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Climate Change in Travel Demand Models

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Introduction

Metropolitan Planning Organizations (MPOs) and its policy boards are required to develop a metropolitan long-range transportation plan (LRTP) with at least a 20-year horizon and a short-range Transportation Improvement Program (TIP) comprising projects drawn from the long-range plan *(1)*. In developing these transportation plans and programs, MPOs need to consider the following seven factors *(2)*:

- (1) Support the economic vitality of the metropolitan area; (2) Increase the safety and security of the transportation system; (3) Increase the accessibility and mobility options available to people and for freight; (4) Protect and enhance the environment, promote energy conservation, and improve quality of life; (5) Enhance integration and connectivity of the transportation system, across and between modes, for people and freight; (6) Promote efficient system management and operation; and (7) Emphasize system preservation.

In order to meet this mandate, MPOs are required to develop travel demand models that forecast the population and employment growth and demand on the transportation system as a result of infrastructure investments in the LRTP and TIP. In addition, travel models have incorporated air quality assessment in order to ensure that LRTPs conforms to state air quality implementation plans (SIPs) for meeting national air quality standards. Travel models have been central in helping MPOs meet their statutory responsibilities and recent advances in travel models have helped provide a more behaviorally sound basis for forecasting travel. However, changes in the atmospheric concentration of greenhouse gases (GHGs) and aerosols, land cover and solar radiation alter the energy balance of the climate system. These changes to the climate system have a potentially long term impact on the validity of forecasts projected by travel models leading to misallocation of resources by MPOs. This white paper is an attempt to explore how to account for these climate change impacts in travel models.

Impacts of Climate Change

Transportation, a key component of economic development, is increasing with growth in population and employment opportunities across the United States. For policymakers attention is on the most pressing problems such as increased congestion, traffic fatalities, and injuries, air pollution, and petroleum dependence associated with this growth. The issue of mitigating the long term effects of GHGs in terms of altering the climate system tends to be pushed to the backburner. Institutional and cultural barriers prevent implementation of policy measures to change travel behavior especially as related to a global phenomenon like climate change. Further exacerbating the issue is the fact that transportation predominantly relies on petroleum which supplies 95% of the total energy used by various transportation modes and these are responsible for 23% of world energy related GHC emissions with about three quarters coming from road vehicles. Over the past decade, transportation's GHG emissions have increased at a faster rate than any other energy using sector *(3)* and it is projected that with current policies and practices in place, global GHG emissions will continue to increase over the next several decades. The

Intergovernmental Panel on Climate Change (IPCC) projects that continued GHG emissions at or above the current rates would cause further warming and induce global climate change during the 21st century that are likely to be larger than observed during the 20th century *(4)*.

While climate change is a global phenomenon, the impacts of climate change will be different in different regions around the world. In North America, the annual mean warming is likely to exceed the global mean warming in most areas. Seasonally, warming is likely to be largest in winter in northern regions and in summer in the southwest. Minimum winter temperatures are likely to increase more than the average in northern North America. Maximum summer temperatures are likely to increase more than the average in the southwest. Annual mean precipitation is very likely to increase in Canada and the northeast United States, and likely to decrease in the southwest. In southern Canada, precipitation is likely to increase in winter and spring but decrease in summer. Snow season length and snow depth are very likely to decrease in most of North America except in the northernmost part of Canada where maximum snow depth is likely to increase *(5)*.

The increased warming in the southwest is going to lead to reduced snow pack and further exacerbating the stress on water resources in the southwest. Another impact of climate change is an increase in the number, duration, and intensity of heatwaves across major cities leading to adverse health impacts. Communities and habitats along the Atlantic and Gulf coasts face increased hurricane activity and will face further stress because development and pollution have reduced or severely degraded the natural resources that can mitigate the impact of hurricanes.

Policies and Measures to Mitigate Climate Change

A wide array of policies and strategies has been employed to restrain vehicle usage, manage traffic congestion, and reduce energy use, GHGs, and air pollution. The potential exists to greatly reduce transportation energy use and GHG emissions by shaping land use policies, regulatory mechanisms and incentives to encourage alternatives to the automobile, and altering the attributes of vehicles and fuels. These changes not only lead to reduced GHG emissions, but also reduced pollution, traffic congestion, oil use, and infrastructure expenditures and meet environmental justice goals. Some of the popular measures *(3)* to reduce GHG include:

- Land use and transportation planning;
- Taxation and pricing;
- Regulatory and operational instruments (e.g., traffic management, control and information);
- Fuel economy standards; and
- Transportation demand management.

Climate change is a minor factor in decision and policy making among MPOs. Most policies and measures are often primarily for sustainable development benefits that include improvements in air pollution, congestion, access to transport facilities and recovery of expenditure on infrastructure development. Achieving GHG reduction is therefore often seen as a co-benefit of policies and measures intended for sustainable transportation. On the other hand, there are many transportation policies that lead to an increase in GHG emissions. Depending on their orientation, transportation subsidies can do both. Van Beers and Van den Bergh *(6)* estimated that in the mid-1990s transportation subsidies amounted to $225 billion or approximately 0.85% of the world GDP. Transportation subsidies results in artificial reducing the costs of travel by personal automobiles and results in higher emissions, and decreases the incentive to economize by changing travel behavior, The recent increase in petroleum prices in the United States might cause travelers to rethink their travel behavior. Transportation subsidies that definitely raise the level of GHG emissions include subsidies on fossil transport fuels, subsidies on commuting and subsidies on infrastructure investments. However, subsidies on flex fuels, and compressed natural gas tend to decrease emissions of GHGs, provided of course that the VMT remains the same. Also, subsidies on public transportation in the form of reduced fares tend to emit fewer GHGs per passenger-mile.

Incorporating Climate Change in Travel Models

A travel model is an approximation of reality and has uncertainties. Given the central role that travel models play in MPO decision making it is necessary that travel models produce the best possible forecasts for future travel. As stated earlier the effects of global warming can produce widely varying changes in climate to different parts of the United States. Therefore, any MPO developing travel models will have to consider the local effects of climate change in their travel models. Travel models, especially activity based models, can, and are in use to test policy options such as transportation demand management, road pricing analysis, and transit oriented development, and transportation project analysis *(7)*. However, while these models offer a mechanism for testing policy options, they are inherently limited from incorporating direct and indirect affects of climate change. Below are some of the other factors that need to be considered in travel demand models to measure the impact of climate change on forecasting travel demand and infrastructure investment decisions.

Fresh Water Availability. One of the key data elements for travel models is population, employment and school enrollment in the base and forecast years. Climate change and global warming are projected to exacerbate the competition for over-allocated water resources in the western and southwestern United States. In the southeastern United States an extended drought, in all probability due to climate change, is putting undue pressure on the water resources available to the large metro areas. These climatic events are projected to increase in the future if no policy changes are implemented to control for GHG emissions. As a consequence, population projections used to forecast travel demand might be erroneous as the cost of accessing fresh water might be prohibitive leading to a decline in population. Therefore, travel demand models should incorporate projections for fresh water demand and supply to adjust their population projections.

Economic Growth. Another element in travel demand models is projections of employment growth and these tend to be based on macroeconomic forces based on traditional economic thought. Moreover, these projections pivot off from existing and historical trends when climate change was not such a major issue. The question then becomes how does an MPO, especially one whose economy is heavily dependent on climate (agriculture, tourism etc.), account for these changes to its economy in the travel model. Therefore, MPOs should use results from climate change models to access the impacts on their local industries and revise their employment projections accordingly.

Freight Movement. As governments implement measures to counter the effects of global warming and climate change, one of the consequences might be increases in the costs of shipping via trucks and an increase in shipping via alternate modes such as rail or waterways. Freight models which have been traditionally focused on the primacy of trucks will have to start including information about alternate modes such rail and inland waterways (where applicable) as well. This calls for an increased understanding and collection of data about the nature and operations of these modes.

Land Use Implications. Insurance companies, citing climate change, have cancelled existing or refused to write new policies for homeowners who are perceived to be a greater risk in the face of increasing number, intensity and duration of hurricanes, wildfires etc. Traditional land use models assume that development will occur where land is available and desirable without taking climate change and consequent risk modeling into account. LRTPs using this information from land use models and projecting increased development in desirable but hazard prone areas will have to recalibrate their land use and transportation models to account for climate change.

Destination and Mode Choice. Given that governments will act to develop policy measures, mandates and incentives to change travel behavior, destination and mode choice models will have to include climate change affects caused due to changes in the relative disutility of destinations and/or modes. For both mode and destination choice models, climate change can be introduced in the form of accessibility measures in the utility functions.

Traffic Assignment. Travel models are increasing being deployed to plan evacuations due to natural disasters. Given that climate change is likely to lead to increased intensity of these events, it will be necessary to incorporate floodplain and wind data into travel models. This will allow travel models to determine which facilities will be unavailable during a natural disaster evacuation and give first responders a chance to determine routing to escape from natural disasters.

Summary

The central role that travel models play in MPO LRTPs have made it critical that travel models deal with climate change. Various measures have been implemented in travel models to account for air quality and these have the ancillary benefit of mitigating the effects of climate change. However, given the complex, global, and long term nature of climate change it is difficult to determine how to incorporate climate change into a regional and local travel model as each jurisdiction is impacted differently due to climate change. Another issue is that there are institutional barriers to incorporating some of the science and results of climate change and hydrological models into travel models and travel modelers should start working closely with climatologists, hydrologists, and water resource engineers. Given all these obstacles, it is necessary to look at individual components of travel models and determine how climate change affects them and how to incorporate them into the modeling framework. This white paper is a small first step towards that goal and provides pointers to some of the issues bought up by climate change and steps to account for them in travel models. Activity based models, because of their ability to consider wider range of variables and interactions than trip based models, offer an avenue for incorporating climate change information. If national governments act to stem the tide of global warming adoption of these measures into travel models can be studied in more detail. However, these measures should still be adopted given the ancillary benefit of a richer understanding of travel model forecasts.

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