Model Integration in GreenSTEP and LUSDR

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Outline

• Introduction: Focusing on Strategic Planning
• LUSDR: Land Use Scenario Development
• GreenSTEP: Greenhouse gas Strategic Transportation Energy Planning model
• Model Integration in LUSDR and GreenSTEP
• New Integrated Modeling Framework
Introduction: Focusing on Strategic Planning

**PAST:** Simpler times encouraged the focus of planning to be on tactics for addressing metropolitan needs and problems.

Fairly regular long-term trends of increasing incomes, automobility, metropolitan population, metropolitan spread, and VMT.

Stable supplies of environmental capital: hydrocarbon fuels, minerals, water, arable land, and waste disposal capacity.

**FUTURE:** Disruptions to past trends make forecasting very complex and uncertain and require a strategic approach to planning.

Destabilizing environmental foundations: sea levels, water availability, natural productivity, ...

Shifting to carbon-neutral energy production and sustainable economic development.

Disruptive technologies (e.g. self-driving cars).
LUSDR Development Context: Rogue Valley Regional Problem Solving

- Insufficient land within urban growth boundaries to accommodate projected future growth.
- Potential that competition among jurisdictions would lead to over commitment of farm land to urban growth.
- Regional Problem Solving: Collaborative decision-making to identify urban growth reserves.
- ODOT interested in the transportation implications.
Why LUSDR?

• Travel models require specific population and employment allocations.
• Developing allocations through a consensus process is very time consuming.
• Much uncertainty due to:
  • Nature of land development;
  • Generality of urban reserve areas; and,
  • Long planning time frame.
Modeling uncertainty provides a more realistic perspective on growth

Household Forecasts for 45 LUSDR Scenarios

.median range

Simulation starting at 2005

RTP 2030 allocation

Simulation starting at 2035
Modeling uncertainty increases information

Traffic Volumes

Legend
- Urban Growth Area
- Urban Reserve
- Freeway
Example: Relationship of Employment Growth to Freeway Ramp Congestion

- Relatively More Employment With More Ramp Congestion
- Relatively More Employment With Less Ramp Congestion

Added Employees By Model Zone:
- 0 - 5
- 5 - 10
- 10 - 20
- 20 - 40
- 40 - 80
- 80 - 160
- 160 - 320
- 320 - 640
- 640 - 1280
- 1280 - 4746
GreenSTEP Development Context

• Oregon’s legislature adopted multiple requirements for planning to reduce GHG emissions at state and metropolitan levels.

• Oregon Global Warming Commission (OGWC) requested modelers to develop tools for evaluating a broad range of potential GHG reduction actions.

Establish goal to reduce GHG emissions 75% below 1990 level by 2050.

Require Oregon Transportation Commission to adopt a statewide transportation strategy for reducing transportation GHG emissions.

Require Land Conservation & Development Commission to adopt metropolitan area targets for reducing GHG emissions from light-duty vehicle travel.

Require MPOs to develop plans to reduce GHG emissions from light-duty vehicles.
Existing transportation models did not address many important interactions
GreenSTEP Policy Sensitivity

- Demographic and income changes
- Relative amounts of development occurring in urban and rural areas
- Metropolitan and other urban area densities
- Urban form (i.e. mixed-use)
- Amounts of metropolitan area public transit service
- Highway capacity
- Vehicle proportions: autos, light trucks, EVs, PHEVs

- Vehicle ages
- Vehicle fuel efficiency
- Pricing of fuel, carbon, VMT, parking
- Use of bicycle & other light-weight vehicles
- TDM and eco-driving
- Effects of congestion on fuel economy
- Lifecycle carbon content of fuels
- CO2 production from electrical power use for transportation
GreenSTEP models at the household level

Household level modeling is important because:

Interactions between factors can have synergistic or antagonistic effects on household travel and emissions.

Policies and conditions (e.g. fuel prices) will affect households unequally.

Household level modeling simplifies transferal to different geographic scales.

**Household Budget Model**

**Rebound Effect Depends on Prices**

<table>
<thead>
<tr>
<th></th>
<th>Year 2001 Prices</th>
<th>4 x Year 2001 Prices</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPG Change</td>
<td>+10%</td>
<td>+10%</td>
</tr>
<tr>
<td>VMT Change</td>
<td>+0.1%</td>
<td>+3.7%</td>
</tr>
<tr>
<td>Fuel Change</td>
<td>-9.9%</td>
<td>-6.1%</td>
</tr>
</tbody>
</table>
GreenSTEP supports broad explorations of decision spaces

Useful for:

Backcasting: Help identify alternative ways of achieving goals.

Education: Improve understanding of how parts of the system affect each other and their relative effects.

Building Consensus: Help stakeholders to understand how their interests are part of a connected whole.
Model Integration Approaches in LUSDR and GreenSTEP

• Data processing, exploratory analysis, model estimation, model implementation, and model control in R.
  • Agile modeling approach

• All model modules written in R.

• Modules interact through common data structures (binary R datasets).

• R scripts control all processes. No GUI, except for the standard R console. Focus is on scripting to automate running many scenarios.

• Modules are loosely coupled - estimated parameters are not interdependent.
  • Facilitate adaptation and extension
Adaptability of GreenSTEP platform

GreenSTEP

Regional Strategic Planning Model (RSPM)
- ODOT’s model to support metropolitan area scenario planning.
- Developed by Brian Gregor.

Energy and Emissions Reduction Policy Analysis Tool (EERPAT)
- FHWA’s model to analyze state transportation GHG reduction scenarios.
- Developed by RSG.

SmartGAP
- FHWA’s model to support metropolitan area smart growth planning.
- Developed by RSG.
New Framework for GreenSTEP, LUSDR, Etc.

**Framework**

**SERVICES**
- Initialize model data store
- Check that model data dependencies are satisfied
- Retrieve data from storage
- Write data to storage
- Run model modules
- Manage errors
- Calculate performance measures from data store

**DATA STORE (HDF5)**
- **Data Groups**
  - Household Characteristics
  - Vehicle Characteristics
  - Place Characteristics
- **Metadata**

**Models**

**MODEL SCRIPT**
1. initializeModel ("HighGasPrice")
2. run ("SynthesizeHH", package="HH")
3. run ("PredictWkr", package="HH")
4. run ("PredictInc", package="HH")
5. run ("PredictAuto", package="Auto")
6. run ("PredictVMT", package="Travel")

**PACKAGES**
- **HH Modules**
  - SynthesizeHH
  - PredictWkr
  - PredictInc
  - Documentation
- **Travel Modules**
  - SynthesizeHH
  - PredictWkr
  - PredictInc
  - Documentation
- **Auto Modules**
  - SynthesizeHH
  - PredictWkr
  - PredictInc
  - Documentation

**Services**
- Simple declarative script for combining modules into model
- Module developers combine modules into R packages
- Compiled code (e.g. Fortran, C++, Java) can be included
Acknowledgements and Contacts

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Development of Ground Passenger Scenarios

Urban
- UGB expansion
- Transit service (4x pop. growth)
- TDM (65% PDX hh & 40% of employers)
- Parking pricing (+30% pay to park)
- 30% mode shift (for trips of <6 mi.)

Tech
- 30% mode shift (for trips of <6 mi.)
- PHEV & EV (+30%)
- Renewable energy
- Fuel carbon intensity (-20%)
- Light truck ownership (-29%-36%)

System Optimization
- Transit service (4x pop. growth)
- Max System Ops & Mgmt.
- Fuel efficiency priority (80% hh)
- Carsharing rates up: high density (1/2,500), medium density (1/5,000)
- TDM (65% PDX hh & 45% employers; more telecom.)
- Speed smoothing
- 30% mode shift (for trips of <6 mi.)

Pricing
- 100% PAYD insurance
- Parking pricing (+30% pay to park)
- Pay for all external costs (+$0.06 per mi)
- Congestion pricing ($.20/mi)

Combo
- Includes all assumptions

Enhanced Combo
- 40% mode shift from SOV trips of <6 mi. (was 30%)
- More pay for parking and at higher cost
- Ave. vehicle age 7.8 yrs (was 10 yrs)
- Increase in PHEV and EV (43%)
- Increase in TDM
- Commercial services vehicles are all electric or natural gas

Enhanced + Price
- $0.15 per mile
- VMT Tax in addition to other taxes (~$0.06 per mile)

Enhanced + Tech
- Cleaner power generation
- Increase PHEV & EV (53%)
- EVs have longer range (cars = 300 mi)

Enhanced + Price + Tech
- Revenue from PHEV
- New PHEV & EV (53%)
- EVs with longer range (cars = 300 mi)
Light-Duty Vehicle Emissions by Income & Density

Emissions vs. Income

- Higher incomes affected more by technology
- Lower incomes affected more by prices

Emissions vs. Density

- At higher densities, enhanced tech has lower emissions than enhanced price
Aggregate Equilibrium Traffic Model

Traffic Allocation Model

- Total DVMT
- Freeway DVMT
- Arterial DVMT
- Freeway Congestion
- Arterial Congestion
- Split DVMT
- Freeway Operations Programs
- Arterial Operations Programs
- Freeway Lane-Miles
- Arterial Lane-Miles
- Freeway Congestion Prices
- Arterial Congestion Prices
- Freeway Average Speed
- Arterial Average Speed
- Freeway Speed
- Arterial Speed

Iterate to Equilibrium

- Freeway Speed
- Arterial Speed

Aggregate

- Network Average ADT/Lane
- Congestion Levels
  - None
  - Moderate
  - Heavy
  - Severe
  - Extreme
  - Weighted Average
  - Smoothed Spline

Percent of DVMT

0 20 40 60 80 100

10000 15000 20000

Average

- Smoothed Spline