# Transportation Modeling for Climate Change Requires New Ways of Working

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## Introduction

The Nobel Prize winning Intergovernmental Panel on Climate has concluded:

- Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level.
- Global GHG emissions due to human activities have grown since pre-industrial times, with an increase of 70% between 1970 and 2004.
- There is *high agreement* and *much evidence* that with current climate change mitigation policies and related sustainable development practices, global GHG emissions will continue to grow over the next few decades.
- A wide array of adaptation options is available, but more extensive adaptation than is currently occurring is required to reduce vulnerability to climate change. There are barriers, limits and costs, which are not fully understood.[1]

Many U.S. states and municipalities are taking action to reduce future greenhouse gas (GHG) emissions, and it is likely that the Federal government will take action either this year or next. Transportation modeling and transportation planning will need to be responsive to these new priorities and regulations. There should be a shift from modeling based on extrapolations of historical data on transportation behaviors to identifying comprehensive land use and transportation scenarios that meet GHG emission target.

In his 2004 book: *Solving Tough Problems: An Open Way of Talking, Listening, and Creating New Realities*, Adam Kahane describes his experiences using scenario planning in addressing conflicts in South Africa, Guatemala and other trouble spots. A common thread running through these challenging situations is that they share three types of complexity:

- *Dynamic complexity* – "… cause and effect are far apart in space and time … Such problems … can only be understood systemically, taking account of the interrelationships among the pieces and the functioning of the system as a whole."
- *Generative complexity* – "… future is unfamiliar and unpredictable… Solutions … cannot be calculated in advance, on paper, based on what has working in the past, but have to be worked out as the situation enfolds.

[1] Intergovernmental Panel on Climate Change Fourth Assessment Report Climate Change 2007: Synthesis Report Summary for Policymakers

- *Social complexity* – "… the people involved look at things differently… Problems of high social complexity cannot be peacefully solved by authorities from on high; the people involved must participate in creating and implementing solutions."[2]

Climate change involves all three types of complexity. The level of dynamic complexity is extraordinary. GHG emissions are coupled to the global economic and political systems, and to the decisions of individuals throughout the world. The transportation investments being made today will affect the climate for many decades or even for hundreds of years.

Climate change involves generative complexity because it could result in discontinuities from historical trends for several important factors that affect transportation behavior. These include energy prices, land use regulation, and transportation investment patterns.

Climate change also involves social complexity. Attitudes about climate change are changing rapidly and vary greatly from individual to individual. This creates uncertainty about future political decisions that will affect future governmental policies, but also creates uncertainty about future behavior. Will people voluntarily curtail some of their driving? Will telecommuting become much more prevalent? Might there be a widespread shift towards small, light-weight vehicles that would operate only at lower speeds?

This uncertainty requires new approaches to model forecasting and transportation planning that will help us understand the importance of our decisions on future GHG emissions. In place of the false assumption of a single predetermined future, there are a range of possible futures. Transportation modeling and planning should work to identify solutions that will be successful across a range of possible futures, rather than optimized for a single, unlikely future forecast. This practice will help to guide us towards transportation investments that will satisfy GHG emission targets along with other societal goals.

## Transportation Modeling and Complexity

Modeling is a powerful tool for addressing complexity, particularly for systems with dynamic complexity, with causes and effects that are separated spatially. When land use feedback is included, effects separated in time also are modeled. Models also can help with understanding generative complexity and social complexity if a wide enough set of future scenarios are considered, and if the models are used to provide useful information about this wide range of scenarios.

With increased computing power, models are becoming increasing complex. However, not all model complexity is beneficial, and there are inherent tradeoffs between model complexity and usefulness for planning. As models become increasingly complex, it becomes more expensive and time and money to use the models. Modelers face a risk in adding complexity to a model past the point of being practical. This is a sort of analog to the *Peter Principle*, formulated by Dr. Laurence J. Peter in his 1968 book of the same name – *In a hierarchy every employee tends to rise to his level of incompetence.* Similarly, model complexity can increase to a level to where the models lose their ability to play a useful role in decision-making.

Some activity models already have become so complex that they are seldom applied in real world transportation planning exercises. In one of the transportation project planning processes we

[2] Kahane, Adam. *Solving Tough Problems: An Open Way of Talking, Listening, and Creating New Realities*, p. 31. San Francisco, CA: Berrett-Koehler Publishers, Inc., 2004.

currently are reviewing, there is a highly sophisticated regional activity model available. Instead of using this model for future transportation analysis, fixed vehicle trip tables are being assigned within a subarea. Almost all of the complexity captured by the regional model has been removed in this transportation planning process. Instead, it is assumed that a certain level of car trips is evitable in 2035 and that the only remaining uncertainty is which streets the cars will use. The fixed vehicle trip-table assignments are are now being converted into very precise numbers for a 2035 microsimulation analysis. This transference of modeled traffic volumes from a simplistic application of a travel demand model to a highly detailed microsimulation model reinforces the misconception that future traffic volumes are pre-determined and precisely knowable.

This is an extreme example, but the project planning process for Environmental Impact Statements (EIS) generally is hostile towards model complexity on the demand side. The typical EIS process is rooted in a simplistic model where transportation demand is precisely known and transportation supply is designed to meet the demand. Modeling travel demand complexity is resisted in EIS analyses for two reasons. First, including it increases the resources needed for modeling. Second, it can lead to messy results that can be counterintuitive. For example, if induced travel is modeled, this results in secondary traffic impacts that complicate the story and might even need to be mitigated. It is easier to exclude these types of results from the analyses, and to keep the analyses and the story simple.

## Induced Travel and Greenhouse Gas Emissions

Induced travel is a key issue in climate change transportation modeling and planning because expanding roadway capacity generally will result in increased VMT and GHG emissions. The travel demand response to a new road includes change in route, change in destination, change in mode, change in time of day, and change in home and/or work destination. All of these can be modeled with advanced integrated land use/transportation models, but EIS analyses typically exclude several or even most of these factors. In addition, these travel demand effects are interrelated with assumptions about the future that are external to the model, including the level of economic activity, energy prices, GHG regulations, technological change, and social change. The GHG emission response to expanded roadway capacity will be different for a high gasoline price scenario than for a low gasoline price scenario. EIS representations of precise future traffic forecasts are highly misleading, implying much more certainty about the future than is possible, with unstable fuel prices and changing GHG regulatory regimes.

In another project we currently are reviewing, future land use assumptions were set in 2003. While the model was being improved to address transit modeling and road pricing issues, the EIS work progressed slowly, and the Draft Environmental Impact Statement (DEIS) was not released until late in 2007. By this time, the regionally adopted land use projections had changed drastically and the changes are large enough to undermine the entire rationale for the project. As we write this, the agency responsible for preparing the DEIS is holding fast to the idea that the 2003 land use projections are still valid for 2030 even though they are inconsistent with current regionally-adopted projections. This approach is driven by a need to for project planners to get through their lengthy process as quickly as possible, rather than by a need to achieve the best possible investments using the latest available tools.

There is a dynamic tension between the work of modelers in adding complexity and the needs and desires of transportation project planners to simply the processes and models. Both sides have valid points. The modelers are trying to make the models more accurate and sensitive to policy. The EIS preparers are trying to complete the process. Unfortunately, a compromise between these positions is unlikely to result in good climate change transportation modeling. Neither perspective emphasizes the key issues identified above – using scenario planning to evaluate alternatives under uncertainty, and to steer towards a desired future. Therefore, good climate change transportation modeling will require re-engineering the entire transportation planning process.

## Recommendations for Climate Change Transportation Modeling

In order to address the emerging needs for climate change transportation model and planning, we recommend the following:

1. <u>Align the planning process and the modeling tools</u> – Planning needs should guide model structure and model application. Today, most model development is focused on matching past data sets ranging from activity surveys to traffic counts. While replicating history is a necessary condition for model confidence, it also is important that models be more sensitive to alternative future macroeconomic forces including energy prices, and future policy initiatives including land use alternatives. There needs to a shift away from "modeling the system" which can never be completely accomplished, towards "modeling the problem" where there can be a greater focus on testing policies.
2. <u>Test wide range of scenarios and steer towards preferred scenario</u> – Transportation planning too often has been a plan for failure where a single future scenario is considered assuming growth in population, limited expansion of transportation infrastructure, and the same basic behavior. Future performance metrics are almost always modeled as worse in the future than today despite enormous planned investments. Alternatives that would perform better are excluded from consideration because they involve changes (e.g. land use changes) that are outside the control of the transportation agency. Instead, we should consider a wider range of alternative futures to reflect the fact that the future is highly uncertain, and a range of scenarios is therefore a more accurate representation of this than a single scenario. Transportation plans should be robust and successful across a range of realistic transportation futures, rather than just a single unlikely modeled forecast. If a proposed project appears to be needed with one adopted land use projection, but not with the subsequent adopted projection, the plan is not robust. Furthermore, transportation investments are not completely independent from the future, as they helps to determine the future, especially in terms of land use patterns and behavior. We will need modeling of a range of scenarios to help us determine which investments will best help us reach our GHG reduction goals. If the planning process helps to educate decision makers and the general public concerning the implications of different future scenarios, it is much more likely that a desired future will be achieved.
3. <u>Use tiered modeling and planning process</u> –National Environmental Policy Act (NEPA) regulations support the use of Tiered EIS, where larger issues are explored at a higher level and general decisions are made, and more detailed analyses are done at the project level. To a certain extent, a type of tiered analysis is being done on an ad hoc basis in transportation planning when the regional transportation plan includes a more sophisticated modeling analysis and individual project EIS use simpler models. However, this process is lacking because the regional modeling is not really resolving the big picture issues. Unanswered questions include: What land use strategies are most effecting in reaching GHG emission targets? How much induced travel results from freeway expansion? What pricing strategies are optimal, and how can equity issues resulting from pricing be addressed? What are the relationships between street spacing and multimodal transportation and GHG emissions? If

these issues were thoroughly explored at the regional level, and a consensus was reached, and the contribution of a project to achieving GHG goals was understood, this consensus could guide project planning. With this consensus on the overarching environmental issues, there would be less need for the detailed analysis at the project level.

4. Shift emphasis to general strategies that are incremental and adaptable – The importance of Federal transportation funding for capital projects and the attractiveness of large, signature projects has caused an overemphasis on large, expensive "mega-projects" (both roadway and transit) that have large lead times, have high cost, and often have unintended consequences. With good modeling tools, multiple scenarios and a tiered modeling planning process, the planning process could be shifted towards a large number of smaller projects that were consistent with the general regional planning consensus, and that would be more effective in meeting community and societal goals, while also being more cost effective. This would allow for considering multi-faceted approaches, such as establishing a network of closely-spaced multimodal streets, medium- to high-density mixed, walkable land use, congestion pricing for high-speed limited access urban roadways, and a regional transit network.

The climate change challenge for our country is enormous, and addressing GHG reduction will require fundamental changes in numerous sectors of our economy. Transportation will be among the more complex challenges, as our system is the result of land use patterns that evolve over a long time, large scale transportation investments and millions of decisions made by system users every day. Fortunately, we have excellent modeling tools available, and the above recommendations focus more on how these tools can be used more effectively, rather than on a need for entirely new tools.