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Integrated Land Use, Travel, and Emissions Model Improvements for Climate Change

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Call for papers on Climate Change Modeling

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Background

Climate change refers to a significant change in long-term weather patterns around the world as measured via temperature, rainfall, wind patterns, etc. Global warming refers to an average global increase in the Earth's temperature. The Earth has a natural greenhouse effect by which greenhouse gases such as carbon dioxide trap heat from the sun and warms the Earth. If not for the greenhouse effect, the Earth would be about 60 degrees cooler. However, more greenhouse gases are being added into the atmosphere, primarily from human activities, causing more heat to be trapped and the earth's surface to warm even further. Carbon dioxide levels are higher now than at any time in the past 650,000 years. The earth's surface temperature has risen by about one degree Fahrenheit - with the last decade being the warmest on record - over the past century.

The primary source of carbon dioxide emissions is the burning of fossil fuels, although changing land use patterns through agriculture and deforestation are also contributing factors. Nationwide, industry represents about 30% of emissions, with transportation coming in second at about 28%. In Washington State, since most of our electricity comes from hydroelectric power, transportation makes up a larger percentage – in the Puget Sound region, transportation contributes more than 50% of all greenhouse gas emissions.

Introduction

The Puget Sound Regional Council is beginning to incorporate the analysis of climate change into our transportation planning processes. The PSRC's VISION 2040 regional growth strategy is one of the first in the U.S. to include climate change as a specific policy to reduce greenhouse gas emissions. The VISION includes the development of a Climate Change Action Plan to achieve this objective. In addition, the Governor of Washington has declared the state's commitment to address climate change with specific targets for reducing greenhouse gas emissions (by 2020, reduce GHG emissions in Washington to 1990 levels; by 2035, reduce GHG emissions in Washington to 25 percent of 1990 levels; and by 2050, reduce GHG emissions in Washington to 50 percent of 1990 levels or 70 percent below our expected emissions that year). The greatest contributor to greenhouse gas emissions in Washington is the operation of motor vehicles. The amount of motor vehicle activity is most commonly measured by Vehicle Miles Traveled (VMT). In order to reduce greenhouse has emissions, we must minimize or reverse the growth in total VMT.

The state of Washington established a Climate Advisory Team (CAT) to recommend mitigations that could achieve reduction in greenhouse gas emissions. The mitigation options to reduce VMT on the transportation system were in some cases strategies that could not be evaluated with the current travel demand forecasting model. As a result, we developed a program to improve our technical capabilities to better represent and analyze transportation and land use strategies and goals, and to help us understand the dynamics of real-world transportation systems. This program is described below, along with the mitigation strategies identified by the Climate Advisory Team and the ability of the model improvements to evaluate these strategies. The PSRC program was developed to address short-term model improvements that could be used in the agency's upcoming transportation plan update

(Destination 2030) and long-term model improvements that could be used to meet the broader objectives of evaluating greenhouse gas emission reductions over the next 40+ years.

High-Priority Mitigation Options

The Washington State Climate Advisory Team identified a list of mitigation options to reduce greenhouse gas emissions[1]. Some of these mitigation options are financial, some are technological, and some are changes to the transportation system; the latter set of options is the focus of the PSRC program to improve the travel demand model, since these are directly related to policies or strategies that can be measured with these tools. These are described below in relation to the set of short-term model improvements envisioned to address these. At the time of the Innovations in Travel Modeling Conference in June 2008, the short-term model improvements will be complete and results can be presented. The long-term model improvements are described as a group following this discussion.

Transit, Ridesharing, and Commuter Choice Programs

The goal of this program is to provide resources to create a transit and ridesharing system that connects activity centers on both an intra-and inter-regional basis for both commute and non-commute travel. As the Puget Sound region moves from a primarily bus-oriented transit system to a mixed bus and rail system, there is a greater need to explore more detailed mode choice models to ensure that the models can accurately predict the modal shifts resulting from new modes. In addition, there is an interest in improving the accuracy of the current ferry mode in the regional model. Currently all transit modes are treated equally in the model, except for changes in service, which is represented by route. There is a need to separate fares by mode and to consider differences in reliability and convenience by mode. Accuracy of the mode choice model will directly affect the estimation of emissions.

We are segmenting the mode choice model into different modes, so that fares and other factors can be considered on a mode by mode basis. This segmenting would be implemented by nesting the current multinomial logit mode choice models for transit modes (local bus, express bus, light rail, commuter rail, and ferry) and nesting the auto modes into those driving on the ferry and those not driving on the ferry. PSRC also has current plans to expand their mode choice model to explicitly recognize reliability and convenience, along with other transit amenities. This will use a transit market segmentation model based on structural equations models and cluster analysis as input to the mode choice model.

Transportation Pricing

Growing traffic congestion, particularly in the urban areas of our state, causes reduced fuel efficiency and increases emissions of greenhouse gases as well as criteria pollutants. The way we pay for transportation influences our decisions on when, where and how we travel, or don't travel. One reason for congestion is that there is little relationship between how a person travels and the cost (personal, social, and environmental) of that travel. Pricing sets a direct economic relationship between the costs and benefits of when, where, and how a person travels.

We are pursuing three different types of short-term model improvements to address this issue of evaluating pricing: adding capability and accuracy to the trip assignment model, adding

[1] http://www.ecy.wa.gov/climatechange/CATdocs/122107_TWG_trans.pdf

capability to the trip generation model, and evaluating the cost of driving. These are described below:

- **Vehicle Assignment** - Emissions models are dependent on accurate speeds and volumes from the regional travel demand models. The PSRC regional travel demand forecasting model has been validated to both speeds and volumes in recent years, but the speed validation requires more rigorous standards to provide more accurate input to emissions models. The aggregate, regional nature of the PSRC travel model limits the ability of the model to accurately predict impacts from bottlenecks and queues on the roadways, but some improvements and tighter speed validation standards can provide needed improvements to the accuracy of the link speeds. We propose to modify the vehicle assignment parameters to better represent speeds in the regional travel model.
- **Tour Generation** - The current trip generation models in the PSRC regional travel forecasting system have some limitations which limit the number of variables that can be used to influence trip-making. As a result, there is no sensitivity in the current models to congestion, tolling, trip chaining, density, accessibility, urban design, age, and life cycle. These variables can clearly affect whether to make a trip or not (including substitutions for working at home, shopping on the internet, etc.) and how many trips and stops are needed to meet daily requirements for activities. We propose to develop tour generation models that can incorporate these sensitivities.
- **Costs of Driving -** The need to accurately represent the cost of driving is very high because these factors have a significant impact on traveler's modal choices. Both parking and fuel costs are estimated for input to the models and both can fluctuate widely and be affected by statewide and national factors, which are outside the sphere of influence of PSRC and its members. Nonetheless, it is important to understand the potential impacts of increasing or decreasing costs and their ultimate impact on emissions. We propose to test the sensitivity of the model to a range of parking costs and gas prices from conservative to a realistic high end. These ranges will then be used to test the sensitivity of the model and predict the potential impacts on vehicle miles traveled and emissions.

The long term solution for evaluating pricing is to disaggregate the travel activities by person and vehicle and integrate this with a meso- or micro-scale dynamic traffic assignment.

Compact and Transit-Oriented Development

The goal of this program is to ensure that growth management plans promote compact and transit-oriented development to reduce VMT and GHG emissions. We propose to address this objective in two ways: with full implementation of a parcel-based land use model integrated with a travel model to assess the impacts of transportation improvements on land use and vice-versa, and with the development of walkability factors to improve the estimation of walk, bike, and transit trips in areas of improved pedestrian environments. These are described below:

- **Integrated Land Use and Travel Model** – PSRC has been developing a parcel-based, market-driven land use allocation model using UrbanSim. This model is implemented to produce changes in land use every year for the next 40 years and at five-year intervals, integrated with the travel model to identify the impacts of accessibility and mobility on land use decisions. We are also migrating some of our travel model components, like vehicle availability and workplace location choice, to the UrbanSim/OPUS framework. The parcel-based detail in the model will produce more accurate assessments of compact and transit-oriented developments than were possible with zone-based models. In addition, the new tools will be able to capture

the impacts of localized improvements in accessibility and mobility, combined with mixed land use opportunities, more accurately.

- **Walk Trips** - Walk trips has been a potential source of error in the model in the past due to their short trip lengths and limited data to identify walk trips. They do, however, have a potentially large impact on emissions because shifting from a short auto trip to a walk trip can reduce emissions. Current mode choice models account only for walk time in estimating walk trips, when urban design, street connectivity, and mixed land use can impact walk trips as well. We propose to use new data sources available at PSRC to create walkability factors, including measures of intersection density, retail floor area, and mixed land uses for each traffic analysis zone to improve the walk, bike, and transit modes in the mode choice model.

The long-term model improvements of applying disaggregate activity models will benefit the accuracy of compact and transit-oriented development tremendously, since the aggregate models assess an average walking distance or transit service to a development and do not measure the improved localized benefits of smaller developments.

Improvement to Freight Railroads and Intercity Passenger Railroads

Rail transport is one of the most energy efficient means to move people and freight over commonly traveled routes on land. The mode choice model improvement for passengers described above for transit programs will also improve the accuracy of the models specifically for rail modes. Our proposed approach is to separate the input data parameters and mode choice models for commuter rail and light rail modes to provide a more accurate representation of these modes. In addition, we are expanding the study area for the region to include several counties to the north and south of the current 4-county Puget Sound region, which will allow a more direct representation of commuter rail opportunities in these areas. The long-term solution for this program is to incorporate analysis of longer-distance passenger rail trips (i.e. those that leave the region) to represent the potential shifts from auto to passenger rail for inter-regional trips.

PSRC currently has a truck/freight model to forecast the movement of freight in the Puget Sound region, but this model does not have a mode choice component to identify the potential to shift from truck to rail if pricing or rail improvements are proposed. Our long-term improvement will include a mode choice component that can more adequately assess the modal options.

Local Transportation Financing Tools and Bicycle and Pedestrian Infrastructure Improvements

There is a growing body of research demonstrating that communities with traditional neighborhood design, connected pedestrian and bicycle networks, available transit and a rich mix of uses are strongly correlated with decreased automobile use[2,3]. Our proposed approach described above for adding walkability factors into the modeling process to better represent walk, bike, and transit trips will directly support the evaluation of new bicycle and pedestrian infrastructure improvements and their ability to capture trips currently made by other modes.

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[2] Lawrence Frank & Company LUTAQH: A Study of Land Use, Transportation, Air Quality and Health in King County, WA, Prepared for the King County Office of Regional Transportation Planning. Seattle WA, December 2005.

[3] Frank, L., G. Pivo. Impacts of Mixed Use and Density on Utilization of Three Modes of Travel: Single Occupant vehicle, Transit, and Walking. TRB 1995; 1466: 44-52.

Long-Term Travel Model Improvements

While the short-term model improvements described above are designed to directly address the new programs identified in Washington to address climate change in the timeframe required by current planning processes, they do not represent the ideal solution for evaluating climate change. Our proposed long-term model improvements involve migrating from an aggregate trip-based travel model to a disaggregate tour-based activity model. This activity model will be integrated with our disaggregate land use allocation model and the future EPA disaggregate MOVES model to estimate emissions for each vehicle, based on the travel behavior of each person, which is based on the long-term choices of each household and firm in the region. These integrated models can also be used with traffic micro-simulation models to more accurately represent traffic operations for pricing strategies. This level of disaggregation produces significantly more accurate estimates of emissions, because the averages do not adequately predict the distribution of emissions for all vehicles.

Emissions Models

The PSRC is actively pursuing improved modeling capabilities for the analysis of CO2 and other greenhouse gas emissions as part of the transportation plan update (Destination 2030). The existing EPA emissions model is capable of analyzing CO2 at only the broadest level, and we are working with EPA and FHWA on utilizing the new MOVES model prior to its official release, estimated to be in fall 2008. The new model will have the ability to produce CO2 emission factors by speed and allow for more detailed analyses. In partnership with EPA and FHWA, we are asking to serve as a pilot project for the model, to begin in spring 2008 in time for the analysis of alternatives for the Destination 2030 update.