and calibrated so that it reflects conditions and observed travel behavior present in each individual metropolitan area. Each travel behavior modeled is sensitive to household characteristics, land use and transportation system characteristics, travel time, and prices.

From the late 1990s until recently, travel demand model structures in Oregon used a "trip-based" modeling approach. The trip-based methodology has been the best practice standard for many years. Recently, the shared model structure is migrating to a newer recommended methodology which is referred to as "Activity Based Modeling" (or Models) (ABM). The key difference between a trip-based travel demand model and an ABM is the treatment of travelers. Trip-based models estimate behavior and travel decisions for zones or groups of travelers. Activity based models work from a synthesized and discrete population for the area, using information and characteristics about individual travelers to estimate travel behavior and decisions made throughout the day. This higher level of detail adds complexity to ABMs but allows more detailed questions to be tested and more information to be provided for all questions. ABMs allow for equity information to be better assessed; how different individuals are specifically impacted. Pricing strategies which can be significantly influential in GHG reduction are also better tested and answered with ABMs.

Oregon's travel demand modeling platform provides a robust modeling system for small communities and medium and large-sized MPOs. With ODOT support, the small to mid-sized Oregon MPOs can do far more planning with their transportation models then MPOs of similar size elsewhere. The frequency with which the models are utilized varies across jurisdictions, with Portland Metro using its model routinely to address policy and program issues, and smaller MPOs and communities using their models less frequently.

How it works: A travel demand forecasting model estimates travel behavior and travel demand for a specific future time frame, based on a number of assumptions. Travel demand models get their behavior data from detailed travel surveys that are typically conducted in the area to be modeled. For example, a Portland model would be based on the observed travel behavior of people living in Portland. Having a rich set of local behavior data, allows transportation modelers to assess new projects and transportation aspects with a high level of understanding and confidence.

A drawback is that travel demand models hinge on observed data, making it a challenge to predict how individual behavior might shift given new travel modes like mobility-as-a-service or new technologies like automated vehicles. While it's important to understand this limitation, it's equally critical to understand that this is a limitation with all behavior models. Travel demand models can forecast future conditions given that long standing behavior trends are not changed. It then takes further adjustments and refinements to assess how significant departures from the behavior that is observed today would alter the model results.

Travel demand models can address a wide array of future conditions such as roadway and transit networks,

Travel Demand Models

Advantages:
- Statewide consistency.
- Reflect local conditions.
- Available in all urban areas.
- Large pool of trained staff.
- Explicitly represent multimodal networks

Limitations:
- Trip Based tools lack detail around certain GHG policy actions like, travel demand management and new pricing policies.
- Data intensive to develop and maintain.
- Must be combine with other tools to estimate GHGs.

population and employment data, socio-economic characteristics, and travel costs. These tools calculate the expected demand for transportation facilities by; estimating the types of activities (work, school, shopping) different households will make in an average day, the places (establishments) they will go to in order to complete those activities, and the travel option (vehicle route, catch a ride, bus, walk, bike) they use to get to those places.

Works best for:

- Predicting future travel patterns and demands based on changes in the transportation system, changes in land use, and changing demographics, at the local and MPO level.
- Testing the impacts of critical "what if" questions about proposed plans and policies.
- Identifying deficiencies in the transportation network.
- Providing information on travel behavior and travel demand for a specified future time frame.
- Analyzing proposed projects and policies and planning future network enhancements.

Considerations:

- Oregon's models are state-of-the-practice travel demand models. They are built to interface with either of two commercial traffic assignment software packages – Emme (INRO) or Visum (PTV). Hence, they require a software purchase, as well as substantial resources to develop, maintain, and operate. Experienced staff are required to adapt them to new areas.
- Future-year traffic projections are based on numerous inputs from policy-makers or other users about population and employment growth, urban form, household socio-economics, travel costs, and transportation infrastructure. It is important that assumptions used to develop the inputs are well-considered, well-informed and clearly defined to provide reasonable future year-projections based on the best information available. Given future uncertainty and GHG impact of these factors, it is suggested that multiple scenarios be evaluated using strategic tools first to set overall vision and assess uncertainty before these broader assumptions are fixed (e.g., specific land use pattern, a single set of economic assumptions, fixed fuel prices). As an example, scenarios might need to adjust vehicle operating cost to account for much lower costs of future electric vehicles, as well as fuel price forecasts.
- Although these models are responsive to several policies related to the management of GHG emissions, such as land use, alternative modes and pricing, because of the runtimes and resources in scenario development only a few

scenarios are typically run, which does not fully evaluate the uncertainties in these inputs and the resulting outcome variations.

- Travel demand models can obtain land use information from land use sketch planning tools and/or land use forecasting models. A local area's travel demand model is best suited to evaluate how travel is affected by changes in land use or network/mode changes and it can be run to estimate volumes on links and the resulting speed characteristics. However, depending on the year the model was developed, some travel demand models are not truly reactive to policies that would fundamentally change how a household travels due to aggressive transportation demand management (TDM) interventions, such as reducing the number of trips, trip-chaining, driving shorter distances, changing the time that trips are taken, or greater use of certain modes. Using older generation travel demand models may result in somewhat higher vehicle miles traveled (VMT) than should be expected under these policies if post-processing methods are not employed.

- Oregon travel demand models are not currently designed to address large paradigm shifts, such as large changes in pricing (both tolls and fuel), how electric vehicle (EV) adoption might change, the impact of changing gas prices, or how automated vehicle (AV) adoption might shift current travel behavior norms. As discussed above, the travel behavior observed and collected to build travel demand models results in a more conservative estimate and ensures stability and inertia into the future.

- Travel demand models are not generally suitable for evaluation of site-specific factors, such as intersections, access control or intelligent transportation system (ITS) facilities. These tools do not typically account for non-reoccurring congestion (i.e., weather, crashes) and thus underestimate benefits of ITS policies and their GHG impacts.[14]

Works well with: Land use models, land use scenarios, MOVES, and Metropolitan VisionEval Model.

Who runs the tool:

- The three largest Oregon MPOs -- Portland Metro, Salem-Keizer and Central Lane – operate and maintain their own travel demand models.
- MPO models in Albany, Bend, Corvallis, Middle Rogue, and Rogue Valley are maintained and operated by ODOT.
- Smaller urban models outside of MPO areas are typically developed, maintained and operated by ODOT.

[14] The Economic and Social Impact of Motor vehicle Crashes, 2010 (Revised May 2015) https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812013.

For more information:

- Portland Metro MPO: https://www.oregonmetro.gov/modeling-services
- Salem/Keizer MPO: https://www.mwvcog.org/programs/transportation-planning/skats/reports-and-data/salem-keizer-metropolitan-areas-travel-demand-model/
- Central Lane MPO: http://www.lcog.org/569/Travel-Modeling
- ODOT Regions, and Albany, Bend, Corvallis, Middle Rouge, and Rogue Valley MPOs: https://www.oregon.gov/ODOT/Planning/Pages/Technical-Tools.aspx#travelDemandModel

Motor Vehicle Emissions Simulator (MOVES)

How MOVES Addresses GHG:

MOVES receives speed and volume data from other tools (e.g., travel demand models) to estimate GHG production.

What it does: MOVES estimates emissions for on-road sources, covers a broad range of pollutants, and allows multiple scale analysis, from detailed urban network-level analysis to national inventory estimation. It computes emission rates (grams/mile) for volatile organic compounds (VOCs), nitrogen oxides (NOx), carbon monoxide (CO), direct particulate matter (PM_{10} and $PM_{2.5}$), and certain air toxics. It estimates emissions for mobile sources and can estimate GHG emissions, including carbon dioxide (CO_2). It encompasses the necessary tools, algorithms, underlying data and guidance necessary for use in all official analyses associated with air quality regulatory development, compliance with statutory requirements, and national and regional inventory projections.

Why it is important: Transportation conformity is a Clean Air Act (CAA) requirement that ensures that federally-supported highway and transit project activities are consistent with ("conform to") the state's air quality implementation plan (SIP). Conformity ensures that public health is protected by early consideration of the air quality impact of transportation decisions in cities with air quality challenges. Transportation conformity is required in nonattainment and maintenance areas for transportation-related criteria pollutants and national ambient air quality standards ($PM_{2.5}$, PM_{10}, ozone, CO, and nitrogen dioxide). MOVES is required for use in SIP development and transportation conformity for nonattainment areas defined by the EPA.

Background: EPA developed MOBILE1 in the late 1970s as its first model to estimate pollution from highway vehicles. It calculated emissions of hydrocarbons, NOx and CO from passenger cars, motorcycles, and light- and heavy-duty trucks. It was based on emissions testing of tens of thousands of vehicles and accounted for the emission impacts of factors such as changes in vehicle emission standards, changes in vehicle populations and activity, and variation in local conditions such as temperature, humidity and fuel quality. MOBILE has been updated periodically to reflect improved data, changes in vehicle, engine, and emission control system technologies, changes in applicable regulations and emission standards and test procedures, and improved understanding of in-use emission levels and the factors that influence them.

In 2010, the MOBILE series of models was replaced by the MOtor Vehicle Emissions Simulator model (MOVES) as EPA's official model for estimating emissions from cars, trucks and motorcycles. MOVES is a state-of-the-art upgrade to EPA's modeling tools for estimating emissions from highway vehicles, based on analysis of millions of emission test results and considerable advances in EPA's understanding of vehicle emissions.

MOVES is EPA's best available tool for quantifying criteria pollutant and precursor emissions, as well as for other emissions analyses of the transportation sector. Although air quality emission models such as MOVES provides a template for the meeting new GHG analysis demands, MOVES is primarily a tool to analyze airborne pollutants that are harmful for human respiration. GHG effects are cumulative and don't require as much detail.

How it works: A significant amount of research has gone into evaluating how a vehicle type (e.g., passenger car) produces emissions under a complex set of possible engine conditions (e.g., varying speeds, idling, and driving conditions). The local vehicle fleet and fuel mix can be modeled assuming local information is available. MOVES could be used to compute GHG emission rates by speed given the fleet, fuel and road characteristics. These rates could then be applied to the congested speed and VMT on each roadway segment and totaled over the analysis area.

Works best for: Estimating emissions from the current vehicle fleet (cars, trucks, motorcycles and buses).

Considerations:

- MOVES needs to be linked to the results of a travel demand model or similar process in order to estimate volume and speeds by roadway segment which MOVES than uses to calculate GHG emissions. The travel demand model that provides volumes and speeds, should cover the affected region, not just project area, and have feedbacks to trip distribution and routing (ideally also feedback to trip generation and land use).

Motor Vehicle Emissions Simulator (MOVES)

Advantages:
- National consistency.
- Best project-level GHG analysis tool when applied correctly.
- Many firms can provide trained staff.

Limitations:
- Not a stand-alone model. It requires that other models be used creating a relatively longer and costlier run time and is subject to any limitations of linked tools.
- Considers tailpipe but not full lifecycle GHG, nor electric vehicle GHG.
- Provides detailed modeling of internal combustion engine emissions but this detail limits the ability to test many scenarios / conditions.

- Use of MOVES linked with travel demand model output, as is done for air quality conformity analysis, has several limitations for GHG reporting. Special attention needs to be given to ensure that MOVES is setup for future GHG assessment as opposed to conformity.

- Any MOVES analysis being conducted for GHG needs to represent the latest Oregon policy assumptions database on the operating characteristics of future vehicles and fuels (e.g., Zero Emission Vehicles, Clean Fuels programs). Additionally, MOVES should be run adding the Low Emission Vehicle database for Oregon. Note: The latest vehicle and fuel assumptions are not necessary in air quality conformity analysis, if thresholds are met with existing vehicle and fuel assumptions. ODEQ needs to be contacted to ensure concurrence on these aspects as well as meteorological and fuel inputs.

- MOVES also typically represents EPA's definition of GHG, which includes emissions from tank-to-wheels, not the full lifecycle of well-to-wheels.

- GHG analysis using MOVES needs to consider at least 3 to 4 time periods to best capture speeds under both congested and non-congested conditions.

Works well with: Must be linked to the results of a travel demand model or similar process in order to estimate GHG.

Who runs the tool: Depending upon the project and pollutant, ODOT Geo-Environmental Group, the larger MPOs, and various consultants typically run the MOVES model for projects in nonattainment areas, using vehicle and fuel emission assumptions provided and updated by the Oregon Department of Environmental Quality. The software is developed, maintained and supported by EPA's Office of Transportation and Air Quality.

For more information:

- MOVES: https://www.epa.gov/moves
- Federal guidance on Mobile Source Air Toxic Analysis (MSAT) in NEPA Documents: https://www.fhwa.dot.gov/environment/air_quality/air_toxics/policy_and_guidance/moves_msat_faq.cfm
- ODOT Geo-Environmental Air Manual: https://www.oregon.gov/ODOT/GeoEnvironmental/Pages/Air.aspx
- EPA guide, "Using MOVES for Estimating State and Local Inventories of Onroad Greenhouse Gas Emissions and Energy Consumption": https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100OW0B.pdf

Land Use Forecasting Models

What it does: A land use forecasting model facilitates creation and analysis of plausible future land use scenarios which can then be evaluated with a strategic or tactical-level travel model.

Why it is important:

Understanding where and how communities will develop in the future years is critical to properly anticipating transportation outcomes and impacts, like GHG emissions. Therefore, all transportation models require an understanding of the land uses for the given project area or region. Planning agencies use different tactics to create plausible or anticipated land use development scenarios for future years. Sometimes, planning agencies will use land use sketch planning tools along with community outreach to develop potential land use scenarios; sometimes planning agencies will hire out firms to help develop likely future land use scenarios or use internal resources and local knowledge to anticipate future growth; some also have the ability to use and use forecasting models.

How Land Use Models Address GHG:

Used with strategic or other tactical models, land use models provide insight on how land use patterns and the transportation network affect each other, and therefore consequently helping to estimate GHG emissions when used in combination with other models.

The complexity of most land use forecasting models precludes widespread use by planning agencies. However, they are useful tools for forecasting land use inputs to transportation models and for analyzing the land use effects of transportation projects, such as fully considering how a development pattern will impact transportation and the cost of the resulting congestion. There are a handful of land use forecasting models used in Oregon, the following sections are broken up by land use tool; Metroscope, the Land Use Scenario DevelopR (LUSDR), UrbanSim, and the Production, Exchange, and Consumption, Allocation System (PECAS).

Background:

- **Metroscope** was developed by Portland Metro staff to allow analysis of combinations of issues and alternatives related to urban growth boundary expansion, zoning capacity, and transportation/infrastructure investment policies. The land development model at the heart of MetroScope is a detailed representation of an urban land market, with methods to estimate supply, demand, and equilibrium prices to allocate development to specific locations throughout the region. Households and employment locations are allocated in the model, and it works in concert with Metro's regional economic and travel forecasting models
- **Land Use Scenario DevelopeR (LUSDR)** was developed by ODOT for use in a visioning study in the Rogue Valley. It has also been used by the MPOs in Salem/Keizer and in Eugene/Springfield. LUSDR has not been actively used in over a decade and so it would not be immediately ready to be used in any current projects; it would require an update process to bring back into use.

- **UrbanSim** is a land use software (tool) available to procure from developer Paul Waddell, currently at the University of California Berkeley. Several planning agencies within Oregon have used versions of UrbanSim in the past. Lane Council of Governments (LCOG) is currently working on using UrbanSim to support some of their land use planning efforts.
- **Production, Exchange, and Consumption Allocation System (PECAS)** is a land use software (tool) available to procure from the developing company HBA Specto Incorporated, based out of University of Calgary. PECAS, and its early versions, were developed as part of the SWIM (TLUMIP) project discussed above. Therefore, the SWIM tool currently integrates PECAS as its land use solution, and therefore PECAS is in active use within Oregon, specifically in SWIM.

How it works:

- **MetroScope** predicts the location of development in the Portland area. The interacting components cover transportation, residential real estate, non-residential real-estate and econometric models. GIS components allow visualization and maintain consistency with source land use data. The MetroScope land use module forecasts housing type and location, based on socio-economic factors, exogenous land capacity assumptions, and available transportation choices. Along with a parallel employment location module, Metroscope forecasts the disposition of households and employment in the region. The model works with a separate regional econometric growth model and Metro's transportation demand model, to forecast on projected growth trends, housing choices and locations, and transportation measures. Portland Metro coordinates with local agencies on data inputs to MetroScope, including vacant, infill and redevelopment land, and land capacity estimates. Model outputs are reviewed with local agencies on a 5-year cycle.

Land Use Forecasting Models

Advantages:

- Able to test broad range of land use policy scenarios.
- While a time-consuming step, developing required land use inputs by other means is similarly time consuming. A land use model provides a more structured, repeatable, approach to land development projections.

Limitations:

- Setup requires substantial data and analytical resources.
- Requires significant staff time, expertise, training, and expert support.
- Increases the time and complexity to obtain regional results.
- Must combine with other tools to estimate GHGs.

- **LUSDR** operates on a zonal (sub-regional) scale within an urban area but not at a parcel or urban block level. It requires a sizable amount data and analytic resources to set up for a specific locality. LUSDR requires "bookend" land use parameters (such as zoning capacity) which are used to create a large series of plausible future land use development patterns. These development patterns can then be analyzed in a travel demand model, to evaluate the transportation performance of each land use scenario. LUSDR and the travel demand model can be run iteratively through time, passing this information back and forth to simulate the effects of land use and transportation interactions. This process allows the testing of many future possible outcomes, to give local and regional agencies insight into how different land use patterns affect the transportation network.

- **UrbanSim** is a simulation system for supporting planning and analysis of urban development, incorporating the interactions between land use, transportation, the economy, and the environment. It is designed for use by communities interested in exploring the effects of infrastructure and development constraints as well as other policies on community outcomes, including GHG emissions among other mobility and environmental measures. UrbanSim is a microsimulation that represents metropolitan real estate markets interacting with transport markets, modeling the choices made by households, businesses, and real estate developers, and how these are influenced by governmental policies and investments
- **PECAS** is a generalized approach for simulating spatial economic systems. It operates by clearing spatial submarkets for various goods, services and factors in a short-run equilibrium, with floor space supply handled separately based on development event probabilities. It is currently being applied in the development of land use transport interaction models for practical use in several contexts in North America.

Works best for: Creating plausible future land use scenarios as input to travel demand models, to analyze land use effects of transportation projects.

Considerations:

- Requires substantial data and analytic resources to set up and run for a specific locality.

Works well with: Travel demand models.

Who runs the tool: Planning agencies responsible for land use projections that deploy land use forecasting models will run and operate the varying land use forecasting models, typically with some contracted support.

For more information:

- Metroscope (Portland): https://www.oregonmetro.gov/forecasting-models-and-model-documentation
- Urbansim: http://www.urbansim.com/

- LUSDR: https://trrjournalonline.trb.org/doi/10.3141/2003-12
- PECAS: http://www.hbaspecto.com/pecas/

OPERATIONAL TOOLS "*Details*"

Operational analysis tools supplement other models by helping with implementation details (for example, signal timing or ITS policies). Operational tools are also effective in quantifying localized transportation impacts under congested conditions. They typically cover a small section of a region in great detail. Demand is fixed, and focus is on vehicle interactions and resulting vehicle speeds, congestion and delay. These tools can range from highly complex traffic simulation models run dynamically to simple methods that provide more detail for use in environmental models (e.g., speed distributions).

ITS/operations policies are important GHG reduction strategies. Their impacts depend on detailed assessment of speeds and congestion, which are hard to model with less detailed tools that aggregate volume-delay functions. Supplementing higher level tools with operational level understanding of speeds and capacities can contribute to improved assessment of ITS and operational policies as well as other policies applied within congested areas**.**

Highway Capacity Manual-Based Tools

What it does: HCM based analysis tools range from sketch planning and screening to more detailed methods and software programs used to evaluate the mobility performance of specific facility types. The tools are used to evaluate alternative changes in transportation network characteristics (such as capacity, roadway geometry, signal timing or ITS strategies) in terms of capacity utilization, vehicle speeds, queuing, number of stops, and delay for a project or portion of the region. Traffic volumes are required inputs into traffic analysis tools, are usually derived from the output of travel demand models when available. Otherwise, volumes are usually based on historical trends. Some of these tools have internal data sets and modules for calculating changes in fuel use and air pollutant emissions resulting from changes in traffic characteristics, however these must be used with caution as most have built in assumptions about the fleet makeup and typically are not in alignment with Oregon's projected fleet assumptions from ODEQ. Therefore, a properly configured MOVES application, or equivalent GHG emission factors should be used for GHG calculation of any traffic analysis work.

How HCM-Based Tools Address GHG:

Used with other models, HCM-based tools provide detailed information about the localized impacts of ITS and operational policies under congested conditions. These tools have some limited ability to help understand localized changes to GHG emissions but are generally too focused for a full understanding of GHG levels.

Why it is important: HCM-based tools are needed to understand the mobility performance of a proposed transportation project or facility. These tools are built to identify needs, evaluate alternatives and provide information on the mobility performance of a project before it is constructed. Together with simulation models, they are the only tools available that provide the ability to test the details of how a transportation project will function with given design features (e.g. the length of an auxiliary lane, signal timing performance, the benefit of an extra turn lane, and so on.)

In general, HCM-based tools are too focused for a full understanding of future GHG levels; however, offer insight on how an individual transportation improvement such as a signal, roundabouts, etc. may impact localized GHG generation. These tools can provide better understanding of speeds, operations and chronic congestion conditions that impact GHG.

Background: Commonly used HCM-based mobility analysis tools include Synchro, SIDRA, Vistro, HCS, and Freeval. Analysis is performed at the facility, segment and intersection levels. Traffic volumes used in HCM-based tools are typically derived from travel demand model output or from historical trends.

How it works: The Highway Capacity Manual is the basis of most of the methodologies used in these tools. In addition, some of these tools extend beyond HCM methodologies. For example, some tools include estimates of fuel consumption and emissions. In general, HCM-based tools allow designers to understand what points in the network are most problematic for vehicle flow (and at what times).

Works best for: A detailed (design level) project understanding. Not typically utilized for GHG evaluation.

Consideration:

- There are few to no examples of traffic deterministic tools being used for GHG analysis in Oregon.
- Use of these tools is limited to selected projects, meaning a focused area. Not a region wide analysis
- Vehicle and fuel assumptions reflect national data rather than the Oregon fleet. Therefore, fuel usage outputs have limited use for Oregon projects.

HCM-Based Tools

Advantages:

- Provides a detailed understanding of specific projects. Some outputs such as vehicle speeds can be used in other models.

Limitations:

- Typically covers roadway projects only.
- Volumes are typically based on travel demand model output.
- Vehicle & fuel data don't represent Oregon specific future assumptions.
- Set up requires time, resources and data.
- Smaller area focus, not appropriate for GHG analysis and understanding.

Works well with: Opportunities exist to provide the improved speed and delay outputs from HCM-based tools for use in environmental models like MOVES.

Who runs the tool: Consultants, TPAU and the ODOT Regions have experience using HCM-based tools. Procedures for use are provided in ODOT's Analysis Procedures Manual.

For more information:

Guidance is provided in ODOT's Analysis Procedures Manual (APM): https://www.oregon.gov/ODOT/Planning/Pages/APM.aspx

Traffic Simulation Models

What it does: Traffic simulation models are complex and highly detailed analysis tools used to evaluate the impacts of changes in transportation network characteristics (such as capacity, roadway geometry, signal timing or ITS strategies) on traffic flow patterns, including vehicle speeds, queuing, number of stops, and delay for a project or portion of the region. Vehicle volumes and demand, which are required inputs into traffic simulation models, are usually derived from the output of travel demand models. Most traffic simulation platforms have internal data sets and modules for calculating changes in fuel use and air pollutant emissions resulting from changes in traffic characteristics (speed and acceleration), however these must be used with caution as most traffic simulation software will have built in assumptions about the fleet makeup that typically are not in alignment with Oregon's projected fleet assumptions from ODEQ. Therefore, a properly configured MOVES application should be used as the final GHG calculation for any traffic simulation work.

How Traffic Simulation Tools Address GHG:

Used with other models, traffic simulation tools provide detailed information about the localized impacts of ITS and operational policies under congested conditions. These tools have some limited ability to help understand localized changes to GHG emissions but are generally too focused for a full understanding of GHG levels.

Why it is important: Traffic simulation models are needed to understand the detailed operational characteristics of a proposed transportation project or development area. These tools are built to perfect the design and understand the performance of a project before it is constructed. They are the only tools available that provide the ability to test and understand the details of how a transportation project will function with given design features (e.g. the length of an interstate ramp, signal timing performance, the benefit of an extra turn lane, impacts of ramp metering, and so on.)

In general, traffic simulation models are too focused for a full understanding of future GHG levels; however, they are the only tools currently available that offer insight on how an individual transportation improvement such as a signal, roundabouts ramp metering, etc. may impact localized GHG generation. These tools can provide better understanding of speeds, operations and chronic congestion conditions that impact GHG.

Background: Traffic simulation models can be divided into two general classes. Many software packages are capable of modeling both, and sometimes both within the same tool depending upon how it is set up.

Mesoscopic simulation, such as DYNAMEQ, TransModeler, and Dynus-T, are based on deterministic relationships between roadway and intersection characteristics and traffic flow.

Microscopic simulation models the movement of individual vehicles through the project network. Microscopic models can be broken down further. *Static* models like Synchro/SimTraffic simulate pre-determined traffic volumes and turning movements that are input by the user. *Dynamic* simulation models, such as Vissim can micro-simulate origin-destination patterns that allow vehicles to dynamically re-route from origin to destination based on real-time congestion in the system, driver information, and alternative routes.

The pre-determined volumes in static models create limitations as vehicles are assumed to not deviate from pre-determined (calculated) courses. The static packages are more suited for individual intersection analysis or signalized arterial corridors. Dynamic models designed to use origin-destination tables as opposed to specific intersection volumes perform better in network-level analysis of mixed facility types (freeways and arterials), as well as transit and pedestrian operations in a larger, but still sub-region area.

Traffic Simulation Models

Advantages:

- Provides a highly detailed understanding of specific projects. Refined impact on vehicle speeds that can be used in other models.

Limitations:

- Typically covers roadway projects only.
- Typically assumes fixed travel demand.
- Vehicle & fuel data don't represent Oregon specific future assumptions.
- Set up requires significant time, resources and data.
- Smaller are focus, not appropriate for GHG analysis and understanding.

How it works: Individual vehicles (and travelers) or flows of vehicles are stepped through the project network at a very fine temporal scale (such as second by second). The software keeps track of every vehicle's position and decisions and every point (example second) of the simulation. Traffic simulation models allow designers to understand what points in the network are most problematic for vehicle flow (and at what times) and provide a computer simulated environment to test potential engineering solutions.

Works best for: A detailed (design level) project understanding. Not typically utilized for GHG evaluation.

Consideration:

- There are few to no examples of traffic simulation models being used for GHG analysis in Oregon.
- Use of these tools is limited to selected projects, meaning a focused area. Not a region wide analysis
- Vehicle and fuel assumptions reflect national data rather than the Oregon fleet. Therefore, fuel usage outputs have limited use for Oregon projects.

Works well with: Opportunities exist to provide the improved speed and delay outputs from traffic simulation models for use in environmental models like MOVES.

Who runs the tool: Consultants and ODOT Region 1 have the most experience using these models. Simpler methods can follow guidance in ODOT's Analysis Procedures Manual.

For more information:

High level guidance is provided in ODOT's Analysis Procedures Manual:
https://www.oregon.gov/ODOT/Planning/Pages/APM.aspx
APM Chapter 8 Mesoscopic modeling
APM Addendum 15A Protocol for Vissim Simulation

OTHER NATIONAL ANALYSIS TOOLS

Other tools are available from federal agencies, other states, and private entities that may estimate emissions from multiple sectors, including transportation. An inventory of national tools can be found in Appendix B. However, further study is needed to determine the applicability of these external tools for use in Oregon and to assess the resources that would be needed to adapt them to work with Oregon's core toolset.

MONITORING TOOLS/DATA "Meeting Expectations?"

In Oregon, several GHG target-setting processes apply at various levels of government. An overview of these processes, and a summary of how Oregon agencies have responded is provided in Appendix C.

Monitoring is used to track progress toward GHG targets. Analysis at this stage should reflect observed (not modeled) behavior as much as possible. This might include a mix of the data sources described below.

Monitoring GHG

Monitoring is a relatively new function for Oregon and ODOT specifically. ODOT is currently in the process of developing knowledge and approaches for monitoring GHG with existing and soon to be available datasets.

While tools exist for scientifically valid estimation and forecasting of future GHG levels, measuring GHG directly is challenging. As a result, alternate "monitoring" approaches are often used to track progress on policies within an agreed-upon target scenario. For example, a community has a "vision" scenario that meets GHG goals and specifies 20% of employees will be covered by a parking fee; adopted plans are assessed and show only 12% coverage.

Monitoring GHG is a relatively new exercise for ODOT and Oregon. Because of legislative mandates in the past several years, State agencies, including ODOT are now working to report on progress towards GHG reduction efforts on regular intervals.

Several alternative data sets are emerging from big data tracking sources, often a mix of observed and synthesized data. More work is needed to assess their quality for monitoring GHG and/or policy actions (e.g., bike mode share), to identify best practices for Oregon communities.

Once targets or strategies are in place, monitoring data and supporting tools can be used to evaluate and track progress at a set-frequency. This tracking can be of individual policies, and/or overall GHG emissions, as noted below.

Oregon Statewide Multi-Sector GHG Monitoring with Data

For statewide GHG targets and strategies Oregon, like many states, has begun to track historic multi-sector GHG emissions. For Oregon, this emissions tracking is completed by DEQ and constitutes the official GHG emission inventory and a monitor of overall GHG production for the state. The tracking is based on observed data and tracked progress of individual sectors.

What it does: Oregon Department of Environmental Quality (DEQ) evaluates statewide greenhouse gas emissions in two ways:

Statewide Multi-Sector GHG Monitoring

Oregon's official statewide multi-sector GHG emissions inventory, published by ODEQ, includes an annual report of transportation emissions based on actual fuel sales.

- **Sector-based inventory (annual)**: Emissions produced in Oregon from the transportation, residential, commercial, industrial and agricultural sectors, including electricity which is produced outside the state but used in-state. For transportation, emissions estimates are based on DEQ's mandatory greenhouse gas reported data on imported fuels in combination with EPA's State Inventory too.
- **Consumption-based inventory (conducted every 5 years)**: Emissions produced around the world due to Oregon's consumption of energy, goods and services. Over half of Oregon's consumption-based emissions occur in other states or nations and are not

included in the sector-based inventory. In a consumption-based framework, commercial transportation is largely allocated to the end use, such as household consumption of goods and services.

Why it is important: Provides an official statewide GHG inventory and forecasts.

For More Information:
https://www.oregon.gov/deq/aq/programs/Pages/GHG-Oregon-Emissions.aspx

Oregon Sub-State GHG Monitoring with Data

Sub-State GHG Monitoring with Data

Data used to monitor statewide GHG emissions is not available at a sub-state level. ODOT is currently evaluating alternative methods for estimating GHG production that is attributable to transportation sources from different sub-areas of the state.

What it does: Ideally, methods similar to statewide monitoring described above would be used to track GHG production at a sub-state level; unfortunately, however, statewide data is not available at a sub-state level. This section looks at existing and potential data that might be used to monitor GHG production for sub-areas of the state.

How it works: In current practice, GHG emissions can be approximated by combining "volume of travel" with "GHG emission factors", reflective of the area to be monitored (taking into account varying miles per person, vehicle mix, and fuel mix). Each possible dataset noted in Table 1 below has strengths and weaknesses. For monitoring purposes, it is best to use an observed, stable data source that will continue to be available over time, at a level of accuracy that will be sensitive to the policy actions being tracked. Methods from simple EPA and other national tools (see Appendix B) may be applicable.

Table 2. Possible Sub-State GHG Monitoring Data

METRIC	POSSIBLE DATA SOURCES	POSSIBLE TOOLS
Volume of Travel*		
• Fuel Sales (statewide) • Vehicle miles traveled (e.g., HPMS)	• Fuel Tax Records • Annual ODOT Mileage Reports	• VisionEval • Travel Demand Models
GHG Emission Factors*		
• GHG per gallon • GHG per kilowatt-hour (kwhr) • Vehicle Miles per gallon, Miles per kwhr • GHG per mile, GHG per gallon	• Fuel Carbon Intensity (ODEQ) • Electricity Carbon Intensity (EPA • EGrid, Public Utility) • Vehicle attributes (ODOT DMV data) • Combine above factors	• VisionEval • MOVES

* Factors obtained from tools (e.g., Travel Demand Model, VisionEval or MOVES) do not reflect observed data. GHG is typically reported in grams of Co2-eqivalent greenhouse gases.

Works best for: Monitoring changes in auto emissions, given data limitations. Used in combination with policy tracking this methodology can provide some evidence for tracking a mix of policies contributing to the change.

Considerations:

Sub-state data for monitoring GHG emissions is challenging at this time.

- **Volume of Travel:** Fuel sales are only tabulated statewide and for selective cities that have fuel taxes. There is also error from fuels bought in one location and used elsewhere, which is particularly problematic when taxation differs or changes over time (e.g., City of Portland's $0.10 per gallon sales tax in 2018). HPMS estimates VMT from traffic counts for each state roadway segment, but has less accuracy for non-state roads, so it is difficult to monitor at a sub-state level.
- **GHG emission factors:** Emissions depend on local vehicles and their frequency of use. In recent years Department of Motor Vehicles (DMV) records have provided good summaries of registered light duty vehicles by county (or more detailed are upon request) and their fuel efficiency. However, odometer readings per vehicle are required to know frequency of use to accurately estimate average fuel efficiency. While odometer readings are collected in selected Air Quality non-conformity areas across the state, the data quality needed for GHG monitoring needs is not currently available. Fuel and electricity carbon intensity are readily available for specific fuels, but the mix of fuels depends upon the vehicle mix and their usage, which is not readily available at a sub-state level.

For More Information on Existing Sources:
Fuel Sales: https://www.oregon.gov/ODOT/FTG/Pages/TaxableDistributionReports.aspx
DMV data: https://www.oregon.gov/ODOT/DMV/Pages/News/driver_stats.aspx
HPMS data: https://www.oregon.gov/ODOT/Data/Pages/Road-Assets-Mileage.aspx
EGrid data: https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid
Electricity Carbon Intensities (MTCO2e/MWh) – Utility-specific emissions are available from DEQ's mandatory greenhouse gas reporting program:
https://www.oregon.gov/deq/aq/programs/Pages/GHG-Emissions.aspx
State-specific carbon intensity values for transportation fuels:
https://www.oregon.gov/deq/FilterDocs/cfp-electrutil.pdf
DEQ's Clean Fuels Program has statewide transportation fuel volumes by fuel type starting in 2016, including alternative fuels, and tracks changes in fuel volumes over time.

GHG Strategy Monitoring with Tools

When tracking the cumulative result of future actions relative to a multi-year GHG strategy, sometimes the only way to estimate progress is to use a model. That model may be the same model used in the original study that set the GHG reduction strategy, or another model that measures the cumulative impact of future policy actions.

Some considerations might include:

- By using the same tool, just like using the same observed data source, differences relative to the original strategy can be minimized. There can also be consistency between policies included in the model and the target metric, and definitions of emissions. For example, both policies and target metric may use the same assumptions for changes in vehicles and fuels, and consistent definitions for commercial travel, heavy duty vehicles, and peak hour timeframes.
- For Oregon metropolitan GHG monitoring, use of VisionEval tools ensures consistency with the ORS definitions used in the target.

Examples of tool-based GHG strategy tracking in Oregon include:

- ODOT STS Strategy (VisionEval tools), tracked 5-year progress using VisionEval tools in STS-Monitoring Report. (April OTC)
- Portland Metro Climate Smart Strategy (VisionEval), tracked using local Travel Demand Model and MOVES in 2018 RTP. (reference)
- Central Lane MPO Scenario Planning Preferred Scenario (VisionEval), tracked progress to address the City of Eugene's Climate Recovery Ordinance, using VisionEval tool as follow-up to the City's Transportation System Plan. (reference)

Tool-Based Monitoring of GHG Strategies

Analysis tools used to develop initial strategies may also be used to monitor progress toward targets. This approach offers some efficiencies due to consistency of assumptions and definitions used to set targets and monitor progress toward them.

Individual Policy Monitoring

Rather than attempting to measuring specific GHG emissions over time, which are difficult to track with observable data, agencies can instead monitor their progress towards implementing policies and actions included in an adopted GHG strategy. This is often done to track progress toward a longer-term strategy or mix of policies over time.

For example, a community GHG strategy may specify that 20% of employees need to be covered by a parking fee. Monitoring would then collect local data to identify parking coverage under currently financially constrained adopted plans, which might show only 12% coverage. This data would be collected locally. A consistent source of local data, tracked over time, may indicate changes resulting from policy actions.

Monitoring Progress Using Non-GHG Measures

Given a specific GHG strategy, state and local agencies can track progress on individual policy implementation activities and associated investments over time.

Examples of policy tracking approaches in Oregon include:

- DLCD's alternative measures in several MPOs (e.g., RVMPO)
- Portland Metro's Climate Smart Communities Strategy Monitoring, found in 2018 RTP Appendix
- ODOT's STS Monitoring Report (OTC April 2018 meeting)

Future GHG Monitoring Possibilities

As ODOT looks to the future, "big" datasets of traveler information are emerging from an increasing number of vendors and sources. These new data sources promise to provide a much more detailed picture for how the transportation system is being used day-to-day and year-to-year, and potentially observe actual emissions. It is hoped that these emerging data sets will improve information on actual emissions, and the effects of emission reduction policies, such as. how different modes are used, time-of-day travel, levels of congestion, and the impacts of non-reoccurring congestion and events.

Although it's exciting to think about the GHG and other questions that these new datasets could help answer, there are still many questions and uncertainty around the quality and feasibility of these new data sources. Almost all new data sources rely on "passively" collected data, i.e., data collected from cell phone or GPS data without full awareness by the user. Even given resolution of societal and legal questions around this data, questions remain about potential sample biases (e.g., cell phone users, rather than all users), data aggregating assumptions and inferences about the data that they are collecting (e.g., assumed home location from where cell phone resides overnight, use of traffic counts or census counts to scale up sample), and how well these assumptions reflect actual observed travel and behavior. One company's travel behavior dataset is not equal to another provider's data. The end product relies heavily on the intelligence, experience, and resource power of the company packaging and selling the data.

Given these issues, it's unclear when this type of information might be available, and what the quality of the data will be; equating to uncertainty around what questions the data can be used to answer. As ODOT and others address these data questions over the next several years, the appropriate role for these datasets to inform the GHG and broader analysis landscape will take shape.

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TOOL ABILITY TO ADDRESS ACTIONS & PROGRAMS

This document illustrates the complexity of methodologies and tools available to assess GHG emissions reductions. It is also important to note that net GHG emissions reductions can be greater or less than the sum of effects attributable to individual actions. For example, certain actions identified with low reduction effectiveness may seem fiscally impractical based on the research. However, when those actions (e.g., parking pricing) are combined with others (e.g., increased transit), the synergistic benefit may be much larger than the simple sum of the reduction estimate from either action alone. Likewise, things outside of the state's control (population migration, emerging vehicle technologies, and fuel prices) can have more effect on GHG emissions than state and local actions.

It is critical that GHG reduction plans are modeled in a holistic way, using the right tool(s) to address the questions posed. In many instances a combination of tools is needed to answer questions and inform decisions during strategic planning, tactical implementation of strategies and monitoring. Based on GHG analysis to date, no single mechanism reduces GHG from the transportation sector sufficiently; combinations of actions are necessary. The most important categories of GHG reduction strategies from the STS are noted below. The analysis of GHG should consider these strategies, as well as the impact of trends outside agency control. This implies an increased need to run many scenarios, increasing the analysis burden.

GHG emissions are heavily influenced by factors beyond the control of the public sector, which creates uncertainty when planning far into the future. Scenario analysis enables decision makers to evaluate the potential range of impacts associated with the uncertainty of these factors. Strategic tools are uniquely designed to run many scenarios that can directly consider these factors to understand risk and uncertainty. For tactical and operational tools, a qualitative evaluation of the influence of these important factors on future GHG emission estimates should be noted.

GHG reduction strategy categories:

- Vehicle and Engine Technology Advancements – Strategies in this category increase the operating efficiency of multiple transportation modes through transition to more fuel-efficient vehicles, improvements in engine technologies, and other technological advances.
- Fuel Technology Advancements – Strategies in this category increase the operating efficiency of fuel-powered transportation modes through transitions to fuels that produce fewer GHG emissions or have a lower lifecycle carbon intensity.
- Enhanced System and Operations Performance – Strategies in this category improve the efficiency of the transportation system and operations through technology, infrastructure investment, and operations management.

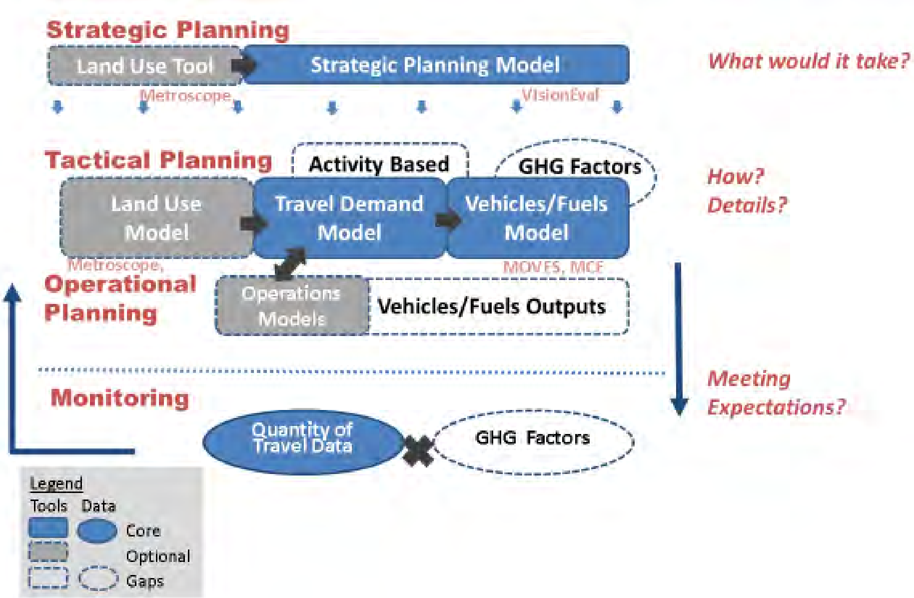
- Transportation Options – Strategies in this category increase opportunities for travelers and shippers to use transportation modes that are more energy efficient and produce fewer emissions.
- Efficient Land Use – Strategies in this category promote more efficient movement throughout the transportation system by supporting compact growth and development. This development pattern reduces travel distances and increases opportunities for using lower energy and zero- energy transportation modes.
- Pricing and Funding Mechanisms – Strategies in this category support a transition to more sustainable funding sources to maintain and operate the transportation system, pay for environmental costs of climate change and provide market incentives for developing and implementing efficient ways to reduce emissions.

Outside Factors:

- Demographic (e.g., population and employment growth)
- Costs relative to household budgets (e.g., economic growth and income growth, fuel and energy price forecasts, vehicle operating costs)
- Shifts in consumer and business behavior/preferences (e.g., choice of home location, vehicle purchases, mode choices) in response to emerging modes, trends and mode prices relative to budgets.

Figure 3 illustrates how different types of tools and data might be used at different analysis levels. Ideally, any question regarding GHG (or any transportation outcome) could be answered at any level of geographic scale and all levels of detail. The reality, however, is that each question has its own unique aspects, complications, timelines, and budget that typically result in only a select handful (most commonly just one) set of analysis options.

Figure 3. Combining Tools to Inform GHG Analysis



When assessing risk and prioritizing across general categories of GHG reduction actions, project details are less important, so strategic tools which address the broadest set of variables are recommended. When differentiating projects within a GHG reduction category, tactical and operational tools are necessary. At this time, guidance and tools for analyzing across tactical and operational levels have not been well established. This includes assumptions that must be made to reduce uncertainties, and thus enable more details of the specific projects to be included in the analysis. Future guidance may include recommendation of selected scenarios to assess risk and/or inclusion of operational models to better estimate vehicle speeds under chronic congestion.

Table 1 (page 7) lists program categories, and specific actions within those categories, and provides a summary of the current capability and suitability of Oregon's analysis tools related to these actions. The table further demonstrates the point that multiple tools must often be used in combination to achieve the best information available on GHG at this time.

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FUTURE TOOLS

Oregon has a broad set of modeling and analysis tools to begin to address the complex issue of GHG emissions reduction. However, improvements in the current tools and guidance on best practice processes are needed to fully measure and evaluate GHG emissions consistently across the state and account for definitional differences between tools. User training will also be required to tailor and use these tools for urban areas that do not currently have them. The future framework will use most of the models in the current core toolkit, with improved interaction between models as current tools are refined and new tools are developed.

There is great potential to integrate or improve consistency of current tools. Tactical tools, like travel demand models can be combined with specialized operational tools, adopting vehicle and fuel characteristics and trends from strategic tools like VisionEval and MOVES. Potentially synthetic populations (used in VisionEval and activity-based models) can be attributed with household data form various models for shared use. Vehicle and fuel characteristics could then be directly linked with the number of miles of travel for each vehicle as estimated from a travel demand model, giving an estimate of GHG that matches both. This would help bring more steps of the process in alignment, creating a greater degree of consistency and confidence in the results.

Currently, SWIM2 and a new ABM model for southern Oregon that covers the Rogue Valley and Middle Rogue MPOs are the only activity-based travel demand models in application in Oregon. It should be noted that at a regional level, other Oregon MPO models are trip-based and are not generally suitable for tolling, pricing or congestion pricing. Microsimulation methods are required to allow for differential values of value-of-time or willingness-to-pay, and to consider time-of-day changes in response to congestion pricing which will affect GHG response. Metro and ODOT are close to being able to do this with activity-based models, and VisionEval can address a simplified congestion pricing impact. Through the OMSC, ODOT and MPOs are coordinating opportunities to move to ABMs over time to expand capabilities of travel demand models.

Along with creating more links and connections between the core tools, undoubtedly some of the national modeling and analysis tools discussed in the Appendix B will need to be incorporated to fully address and assess GHG emissions. Additionally, there is need for more guidance on operational tools and continually expanding monitoring datasets. The OMSC can help to provide guidance and direction on the most promising tools/data in addressing GHG evaluation gaps and facilitate shared knowledge and collaboration.

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CLOSING THOUGHTS

Although no single tool by itself provides full evaluation of GHG emissions, Oregon's "core" modeling and analysis tools can address the majority of GHG analysis needs. To fully address GHG emissions reduction, continued research and development of tools and processes will be required and will need to be incorporated into practice. Therefore, this is a living document and future addendums are anticipated.

Modeling and analysis tools are not generally "off-the-shelf" or "push button" tools, where the analyst can install software and start assessing GHG. They require staff expertise to develop, use and maintain them. Varying levels of analysis require varying levels of complexity and effort. As an example, assessing actions and programs at a regional level with a high-level tool like VisionEval would require one tool with relatively simple design and input structure, while trying to fully assess how in-vehicle ITS might impact areas of chronic congestion during the peak period would require a suite of complex interconnected tools. Local agencies will have to determine what level of analysis is needed for the programs and actions they are considering.

Collecting, maintaining and entering data to make these tools responsive to local conditions can be expensive and time-consuming. There is uneven capability and depth of knowledge across MPO staff and local city staff and many rely heavily on ODOT and the larger MPOs for assistance in defining opportunities and applying the tools.

The current tools available to Oregon's modeling agencies are advanced when compared to common practice and they address a majority of the GHG reduction actions and programs that a local agency might want to assess. However, further enhancement of these tools is necessary and will focus on common capabilities with minimal duplication.

There are many choices available for further enhancement of Oregon's core tools. There is overlap or duplication in the national tools and their functions and the preferred approach is to identify a small suite of tools that provide common capabilities to as many agencies and local governments as possible. The OMSC is the preferred forum to discuss and coordinate ideas and needs and to cooperatively define and plan for tool development and application.

Finally, it is important to remember that the tools themselves are not decision-makers and do not provide "the answer" to the complex issue of GHG emissions reduction. Analysts evaluate, compare, and assess output from the modeling tools to develop options and scenarios, and to compare these scenarios on how well they achieve stated goals or visions. This information is used by stakeholders and policy-makers to make decisions on how to best accomplish GHG emissions reduction consistent with community values and unknowns about future travel conditions.

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APPENDIX B: NATIONAL TOOLS

A number of tools outside of Oregon's "Core" Toolbox are available from federal agencies, other states, and private entities. These tools estimate emissions from multiple sectors, including transportation. They include calculators for estimating emission reduction from various strategies. They typically follow international protocols, usually meaning that they include instruction manuals outlining methodologies and requirements for documenting a GHG inventory for membership to an environmental registry.

The following tools may have some use or application in Oregon; more analysis and research are needed to determine the applicability for use here and the resources required to adapt them to work with Oregon's core Toolbox. Definitions of VMT and vehicle and fuel assumptions may not be consistent with those forecast for Oregon, so careful attention and local expert judgment commonly needs to be applied to properly use and report this information. These tools are presented in three groupings: Sketch-Level Tools and Technology Scenario Models, and Other.

National GHG Inventory Tools and Calculators

What it does: Various tools and calculators exist to estimate GHG emissions from multiple sectors, including transportation. They typically use simple factor methods, so they can cover all sectors with limited data collection resources. They may also include calculators for estimating emission reduction from a typical set of GHG reduction strategies for each sector. They typically align with international protocols, essentially instruction manuals outlining methodologies and requirements for documenting a GHG inventory for membership to an environmental registry.

Why it is important: Given the complexities involved in trying to assess the production as well as strategies to reduce the GHG emissions across multiple sectors, these tools and calculators estimate in ways that are not covered by the other transportation and land use modeling tools use observed data that aligns closer with the monitoring role as outlined in this document. However, these tools and calculators have been used strategically to help provide context for understanding sources of GHG production and set goals for reduction.

Background:

How it works: The calculators in these tools typically pivot off a GHG inventory of a past year, or potential reference future year. The methodologies largely hinge off local estimates of VMT and vehicle emission factors.

Work best for: VisionEval Tools (using Oregon vehicles and fuels), Travel Demand Models or fuel sales combined with emission factors have been used to provide transportation sector GHG emission estimates for historic and future year reference scenarios. Various Oregon communities, including Portland Metro, Eugene, Ashland, and Corvallis, have developed these inventories, sometimes in the context of a full climate action plan.

Considerations:
To retain consistency with other Oregon GHG reporting (e.g., vehicle and fuel assumptions) it is recommended that VisionEval GHG emissions be used for transportation sector emissions, from either a reference forecast scenario in a local metropolitan or (sub-state reporting from) the statewide VisionEval tools.

Who runs the tool: Consultants are typically hired by local agencies to collect the data needed to estimate GHG emissions across multiple sectors. Transportation GHG emissions from VisionEval models can be obtained by contacting the local MPO and/or ODOT TPAU.

For More Information:
International Council for Local Environmental Initiatives (ICLEI):http://icleiusa.org/clearpath/
Clean Air and Climate Protection (CACP):
http://www.4cleanair.org/Oldmembers/members/committee/software.html
EPA GHG Inventory Tools: https://www.epa.gov/statelocalenergy/local-greenhouse-gas-inventory-tool
https://www.epa.gov/statelocalenergy/download-state-inventory-and-projection-tool/

National Sketch-Level Tools

Tools in this category are generally considered as post processors. They start with a baseline scenario derived from the regional Transportation Demand Model or national survey data, then adjust account for how the various strategies are anticipated to alter VMT, speed, mode choice, and trip generation. The refined vehicle activity is coupled with appropriate emission rates. There are many tools in this category, many of which differ only slightly (e.g. similar algorithms adapted to different regions). The tools shown here represent the variety of available approaches (note, some tools like IDAS are no longer supported but have been kept in as examples of the types of functionality these tools typically offer).

IDAS

The ITS Deployment Analysis System (IDAS) tool is currently no longer supported but was originally developed by Cambridge Systematics for FHWA. IDAS still available for purchase and can estimate the impacts, benefits and costs resulting from the deployment of ITS components. The tool addresses more than 60 types of ITS investments. Among the effects calculated are travel time, safety, and environmental benefits, including effects on criteria pollutant emissions and fuel consumption (which in turn can be used to calculate impacts on CO_2 emissions).

IDAS operates as a post-processor to Travel Demand Models, enabling the user to import data from a Travel Demand Model into the IDAS software to recreate the transportation network under evaluation. IDAS provides the opportunity to build different network alternatives by enabling users to choose from a menu of ITS and operations components and then deploy the selected network components. As the user chooses various components, IDAS maintains a database of the impacts and costs of the components, based on national data. After all the components are selected, users can program IDAS to perform an internal network assignment and mode choice analysis to estimate the changes in modal, route, and temporal decisions of travelers resulting from the ITS and operations technologies. The software then generates reports that show the incremental change in performance measures and the annual benefit-cost ratios for the selected investments.

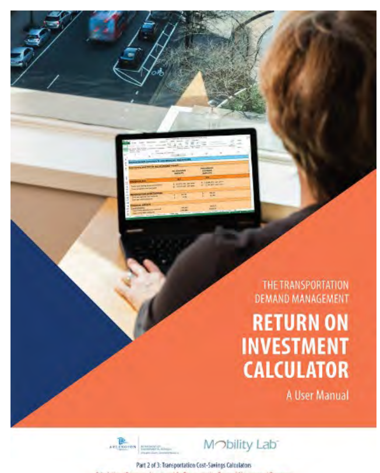
IDAS can estimate the following system wide performance measures:

- Mobility or travel time (recurring delay).
- Travel time reliability (nonrecurring delay).
- Crashes (fatalities, injuries, property damage).
- Emissions (hydrocarbons, carbon monoxide, NOx, PM_{10}).
- Fuel use.
- Agency efficiency and productivity.
- Capital, operating, and maintenance costs.
- Benefit-cost ratios.

For more information: Available through the University of Florida McTrans, website: http://mctrans.ce.ufl.edu/featured/idas/

TDM ROI Calculator

The TDM Return on Investment Calculator (TDM ROI) was developed by LDA Consulting and is now provided by the research-and-development based initiate, Mobility Lab. The informaiton in the TDM ROI Calulator builds upon earlier work in Arlington, the Washington D.C. region, and elsewhere to help users calculate vehicle trips and miles travelled reduced by their TDM programs and to calculate benefit-cost ratios or ROI. The calculator is a spreadsheet-analysis method and a user manual that together can be used to deploy the TDM ROI Calucator in one's area.



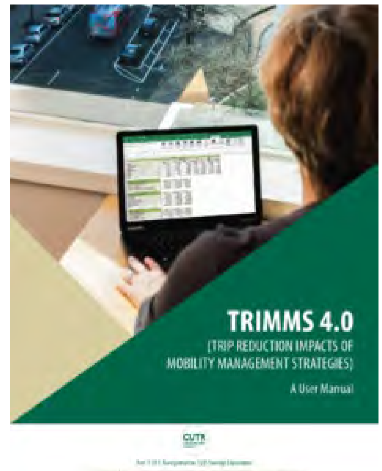
For more information: https://mobilitylab.org/calculators/download-tdm-roi-calculator/

TRIMMS™

The TRIMMS (Trip Reduction Impacts of mobility Management Strategies) tool was developed by the National Center for Transit Research and the Center for Urban Transportation Research at the University of South Florida under a grant from the Florida Department of Transportation and the U.S. Department of Transportation. TRIMMS is a visual basic (VB) application spreadsheet model that estimates the impacts of a broad range of transportation demand initiatives and provides program cost effectiveness assessment, such as net program benefit and benefit-to-cost ratio analysis.

TRIMMS evaluates strategies directly affecting:

- Cost of travel, such as public transportation subsidies, parking pricing, pay-as-you-go pricing, and other financial incentives like commuter mode subsidies in the form of cash, discount passes, and vouchers.



- Employer-based program support strategies, such as TDM program support initiatives, alternative work schedules, telework and flexible work hours, and worksite amenities (e.g., provision of childcare facilities and the presence of sidewalks connecting transit stops within or nearby the worksite), rideshare matching services, the provision of guaranteed ride home or emergency ride home for vanpool and carpool users; vanpool formation support; program promotion; and employee transportation coordinators.
- Estimating the impact of land-use controls on transit patronage levels. These strategies include land-use policy changes affecting gross population density and retail establishment density levels, transit station accessibility improvements, and transit-oriented development initiatives. The approach to estimate changes in transit demand levels is based on constant-elasticity demand functions

TRIMMS predicts mode share and VMT changes brought about by the above TDM initiatives using constant elasticity of substitution (CES) trip demand functions. These functions estimate changes from baseline trip demands taking into account users' responsiveness to changes in pricing and travel times. The evaluation of program support strategies is based on regression equation coefficients that are weighted based on the relative strength of program support strategies and pricing strategies.

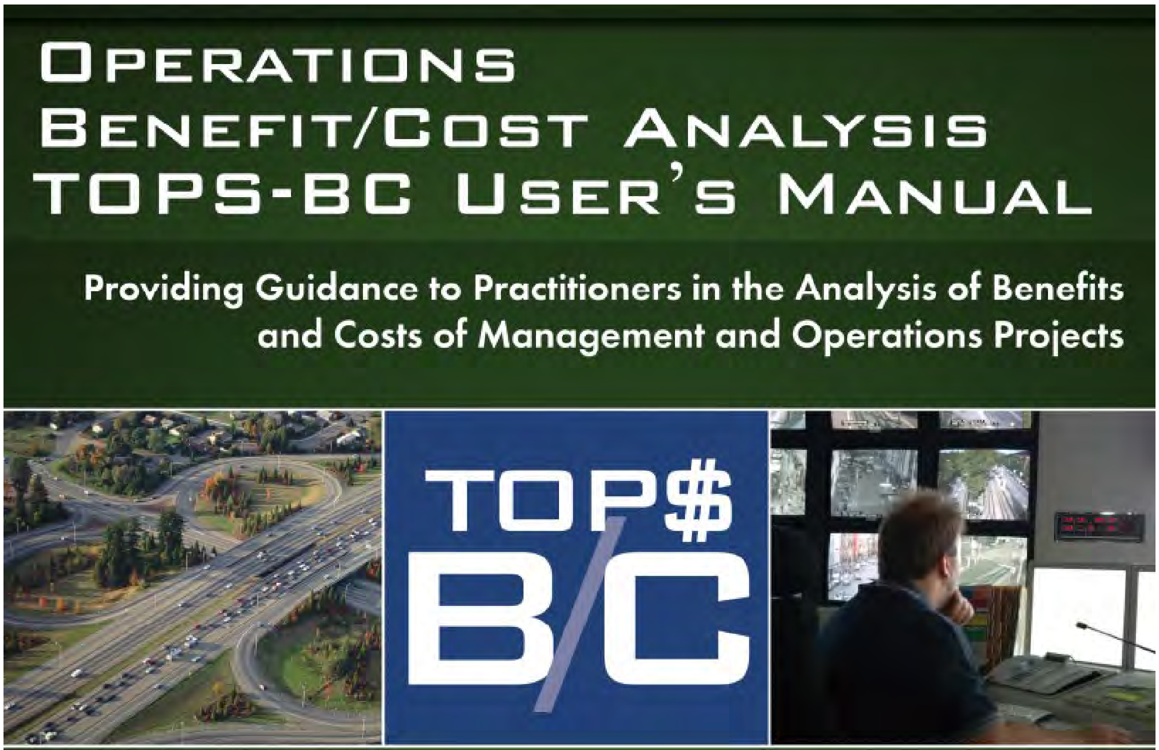
Starting from a baseline scenario describing a TDM program in terms of commuter travel behavior (mode shares, average trip lengths, peak and off-peak spreads), TRIMMS evaluates the impacts of TDM implementation by estimating changes in travel behavior (mode shares, VMT reductions). Changes in the baseline scenario are then used to estimate changes in the external costs associated with these travel behavior changes.

For more information: http://trimms.com/

Tool for Operations Benefit Cost Analysis (TOPS-BC) *

**[text is largely taken from the tool's webpage]*
As part of the USDOT Planning for Operations Initiative, the FHWA Office of Operations offers the Tool for Operations Benefit-Cost Analysis (TOPS-BC). TOPS-BC is companion resource to FHWA's Operations Benefit / Cost Desk Reference - https://ops.fhwa.dot.gov/publications/fhwahop12028/index.htm.

TOPS-BC is a sketch-planning level decision support tool developed by the FHWA Office of Operations. It is intended to provide support and guidance to transportation practitioners in the application of benefit/cost analysis (BCA) for a wide range of Transportation System Management and Operations (TSMO) strategies. The tool was developed based on guidance and input from planning and operations practitioners with the primary purpose to help in screening multiple TSMO strategies and for providing "order of magnitude" BCA estimates.



Although the tool contains default parameters, sketch methods for estimating impacts of investments (e.g., change in travel speeds or crashes), and procedures for monetizing those impacts, users are encouraged to use local data or data derived from more robust traffic, safety, or cost models. Even in these cases, however, TOPS-BC can be used to provide a framework for organizing and cataloguing the various benefit and costs elements.

For more information: https://ops.fhwa.dot.gov/plan4ops/topsbctool/index.htm

Vehicle Technology Scenario Models

GREET and VISION Models and the AFLEET Tool

The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) model is designed primarily for analyses of advanced technology and alternative fuel vehicles. GREET was developed as a multidimensional spreadsheet model in Microsoft Excel to fully evaluate energy and emission impacts of advanced vehicle technologies and new transportation fuels. It includes the fuel cycle from wells to wheels and the vehicle cycle through material recovery and vehicle disposal. It allows researchers and analysts to evaluate various vehicle and fuel combinations on a full fuel-cycle/vehicle-cycle basis. It allows analysis and comparison of various vehicle and fuel combinations on a full fuel-cycle basis. GREET was updated in October 2017, with an accompanying Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET) Tool. AFLEET has been designed for Clean Cities stakeholders to estimate petroleum use, emissions, and cost of ownership of light-duty and heavy-duty vehicles using simple spreadsheet inputs.

VISION was developed to provide estimates of the potential energy use, oil use and carbon emission impacts of advanced light and heavy-duty vehicle technologies and alternative fuels through the year 2050. Beginning in 2008, the analysis horizon has been extended to 2100. The model consists of two Excel workbooks: a base case of U.S. highway fuel use and carbon emissions to 2050 (to 2100 in 2008 and newer versions) and a copy (of the base case) that can be modified to reflect alternative assumptions about advanced vehicle and alternative fuel market penetration.

Vehicular emissions of baseline gasoline and diesel vehicles are based on MOBILE and PART5. Sulfur oxide (SO_x) emissions are calculated from the sulfur contents of fuels, CO_2 emissions from carbon balance, and nitrous oxide (N_2O) emissions are assumed with emissions testing results and technology potentials. VISION consists of more than 100 fuel production pathways and 70 vehicle/fuel systems. Both the GREET and the related VISION models are developed and maintained by Argonne National Laboratory and updated annually to reflect The US DOE, Energy Information Administration's, Annual Energy Outlook projections extended through 2100.

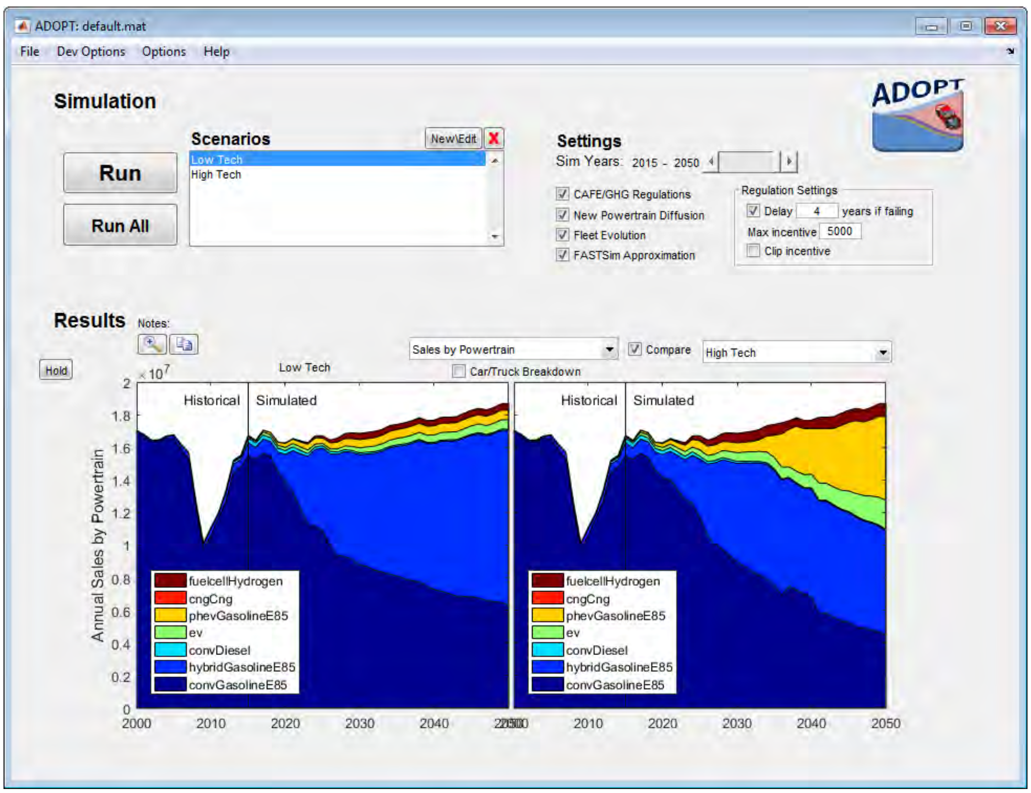
Insofar as GREET and outputs from GREET are used with other Oregon models, Oregon DEQ recommends using a version of the program with Oregon-specific parameters, OR-GREET 3.0. The program can provide updated certified individual fuel pathways to ODOT and others. The program has also calcualted individual grid mixes for a number of Oregon's electrict utilities based on GHG Reporting Program data.

For more information:
GREET Model: http://greet.es.anl.gov/
Oregon Clean Fuels Program and OR-GREET Model:
https://www.oregon.gov/deq/aq/programs/Pages/Clean-Fuel-Pathways.aspx
AFLEET Tool: https://greet.es.anl.gov/afleet
VISION Model: http://www.anl.gov/energy-systems/project/vision-model
Oregon DEQ Carbon Intensity Calculations for Electricity Used in the Clean Fuels Program: https://www.oregon.gov/deq/FilterDocs/cfp-electrutil.pdf

Automotive Deployment Options Projection Tool (ADOPT)

ADOPT is a light-duty vehicle consumer choice and stock model, developed by National Renewable Energy Lab (NREL), US Department of Energy. It estimates vehicle technology improvement impacts on future U.S. light-duty vehicle sales, energy use, and emissions. ADOPT provides consumer choice estimates based on questions like:

- How much impact do lower battery prices have on electric vehicle sales?
- How quickly would the market adopt a co-optimized engine/fuel combination that achieves a 10% efficiency improvement?
- How do fuel prices impact the electric vehicle/plug-in hybrid electric vehicle sales mix?
- How does vehicle light weighting impact powertrain sales?



Starting with the majority of existing vehicle makes, models, and trims to fully represent the market, ADOPT applies numerous inputs—technology improvements, fuel prices, and vehicle purchase incentives—over time. ADOPT then estimates sales based on the variable weighted value of key attributes, including vehicle price, fuel cost per mile, acceleration, size, and range. ADOPT also considers consumer income level as well as regulations and standards that influence sales and average fuel economy.

ADOPT incorporates the FASTSim vehicle powertrain model to apply specified technology improvements to vehicles over time, and to create new model options by combining high-selling powertrains and high-selling vehicle platforms.

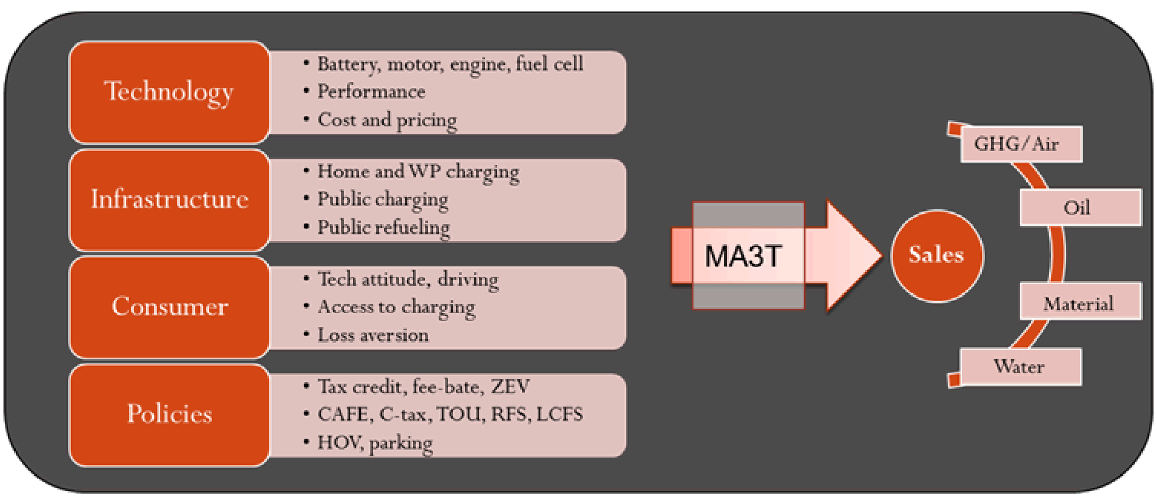
ADOPT could be used to estimate alternate vehicle mix scenarios for use with VisionEval or MOVES models.

For more information:
ADOPT: https://www.nrel.gov/transportation/adopt.html
FASTSim: https://www.nrel.gov/transportation/fastsim.html

Market Acceptance of Advanced Automotive Technologies (MA³T)

The Oak Ridge National Laboratory developed Ma3T model for the DOE Vehicle Technologies Program, to simulate the diverse purchasing behaviors among individuals in the market place. MAT3 estimates market acceptance as a function of technology, infrastructure, behavior and policy, including modeling the effect of a wide range of charging options and effective electric battery range limitations. The framework integrates various data and behavioral models at varying appropriate levels of detail. In addition to vehicle sales mix, MA^{3}T outputs include emissions, oil, materials and water usage covering 2005-2050.
The model is available as a free download.

Implemented using Microsoft Excel for Windows, MA^{3}T simulates market demand for advanced vehicle technologies by representing relevant attributes of technologies and consumer behavior such as technological learning by doing, range anxiety, access to recharging points, daily driving patterns, and willingness to accept technological innovation. MA^{3}T projections capture the temporal interaction between market penetrations and product diversity and risk. MA^{3}T characterizes daily driving distance variation with the Gamma distribution, validated with real-world high-resolution travel data. MA^{3}T explicitly quantifies range anxiety for electric vehicles and reflects the effect of charging and refueling infrastructure on the appeal of plug-in electric vehicles and alternative fuel vehicles.



For more information: https://www.ornl.gov/content/ma3t-model

Other National Tools/Resources

There are a seemingly endless number of tools and resources available from national, state, local, and private sources, from across the United States and the world. In addition, this list is always growing and changing. It would not be possible to list all tools and resources related to GHG. Therefore, this Other Tools / Resource section focuses just on the other tools and resources that ODOT is aware of and that are worth a brief highlight. The following is a brief blurb on a little over a dozen additional resources that are on ODOT's radar.

The EPA is a main source of GHG related tools and resources. The EPA website provides the following GHG analysis tools. See their website for further information and for additional tools and resources: https://www.epa.gov/state-and-local-transportation/estimating-road-greenhouse-gas-emissions

- Smart Growth Index (https://www.epa.gov/smartgrowth/smart-growth-index)
  The US EPA's Smart Growth Index is a GIS sketch model for simulating alternative land-use and transportation scenarios and evaluating their outcomes using indicators of environmental performance.
- Travel Efficiency Assessment Method (TEAM) (https://www.epa.gov/state-and-local-transportation/epas-travel-efficiency-assessment-method-team-development-and-case)
  EPA developed TEAM to assess the potential of travel efficiency strategies (such as commuter programs, land-use changes, transit improvements, increased parking charges, road pricing, etc.) to reduce criteria pollution and GHG emissions. TEAM uses regionally derived travel model data and other travel activity information, sketch-planning analysis and MOVES (discussed above) to estimate emission reductions in a less resource intensive manner than approaches that rely on traditional travel demand forecasting models.
- SmartWay FLEET Performance Model (https://www.epa.gov/smartway)
  Used to conduct assessments of the environmental performance of fleet (truck) operations, and calculate additional fuel savings and emission reductions (carbon dioxide, CO2; nitrogen dioxide, NOx; and particulate matter, PM) that can be achieved through a range of options and strategies.
- Diesel Emissions Quantifier (https://cfpub.epa.gov/quantifier)
  Characterizes a truck or bus fleet and calculate the tons of emission reductions (carbon monoxide, CO; CO2; NOx; hydrocarbons; and PM) that a retrofit project will generate.
- Airport Ground Support Equipment (https://www.epa.gov/state-and-local-transportation/transportation-related-documents-state-and-local-transportation#airports)
  A spreadsheet tool that provides users with a quick analysis of the emission benefits and cost-effectiveness of controlling Airport Ground Support Equipment (AGSE) emissions.

California has always been several years ahead of Oregon in relation to GHG monitoring and analysis. Because of this ODOT staff try to learn and borrow as much as possible from work and efforts already completed in and for California. The California Air Resource Board (CARB) website provides various links to the technical methodology and evaluation of tools used by California MPOs for compliance with CARB regulation of SB375 GHG Reduction targets, including the following. For more information, see:
https://www.arb.ca.gov/cc/sb375/sb375.htm
https://www.epa.gov/smartgrowth/tools-and-resources-sustainable-communities#transportation

- California Emission Estimator Model (CalEEMod) (http://www.aqmd.gov/caleemod)
  CalEEMod is a statewide land use emissions computer model designed to provide a uniform platform for government agencies, land use planners, and environmental professionals to quantify potential criteria pollutant and greenhouse gas (GHG) emissions associated with both construction and operational from a variety of land use projects. CalEEMod replaces the URBEMIS model.

- "Quantifying GHG Mitigation Measures:
  (https://www.arb.ca.gov/cc/capandtrade/auctionproceeds/capcoa_quantifying_ghg_measures.pdf)
  A Resource for Local Government to Assess Emission Reductions from Greenhouse Gas Mitigation Measures" (August 2010), prepared by CAPCOA with the Northeast States for Coordinated Air Use Management, National Association of Clean Air Agencies, Environ, and Fehr & Peers. The California Air Pollution Control Officers Association (CAPCOA), a non-profit association of the 35 local air quality agencies in California, prepared a document literature review which provides various simple rules-of-thumb for quantifying the impact and cost of various community actions on VMT and GHG.

- Further California research links and resources of interest:
  https://arb.ca.gov/cc/sb375/policies/policies.htm
  https://ww2.arb.ca.gov/research/research-land-use-and-transportation-planning
  https://www.arb.ca.gov/msprog/clean_cars/clean_cars_ab1085/clean_cars_ab1085.htm

The following are additional tools and resources that have been brought to ODOT's attentions from a number of sources. One of those resources is the Council on Environmental Quality (CEQ), which in 2016 provided a non-exhaustive summary of GHG accounting tools, methodologies, and reports for informational purposes. Some of the following are from that report, others have been brought to ODOT's attention from a variety of sources. More on the CEQ 2016 guidance can be found here:
https://obamawhitehouse.archives.gov/administration/eop/ceq/initiatives/nepa/ghg-guidance

- Smart Location Calculator (https://www.slc.gsa.gov/slc)
  Where people work has an enormous impact on their daily commute. Workplaces that are centrally located in walkable neighborhoods with great transit service and a variety of nearby destinations enable employees to rely less on their personal vehicles

for commute and daytime trips. This can result in less driving and less greenhouse gas emissions. The Smart Location Calculator is a simple tool for exploring how workplace location affects worker commute travel. Indicators include worker commute greenhouse gas emissions, mode-share, vehicle miles traveled, and workplace accessibility via transit. The Calculator provides a Smart Location Index (SLI), which ranges in value from 0-100, where 0 indicates the least location efficient site in the region, and 100 indicates the most location efficient site. These scores are relative to the region, and should not be compared across regions,

- Infrastructure Carbon Estimator (ICE) (http://www.fhwa.dot.gov/environment/climate_change/mitigation/tools/carbon_estimator/index.cfm)
  ICE was designed with the specific intent of helping practitioners evaluate various GHG impacts associated with roadway projects, including roadway materials, operation of construction equipment, roadway maintenance, and (with user input) changes in tailpipe emissions associated with construction delay and changes in tailpipe emissions resulting from improved pavement smoothness.

- Transport Emissions Evaluation Models for Projects (TEEMP) (https://www.itdp.org/what-we-do/climate-and-transport-policy/transport-emissions-evaluation-models-for-projects)
  TEEMP, a tool applied within and outside the US by the Institute for Transportation and Development Policy, is a suite of Excel-based spreadsheet models that can evaluate emissions resulting from many types of transportation projects, primarily at the local government level. The TEEMP sketch models enable the estimation of emissions in both 'project' and 'no-project' scenarios and can evaluate short- and long-term project impacts.

- Energy Policy Simulator, Vensim (https://us.energypolicy.solutions/scenarios/home)
  A computer simulation using systems dynamic feedback was leveraged to quickly quantify various multi-sector GHG reduction policies nationally. The simulator includes transportation policies on vehicle and fuel programs, as well as simplified demand management in an easy to use user interface.

- Commute Mode Switching Tool (https://www.energy.gov/eere/femp/downloads/commute-mode-switching-impact-tool)
  The US Department of Energy provides the Commute Mode Switching Impact Tool, a narrowly focused Excel tool to translate user-input mode changes or telework activity into GHG emission changes. This tool, which is intended to help Federal agencies project the impact that changes in employee commute modes would have on commute emissions, may also be of interest to other large organizations and agencies with worksites in metropolitan areas.

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APPENDIX C: OREGON GREENHOUSE GAS SCENARIO PLANNING AND TARGET- SETTING PROCESSES

Several GHG target setting processes apply to Oregon:

- Multi-sector Statewide GHG: The Oregon legislature (HB 2001/SB1059) set an overall multi-sector target of 75% reduction
- Metropolitan GHG reduction targets for MPOs, to achieve the statewide goals (2017 ORS 468A.205)
- City climate reduction ordinances
- Intergovernmental Panel on Climate Change (IPCC) GHG reduction goals

In response to these targets, ODOT and various local agencies have developed transportation or multi-sector GHG strategies, i.e., a scenario or set of key paths that lay out a mix of policies that, if implemented, would be expected to meet GHG reduction targets. Examples of GHG strategies include the following (the tools used in these efforts are noted):

- **Statewide Transportation Strategy** - In 2012 ODOT completed a broad multi-agency stakeholder process to arrive at a recommended scenario that met legislatively-mandated GHG reductions by 2050 for the transportation sector. This Statewide Transportation Strategy (STS) assumes a number of targets for investments and policy actions of state and local agencies, combined with federal actions, and consumer and market trends. Progress towards the STS is monitored every five years, tracking adopted plans against the recommended investment and policy targets. The most recent monitoring was reported to the Oregon Transportation Commission in April 2-18. The STS strategies have informed scenario planning targets and metrics that can be helpful in scenario planning and monitoring. This process used the VisionEval tool for ground (light duty vehicles), and other methods for freight and air transportation. The process is validated to statewide fuel sales, VMT (from HPMS), and vehicles (form DMV).
    - **Tool**: Statewide VisionEval, applied by ODOT
    - **For more information**: https://www.oregon.gov/ODOT/Planning/Pages/STS.aspx

- **Metropolitan Area Scenario Planning Strategies** - Several Oregon MPOs have engaged in scenario planning processes with support from the OSTI program, evaluating alternative scenarios to meet state-mandated GHG targets for metropolitan areas. Using the VisionEval family of tools, these efforts have resulted in communities adopting or otherwise indicating a preferred path for meeting GHG targets, representing a mix of policy actions. Scenario planning for GHG is mandated for the large metropolitan areas of Central Lane MPO and

Portland Metro, and voluntary for smaller MPOs. CAMPO and RVMPO have both undertaken voluntary GHG scenario planning efforts in recent years. CLMPO is currently in the midst of their scenario planning effort, which is described further below. Metro's strategy, which was completed in 2014, is also described in further detail below.

  - **Tool**: Metropolitan VisionEval Tool, applied by OSTI (ODOT and DLCD) in collaboration with local MPO with input from local jurisdictions.
  - **For more information** on various OSTI scenario planning efforts: https://www.oregon.gov/ODOT/Planning/Pages/Strategic-Assessment.aspx
    MPO Targets: https://www.oregonlaws.org/ors/468A.205

- **Central Lane Sustainable Transportation Initiative (In Process) -** CLMPO is working with ODOT and DLCD on a Strategic Assessment that is intended to guide the policy development and investment strategy options of the upcoming CLMPO Regional Transportation Plan update. The purpose of the Strategic Assessment is to build upon the results of Central Lane Scenario Planning (CLSP) work and the Eugene Transportation Plan scenario findings to test and quantify what regional policies, programs and investment actions, grouped to make scenarios, will allow the MPO to achieve its long range local and State planning vision and goals. Scenarios based upon local Transportation System Plans, CLMPO planning documents, CLSP work and local partner jurisdiction direction will be modeled to determine what the future may look like (i.e. the outcome of plans and trends). The scenarios will be analyzed to determine a suite of outcomes the MPO area may expect from implementing different policy choices, including, but not limited to: mode share, vehicle miles traveled, public health, greenhouse gas and fossil fuel emissions, sustainability, resilience to emerging trends, shared autonomous vehicle impacts, and equity. Results will be shown for the year 2045 and potentially beyond.
  - **Tool**: Metropolitan VisionEval Tool.
  - **For more information** on CLMPO's scenario planning work: http://www.thempo.org/367/Sustainable-Transportation-Initiative
- **Portland Region Climate Smart Strategy (2014) –** In 2015, the Oregon Land Conservation and Development Commission approved the Portland metropolitan area's plan – called the Climate Smart Strategy – for reducing greenhouse gas emissions from passenger cars and trucks. Developed in partnership with ODOT and local and regional partners, the Climate Smart Strategy defines the Portland region's approach for reducing greenhouse gas emissions and VMT. The strategy relies on a multi-pronged approach of policies, investments and actions that include transit-oriented development and walkable communities with job centers, compact land use, expanding travel options to increase walking, biking, and use of transit, implementing new technologies and other system management strategies to minimize idling and congestion, as well as household and commuter travel information programs, incentives and trip reduction services. The strategy

also calls for supporting state efforts to accelerate electric vehicle adoption and transition to cleaner, low carbon fuels and more fuel-efficient vehicles. Other regions have adopted transportation-focused energy reduction goals. These types of regional approaches can help the state meet its overall emissions and fuel use reduction goals if implemented and advance implementation of the STS.

- **More information** about Metro's strategy can be found here: https://www.oregonmetro.gov/sites/default/files/2015/05/29/ClimateSmartStrategy-FinalVersion-2014.PDF

- **City Climate Action Plans** - Several Oregon MPOs have engaged in city-wide efforts to inventory GHG emissions, consider the impact of various actions, and map a plan to multi-sector GHG reduction, often called a Climate Action Plan. These plans identify actions by the city, both internal operations and otherwise, to reduce GHG emissions. In some cases, these actions are driven by City GHG or fossil fuel reduction ordinances (e.g., Eugene's 2014 Climate Recovery Ordinance)
    - **Tool**: ICLEI or CAPCO applied by consultant in collaboration with local jurisdiction. ODOT has assisted with VisionEval inputs for transportation.
    - **For more information:** See local agency websites

- **City GHG Inventories**. While not a specific strategy, GHG inventories developed by cities can provide context for understanding how cities contribute to climate change, providing context and goals for GHG reduction over time, while also educating on the potential GHG reduction strategies and their effectiveness.
    - **Tool**: EPA GHG Inventory Tools, either in-boundary or consumption-based.
    - **For more information**: See local agency websites
      Metro (Portland (rev.2015), Beaverton (2014), Gresham (2011), McMinnville (2009), Milwaukie (2009)), Eugene (2014), Ashland (2017), Corvallis (2017), Bend (2018)